European Commission

THE EU BLUE ECONOMY REPORT 2020

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The EU Blue Economy Report 2020

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FOREWORD

Oceans, coastal areas and marine activities are playing a crucial role now and in the future of the European Union and its citizens. Healthy oceans and coastal areas are vital for our societies and the future of our planet. They are the lungs of our planet, producing half of the oxygen we breathe. They are a source of healthy food, contributing 16 % of the animal protein we eat and provide the basis for numerous economic activities that generate growth and jobs.

We are determined to continue our endeavour to support sustainable growth in the marine and maritime sectors through the European Union Blue Growth Strategy. The need to recognise and acknowledge the value of oceans – be it cultural, social or economic – is even more acute now, when we traverse a major crisis caused by the coronavirus pandemic. The European Blue Economy can and must be a central and solid pillar contributing to the general resilience of our society.

The European Union puts highest priority to the increasing climate, environmental and social challenges that society is facing today. At the epicentre of the response stands the European Green Deal, an ambitious package of measures aiming at cutting greenhouse gas emissions, investing in cutting-edge research and innovation, and preserving Europe's natural environment. The European Green Deal will underpin a new growth strategy that aims to transform the economy and society to part of the way for a more sustainable future. Research and innovation is a fundamental pillar of this European response.

We will make sure that research, innovation and education contributes to the transition towards a European Blue Economy, in particular through the future Horizon Europe programme and its specific Mission on Healthy oceans, seas, coastal and inland waters. This will contribute to deploy European solutions for the reduction of marine pollution including plastics, mitigation of climate change in the ocean, sustainable use and management of ocean resources, development of new materials including biodegradable plastic substitutes, new feed and food systems, coastal and maritime spatial planning and ocean governance.

Hence, I am happy to present to you the 2020 Blue Economy report. This year's edition goes beyond looking at the economic performance of marine activities. The report highlights the need to preserve marine ecosystems to optimise potential benefits of ecosystem services and marine and maritime economic sectors. With this aim, the European Commission is investing in research, innovation and education to create a brighter blue future, even and particularly during this difficult period.

***Mariya Gabriel**, Commissioner for Innovation, Research, Culture, Education and Youth, responsible for the Joint Research Centre (JRC)*

FOREWORD

The EU Blue Economy Report has become the reference to understand past developments, trends and future opportunities in the Blue Economy and all individual economic activities related to our seas and oceans in the EU and its Member States.

I am very proud of this year's edition. It is more than an annual update, as we continue to develop and expand its scope to cover additional sectors and activities. Our seas and oceans are such an important part of our life. We rely on them for food and tourism, for transport and renewable energy. They are a source of rich biodiversity and valuable eco-system services. At the same time, they also face a unique set of challenges, from depleting fish stocks to increasing environmental pressures.

I would like to draw particular attention to the section on ecosystem services. This section elaborates the important links of the oceans and the blue economy with the European Green Deal, our sustainable growth strategy. Understanding the importance of natural capital and the ecosystem services derived from it is fundamental to ensuring its sustainable use. With the EU Blue Economy Report, now and in future editions, we aim to develop this important area of work.

Our original idea was to present this publication at the European Maritime Day in Cork. However, the coronavirus crisis has affected our plans, taking a heavy toll on lives and livelihoods. Many thriving businesses have been hit hard by supply and demand disruptions, the blue economy making no exception. The European Commission has quickly adopted strong support packages for the economy at large and for blue economy sectors in particular, including for fisheries and aquaculture, which are the lifeline of many coastal communities and crucial to ensure food and nutrition security for our population.

Despite the setback brought on by the coronavirus crisis, I strongly believe in a bright future for the blue economy. Several sectors marked a dynamic development before the crisis and have a strong potential to contribute to a swift and sustainable recovery in line with the EU Green Deal. Maritime renewable energy, food from the sea, sustainable coastal and maritime tourism, the blue bio economy and many other activities constituting the blue economy will help us come out of this crisis stronger, healthier, more resilient and sustainable.

This report builds on data for 2018, the most recent available, and looks both at established sectors that have proven their value to society and at emerging activities that offer a preview into the future. For all these sectors, I believe we are at the beginning of a fascinating story, full of opportunities to bring forward the strategic approach to a sustainable blue and green economy. I wish you a pleasant and interesting reading.

Virginijus Sinkevičius*, EU Commissioner for Environment, Oceans and Fisheries*

CONTENTS

EXECUTIVE SUMMARY

In its third edition, the *EU Blue Economy Report* continues to analyse the scope and size of the Blue Economy in the European Union. It aims at providing support to policymakers and stakeholders in the quest for a sustainable development of oceans, coastal resources and, most notably, to the development and implementation of polices and initiatives under the European Green Deal in line with the new approach for a sustainable Blue Economy.

For the purposes of the *Report*, the Blue Economy includes all those activities that are marine-based or marine-related. Therefore, the *Report* examines not only established sectors (i.e. those that traditionally contribute to the Blue Economy) but also emerging (those for which reliable data are still developing) and innovative sectors, which bring new opportunities for investment and hold huge potential for the future development of coastal communities. Analyses are provided for the EU as a whole and by sector and industry for each Member State.

The European Green Deal and the European Strategy for data will necessitate reliable, accurate and centralised data for its initiatives. This *Report* intends to serve as a useful input to assessing the potential of oceans and coasts for shifting to more sustainable economy and to supporting the development of policies in line with the strategic approach for a sustainable blue economy at all levels of governance.

The third edition of the *Report* seeks to include new elements, which have an impact on the Blue Economy, including challenges like climate change, new sectors such as Submarine cables), enablers such as Maritime Spatial Planning, new areas of analysis such as Ecosystem Services or potential solutions like Multi-purpose platforms.

The Blue Economy established sectors include the following seven sectors: *Marine living resources*, *Marine non-living resources*, *Marine Renewable energy*, *Port activities*, *Shipbuilding and repair*, *Maritime transport* and *Coastal tourism*. The analysis of these sectors is based on the data collected by the European Commission through Member States and the European Statistical System. Fisheries and aquaculture data were collected under the EU Data Collection Framework (DCF). Analyses for all other established sectors are based on Eurostat data from Structural Business Statistics (SBS), PRODCOM, National Accounts and tourism statistics.

According to the most recent figures, the established sectors of the EU Blue Economy directly employed close to 5 million people and generated around €750 billion in turnover and €218 billion in gross value added in 2018 (Table 1).

Table 1 EU Blue Economy established sectors, main indicators, 2018

Indicator	EU Blue Economy 2018
Turnover	€750 billion
Gross value added	€218 billion
Gross profit	€94 billion
Employment	5 million
Net investment in tangible goods	€14 billion
Net investment ratio	22%
Average annual salary	€24,700

Notes: Turnover is calculated as the sum of the turnover in each sector; it may lead to double counting along the value chain. Nominal values. Direct impact only. Net investment excludes maritime transport and coastal tourism. Net investment ratio is defined as net investment to GVA.
Source: Eurostat (SBS), DCF and Commission Services.

The Blue Economy emerging and innovative sectors include some *Marine renewable energy* (i.e. *Ocean energy*, *floating solar energy* and *offshore hydrogen generation*), *Blue bioeconomy and biotechnology*, *Marine minerals*, *Desalination*, *Maritime defence*, and *Submarine cables*. These sectors offer significant potential, especially as regards renewable energies where the EU is in the lead hosting 70 % of global ocean energy (wave and tidal) installed capacity in its waters. The *Maritime defence* sector accounts for over 177 000 jobs and within *Blue bioeconomy* sector, the algae sector generated an estimated turnover of over €350 million. Desalination continues to be a key sector for those countries that are more likely to suffer water shortages (e.g. Spain), not least as a result of climate change, even if with important side effects (brine, energy consumption etc.).

Preserving and increasing the natural capital accumulated in the seas and oceans is critical for them to deliver sustainable ecosystem services and for the EU to achieve the Sustainable Development Goals (SDGs) set by the UN for 2030. The Marine Strategy Framework Directive (MSFD) provides a comprehensive, holistic approach to the protection of European Seas, acting as the environmental pillar of the wider EU Maritime Strategy. Climate change (rising temperatures, acidification, deoxygenation, sea level rise) constitutes yet an additional pressure compounding the effects of pollution, biodiversity and other existing threats.

The Blue Economy is linked to many other economic activities and its impact goes beyond the above-mentioned sectors. Success stories and more niche sectors or activities in the Blue Economy are presented in the form of case studies and boxes. These include; the impacts of recreational boating, Blue Economy projects financed by the European Investment Bank (EIB) and the European Reconstruction and Development Bank (EBRD), the use of Multi-Purpose Platforms (MUPs) to combine several sectors and how the EU Blue Economy compares to that of the US, among others.

The *Report* comprises an overview of the EU Blue Economy for each sea basins, providing more figures than past editions. Finally, the *Report* is completed with an Annex providing a short analysis of the Blue Economy in each Member State.

CHAPTER 1
INTRODUCTION

*'How inappropriate to call this planet Earth
when it is quite clearly Ocean'*

Arthur C. Clarke

Aim of the report

The ocean underpins life on our Planet, ensures that essential needs of our society are met and supports countless economic activities. Besides the traditional exploitation of living resources (fishing, aquaculture and the processing sector), a broader vision of the Blue Economy can offer important sources of sustainable economic development for Member State economies, coastal communities in particular, and a better understanding of the value of the ocean and its ecosystems.

A sustainable Blue Economy allows society to obtain value from the oceans and coastal regions, whilst respecting the long-term capacity of the oceans to regenerate and endure such activities through the implementation of sustainable practices. This implies that human activities must be managed in a way that ensures the health of the oceans and where economic productivity is safeguarded, so that the potential they offer can be realised and sustained over time.

The ***EU Blue Economy Report*** seeks to continuously improve the measuring and monitoring of the socio economic impact of the Blue Economy, without disregarding the environmental implications. As the European Union embarks on the new **European Green Deal**[1], the need to ensure that all angles are being considered becomes more and more evident so economic growth and employment go hand in hand with protecting and restoring nature and fighting climate change.. The *Report* should be seen as a tool to support relevant initiatives and policies under the new European Green Deal, which aims at implementing the United Nation's 2030 Agenda by putting "sustainability and the well-being of citizens at the centre of economic policy and the sustainable development at the heart of the EU's policymaking and action"[2].

To achieve the aims embedded in the new European Green Deal "it is essential to increase the importance given to protecting and restoring natural ecosystems, to the sustainable use of resources and to improving human health. This is where transformational change is most needed and potentially most beneficial for the EU economy, society and natural environment"[3]. The *EU Blue Economy Report* aims to continue to provide accurate and reliable data and trends for the maritime sectors and activities, as good data is essential in order to develop and implement policies. The *EU Blue Economy Report* also provides a solid ground on which to make policy decisions and supports the transition into more carbon efficient and less polluting technologies and activities.

The *Report* is accompanied by the *Blue Economy Indicators (BEI)*, an IT tool that stores and disseminates additional breakdowns of the data, to guarantee transparency[4]. The BEI ensures that the data reported are available to all in a way that is easily accessible, and where data can be use and re-used. The data available at the BEI are based on the same methodology explained in Annex 3.

In addition to the European Green Deal, the report and particularly the Blue Economy Indicators strive for more and better data in line with the European Commission's **European Data Strategy**[5] to ensure that the EU is a front-runner in an ever more-digital world. The goal of the strategy is to create a policy environment to make the EU a leader in a data-driven society. Creating a single market for data will allow it to flow freely within the EU and across sectors for the benefit of businesses, researchers and public administrations. Only with high quality, data can policy makers and citizens make adequate and informed decisions.

The report and the IT tool (BEI), which stores and disseminates the data play a crucial role to ensure transparency. They ensure that the data being reported is available to all in a way that is easily accessible and user-friendly, even for those who may have limited knowledge on the topic. Moreover, the strategy itself aims at "making more high-quality public sector data available for re-use […]"[6]. The report, in its downloadable format, certainly attempts to meet this objective but most importantly, the BEI provides for this by not only making all data public but also allowing all users to extract and download them in a variety of forms, hence enabling them to use and re-use the data.

What does the Blue Economy include?

For the purpose of this *Report*, the EU's Blue Economy encompasses all sectoral and cross-sectoral economic activities based on or related to the oceans, seas and coasts:

- **Marine-based activities:** include the activities undertaken in the ocean, sea and coastal areas, such as *Marine living resources* (capture fisheries and aquaculture), *Marine minerals*, *Marine renewable energy*, *Desalination*, *Maritime transport* and *Coastal tourism*.
- **Marine-related activities:** activities which use products and/or produce products and services from the ocean or marine-based activities like seafood processing, biotechnology, *Shipbuilding and repair*, *Port activities*, technology and equipment, digital services, etc.

Yet, the ocean also has an economic value that is complex to quantify, in terms of provision of resources, habitat for marine life, carbon sequestration, coastal protection, waste recycling and storing, and processes that influence climate change and biodiversity. To the extent possible, the *Report* covers most of these issues too.

In terms of geographical scope, the *Report* focuses on the EU territory, including when and where possible outermost regions and landlocked Member States.

The *Report* compiles the data on the economic activities emerging directly from the identified sectors. However, some Blue Economy sectors generate significant indirect economic effects (i.e. up into the supply chain) and induced economic effects (i.e. general consumption and expenditure stemming from the household disposable income generated by Blue Economy activities). At times and

[1] Commission Communication on "The European Green Deal" COM (2019) 640 final.
[2] COM (2019) 640 final, p. 3.
[3] COM (2019) 640 final, p. 4.
[4] The Blue Economy Indicators tool can be accessed through the online dashboard available at: https://blueindicators.ec.europa.eu/.
[5] Commission Communication on "A European Strategy for Data" COM (2020) 66 Final.
[6] COM (2020) 66 Final p. 13.

where possible, these effects are incorporated into other Blue Economy sectors or are made reference to in the sector specific chapters.

Content and structure

Following the present Introduction, **Chapter 2** provides an **overview** of several broad issues, such as the general economic and political context, providing a background to the Blue Economy, including the sources of financing available for the Blue Economy projects. The chapter further includes a summary of the main features of the established and emerging sectors. It concludes with a brief and preliminary assessment of the initial impacts and early response to the COVID-19 health crisis, to the extent known at the time of writing.

With the European Green Deal as background, **Chapter 3** looks at the **Human impacts** on the ocean. In particular, it looks at the socio-economic impacts and costs caused by the rising sea level in the EU coastal regions under different IPCC scenarios, and the investments needed to protect these regions. This chapter also provides projections and cost-benefit assessment methodology that can assist managers and stakeholders involved in the maritime spatial planning policies.

It also tackles the issue of the greenhouse gas emissions and its trends in some Blue Economy sectors, as well as how the oceans can contribute to carbon sequestration, i.e. *Blue Carbon*. Therefore it provides a solid ground on which to make policy decisions in support of the transition into more carbon efficient and less polluting technologies and activities, without disregarding the importance of creating a more sustainable economy and maintaining jobs. The chapter also includes an estimate of the costs generated by marine pollution, notably by litter and of the effects of climate change on European fisheries and aquaculture.

To complement the previous chapter, **Chapter 4** seeks to better clarify what is meant by **natural capital and ecosystem services** and what they encompass. It also highlights the importance of maintaining the ocean system in good health and the significant economic impact that its degradation can have in the future. It comprises, where possible, an estimation of the economic value of Blue Economy sectors, benefiting from the marine ecosystem.

Chapter 5 The report then reviews a series of traditional Blue Economy activities, the "established sectors", looking at the main economic indicators as well as the trends, drivers and interactions with other sectors or activities. This chapter provides analysis at an EU level, but also emphasises the contribution made by key MSs to different sectors. The established sectors include the following:

- Marine living resources.
- Marine non-living resources.
- Marine renewable energy.
- Ports activities.
- Shipbuilding and repair.
- Maritime transport.
- Coastal tourism.

Chapter 6 provides an analysis of the emerging sectors, i.e. sectors that are either new or for which there is limited data. The chapter attempts to highlight the impact that these sectors have and their potential for further growth and expansion. The following sectors are included in the section:

- Ocean energy.
- Blue bioeconomy and biotechnology.
- Marine minerals.
- Desalination.
- Maritime Defence.
- Submarine cables.

The report comprises a series of additional topics. **Chapter 7** compiles a number of case studies that explore different sectors or niches sections of the Blue Economy. They range from a case study on the economic impact of education and skills in the Blue Economy, the economic benefits of Multi-purpose platforms, the relevance of Marine observation, the importance of R&D investments at a regional level, with a specific focus on Catalonia (ES), the impact of the EU recreational boating industry and, finally, the main results from the Portuguese Satellite Accounts for the Sea.

Finally, **Chapter 8** is split into two main sections. The first section provides an overview of the impact of the Blue Economy in the EU at a sea basin level, presenting results for employment and GVA for all seven Blue Economy established sectors. The second aims at analysing the EU Blue Economy in contrast with some of its major counterparts, seeking to put the EU Blue Economy results into perspective vis-à-vis major world actors. This year, the comparison is with the Blue Economy in the United States, as reported by the National Oceanic and Atmospheric Administration (NOAA).

A series of **Annexes** complete the *Report* offering an overview of the Blue Economy for each of the EU Member States, including where available, a summary of Blue Economy strategies and reports at national or regional level. They Annexes include also a series of additional tables with complementary detailed data on the established sectors and a detailed explanation on the methodology used across the *Report*.

Note on the COVID-19 outbreak

The outbreak of COVID-19 reached the EU in late February 2020. At the time this report was finalised, most EU Member States, as well as other countries around the globe, were still implementing strict confinement restrictions and planning the de-confinement process. While it is clear that the extent of the impact of the COVID-19 and the resulting economic crisis will be heterogeneous across the Blue Economy sectors and activities, this impact will also depend on the duration of the crisis, which is still unknown at the time of writing. Nevertheless, Section 2.5 highlights the initial effects and the early response to the crisis by summarising the main measures put in place by the EU and its Member States.

Note on the treatment of the United Kingdom in this report

This report is based on data going no further than December 2019 when reporting current status; it therefore includes the United Kingdom (UK) in the analysis. Hence, all references made to the EU-28 concern the period/data when the UK was an EU Member State. For any analysis including future estimates and projections, the UK has not been included.

CHAPTER 2

EU OVERVIEW

This chapter provides the background and context to the report and the chapters that will follow hereafter. As a starting point, it presents the Blue Economy in the context of the overall EU economy. This is followed by a brief overview of the policy instruments that allow and enable the Blue Economy to further develop in a sustainable manner, including MSP, the MSFD and EU ETS. The subsequent section focuses on the financing of the Blue Economy and the sources of funding (namely BlueInvest, EIB and ERDF). It then uses a number of concrete examples to illustrate the investments described.

This chapter also presents an overview of the Blue Economy in general, serving as background particularly for Chapter 5 and putting the EU Blue Economy into perspective. Without going into too much detail, it looks at the main features of the established sectors, the evolution of the various sectors and how these compare. The final section provides a summary of the initial impacts of the COVID-19 health crisis on the Blue Economy and the responses that have been so far put in place by the EU and the MS.

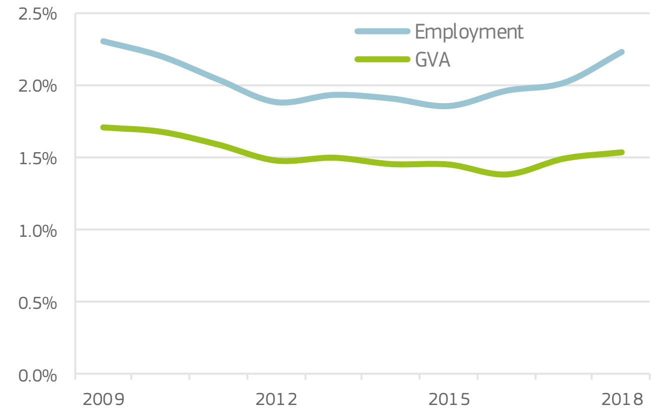
2.1. GENERAL ECONOMIC CONTEXT

The Blue Economy is embedded in the overall EU economy and is therefore highly influence by the economic cycle. The EU-28 GDP was estimated at €15 900 billion in 2018 (€13 500 without the UK) and employment at 224 million people (194 million people without the UK)[7]. The contribution of the Blue Economy established sectors to the EU-28 economy in 2018 was 1.5 % in terms of GVA and 2.2 % in terms of employment (Figure 2.1).

The relative size of the EU Blue Economy in terms of GVA with respect to the overall economy has remained stable at around 1.5 % since 2012, while it has increased in terms of employment from 1.8 % in 2015 to more than 2.2 % in 2018. Although data for the EU Blue Economy established sectors are only available until 2018, given the relative stability in their share over the total economy, its size is expected to continue to expand at similar rates in 2019.

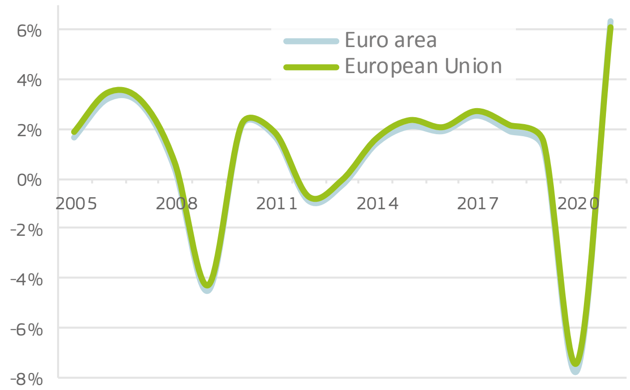
A positive general economic environment supported the EU Blue Economy during the last decade, particularly since the end of the double-dip recession in 2013 (Figure 2.2). However, the outbreak of the coronavirus pandemic in February 2020 represents a major shock for the global and EU economies, with severe socio-economic consequences. Despite the swift and comprehensive policy response at both the EU and the national level, the EU economy is expected to experience a recession of historic proportions this year, according to the latest Commission economic forecast[8]. The different sectors of the Blue Economy will be significantly impacted (See Section 2.5 for further details).

Figure 2.1 Contribution of the Blue Economy to the overall EU economy



Note: Data for 2018 are provisional.
Source: Eurostat (SBS), DCF and Commission Services.

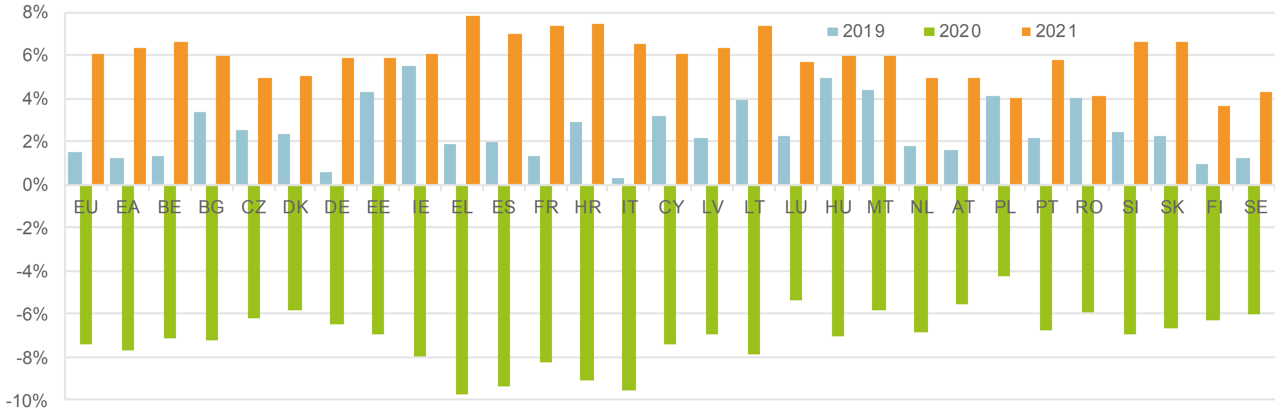
Figure 2.2 GDP annual growth, real terms, annual data



Notes: EU 27. Data for 2020 and 2021 are forecast.
Source: Eurostat, AMECO and Commission Services.

[7] The data on GDP and population were extracted from Eurostat on 28 February 2020.
[8] European Commission (2020). European Economic Forecast. Spring 2020. European Economy Institutional Paper 125.

Figure 2.3 GDP annual growth, real terms, breakdown by Member State



Notes: EU 27. Data for 2020 and 2021 are forecast.
Source: Eurostat, AMECO and Commission Services.

According to the Commission Economic Forecast, the **euro area** economy is projected to contract by a record 7.7% in 2020 and grow by 6.3% in 2021. Further, the **EU economy** is forecast to contract by 7.4% in 2020 and grow by 6.1% in 2021 (Figure 2.2). The shock to the EU economy is symmetric in that the pandemic has hit all Member States, but both the drop in output in 2020 (from -4.3% in Poland to -9.7% in Greece) and the strength of the rebound in 2021 are set to differ (Figure 2.3). Each Member State's economic recovery will depend not only on the evolution of the pandemic in the country, but also on the structure of its economy and its capacity to respond with stabilising policies. Given the interdependence of the EU economies, the dynamics of the recovery in each Member State will also affect the strength of the recovery in other Member States. A comprehensive response at the EU and the national level is being implemented to mitigate the impacts of the crisis and support the recovery (See Section 2.5 for details).

The economic output is thus set to collapse in the first half of 2020 with most of the contraction taking place in the second quarter. It is then expected to pick up, assuming (i) that containment measures will be gradually lifted, (ii) that after these measures are loosened the pandemic remains under control, and (iii) that the unprecedented monetary and fiscal measures implemented by Member States and the EU are effective at cushioning the immediate economic impact of the crisis as well as at limiting permanent damage to the economic tissue.

At the time of writing, the European Commission can only tentatively map out the scale and gravity of the coronavirus shock. While the immediate fallout will be far more severe for the global economy than the financial crisis, the depth of the impact will depend on the evolution of the pandemic, the ability of the Union to safely restart economic activity and to rebound thereafter. Both the depth of the recession and the strength of the recovery will be uneven, conditioned by the speed at which lockdowns can be lifted, the importance of services like tourism in each economy and by each country's financial resources.

The coronavirus pandemic has severely affected consumer spending, industrial output, investment, trade, capital flows and supply chains. The expected progressive easing of containment measures should set the stage for a recovery. However, the EU economy is not expected to have fully made up for this year's losses by the end of 2021. Investment will remain subdued and the labour markets will not have completely recovered.

While short-term work schemes, wage subsidies and support for businesses should help limit job losses, the COVID-19 pandemic will have a serious impact on the labour market. The unemployment rate in the euro area is forecast to rise from 7.5% in 2019 to 9.5% in 2020 before declining again to 8.5% in 2021. In the EU, the unemployment rate is forecast to rise from 6.7% in 2019 to 9% in 2020 and then fall to around 8% in 2021.

2.2. POLICY INSTRUMENTS

The following section illustrates a number of EU policy instruments that are relevant to the Blue Economy. Although it is by no means a comprehensive list, the section should be seen as an introduction to some of those which are deemed important in terms of sustainability. Future editions of this report may highlight additional existing policy instruments.

2.2.1. THE EU EMISSION TRADING SYSTEM

The EU emissions trading system (EU ETS) is central to the EU's policy to combat climate change and its key tool for reducing greenhouse gas emissions cost-effectively. The EU ETS was launched in 2005 and currently covers around 45 % of the EU's GHGs from the 27 EU Member States, United Kingdom, Iceland, Liechtenstein and Norway. It limits emissions from more than 11 000 heavy energy-using installations (power stations and industrial plants) and airlines operating between these countries.

The EU ETS was designed with the intention to reduce GHG emissions, from all sectors covered, by 21 % in 2020 compared to the 2005 levels. Recently, the European Commission proposed a more ambitious goal within the framework for climate and energy policy: a 40 % reduction in EU greenhouse gas emissions by 2030 compared to 1990 levels. Achieving this objective will require emission reductions of 43 % compared to 2005 levels, in line with the 2030 climate and energy policy framework and as part of the EU's contribution to the 2015 Paris Agreement. Under the European Green Deal, the European Commission will present a plan to increase the EU's greenhouse gas emission reduction target in a responsible way, including for the EU ETS.

In the EU ETS, a central authority regulates the overall carbon emissions by setting limits on the amount of emissions that can be produced. This amount is then allocated to firms, in the form of emission permits representing the right to emit or discharge a specific volume of carbon emissions, which is normally based on historical consumption. In the EU ETS case, an emission limit (or cap) was established during the first two phases (or trading periods), for each individual firm, via National Allocation Plans (NAPs) submitted by the participating countries and approved by the European Commission. Under the third trading period (2013-2020) the system of NAPs is replaced by harmonised EU-wide caps and allocation rules. Airlines were integrated into the EU ETS in 2012; petrochemicals, ammonia and aluminium industries followed shortly after (2013). The legislative framework of the EU ETS for its next trading period (phase 4) was revised in early 2018 to enable it to achieve the EU's 2030 emission reduction targets in line with the 2030 climate and energy policy framework and as part of the EU's contribution to the 2015 Paris Agreement[9].

Currently, emissions from international shipping, including between the EU Member States, are not covered by the EU ETS. The first step towards reducing EU maritime emissions effectively is to quantify these emissions accurately, provided for by the 2015 Regulation on the monitoring, reporting and verification of CO_2 emissions from large ships (MRV Regulation). This Regulation has created a system that began collecting and publishing verified annual CO_2 emission data of large ships using EU ports in 2018, constituting the successful first step in the Commission's three-step strategy to address maritime emissions. Following the European Green Deal communication, the Commission will, among other measures, propose to extend European emissions trading to the maritime sector.

Firms are required to annually return permits equivalent to their emissions. Under such a trading system, firms that keep their carbon emission levels below their allowed quota may sell their surplus permits to other firms. While firms producing excess carbon emissions have to acquire extra allowances from firms performing well or else pay a fine. Trading brings flexibility that ensures emissions are cut where it costs least to do so. A robust carbon price also promotes investment in clean, low-carbon technologies.

Effort sharing 2021-2030

EU Member States have binding annual greenhouse gas emission targets for 2021-2030 for those sectors of the economy that fall outside the scope of the EU Emissions Trading System. These sectors, including transport, buildings, agriculture, non-ETS industry and waste, account for almost 60 % of total domestic EU emissions. The sectors of the economy not covered by the EU ETS must reduce emissions by 30 % by 2030 compared to 2005 as their contribution to the overall target. The Effort Sharing Regulation translates this commitment into binding annual greenhouse gas emission targets for each Member State for the period 2021-2030, based on the principles of fairness, cost-effectiveness and environmental integrity[10].

2.2.2. MARINE STRATEGY FRAMEWORK DIRECTIVE

The EU's Marine Strategy Framework Directive has been in force since 2008. It requires Member States to set up national marine strategies to achieve, or maintain where it exists, 'good environmental status' by 2020[11].

The MSFD promotes the ecosystem-based approach, which is a strategy for the integrated management of land, water and living resources that promotes conservation and sustainable use in an equitable way. The goal of ecosystem-based management is to maintain an ecosystem in a healthy, productive and resilient condition so that it can provide the goods and services humans want and need. It considers the cumulative impacts of different sectors, and aims to ensure that the cumulative pressures of human activities do not exceed levels that compromise the capacity of ecosystems to remain healthy, clean and productive.

9 European Commission (2020).
10 DG CLIMA. Effort sharing 2021-2030: targets and flexibilities. Available at: https://ec.europa.eu/clima/policies/effort/regulation_en
11 Meaning: "the environmental status of marine waters where these provide ecologically diverse and dynamic oceans and seas which are clean, healthy and productive within their intrinsic conditions, and the use of the marine environment is at a level that is sustainable, thus safeguarding the potential for uses and activities by current and future generations"

The MSFD is one of the most ambitious international marine protection legal frameworks, aligning the efforts of MS in coordination with non-EU countries, to apply an ecosystem-based management and to achieve good environmental status. The scope of the Directive stretches from the coast to the edge of Member States' jurisdiction, and protects the full range of marine biodiversity.

The MSFD requires integrated planning (the marine strategies) to be developed based on 11 descriptors and a number of criteria and parameters to be assessed by each of the Member States. The MSFD descriptors set objectives such that biological diversity (D1), food web structure (D4) and sea-floor integrity (D6) are maintained; while the impacts from non-indigenous species (D2), fishing (D3), excess nutrients (D5), changes in hydrographical conditions (D7), contaminants in the environment (D8) and in seafood (D9), marine litter (D10) and underwater noise (D11) do not adversely alter the marine ecosystems.

As the transboundary nature of certain pressures and ecosystems makes them very difficult to manage at the Member State level alone, the Directive states that regional sea conventions can aid cooperation.

The MSFD integrates, but does not regulate specifically, all activities that affect marine ecosystems (e.g. fisheries and aquaculture, shipping, offshore oil and gas extraction, renewable energies). About 75 % of the MSFD measures stem from other legislative frameworks. Hence, streamlining and coordination with other sectoral policies is essential to attain the objectives, both at a national and an EU levels. The Blue Growth strategy needs to be compatible with sustainability according to the MSFD, especially with respect to the potential expansion of maritime activities such as offshore energy generation and aquaculture. To ensure that the expansion of traditional activities or that the deployment of new economic activities do not pose additional pressures on the marine environment, the EU and its Member States need to ensure strong links between the MSFD and the policies that regulate maritime activities. Doing so may help reach the objectives of the European Green Deal.

2.2.3. MARITIME SPATIAL PLANNING

Throughout this report, it is clear that there is a high and rapidly increasing demand for maritime space for the different purposes. These include: installations for the production of energy, oil and gas exploration and exploitation, the extraction of raw materials, maritime shipping and fishing activities aquaculture installations, tourism, ecosystem and biodiversity conservation, and underwater cultural heritage. This convergence of uses over the maritime space, as well as the multiple and cumulative pressures on coastal resources, requires an integrated planning and management approach. Maritime Spatial Planning (MSP) seeks to manage human activities in maritime space so that the various economic and social objectives can be achieved in an efficient, safe and sustainable way. In this context, MSP is considered an important tool for the sustainable development of the blue economy of marine areas and coastal regions, and for the restoration of Europe's seas to environmental health[12].

MSP in the EU

In the EU, the fundamentals of maritime spatial planning present in the *Communication on Integrated Maritime Policy* of 2007[13] were further developed in the Communication *Roadmap for Maritime Spatial Planning: Achieving Common Principles in the EU* in 2008[14]. This launched a debate that led to the adoption of the MSP Directive in 2014[15].

Once the Marine Strategy Framework Directive (MSFD)[16] established the conditions for protecting the marine environment, the MSP Directive can be seen as a key enabler for achieving the economic potential of the seas while ensuring long-term sustainability[17]. The underlying goals of planning the use of maritime space include:

- Conflict reduction and avoidance: between sectors, but also adjacent Member States and third countries.
- Encouraging compatibilities for activities in the same space or adjacent areas.
- Ensuring that competing activities do not harm the ocean environment.
- Cost reduction: mainly procedural costs such as transaction costs, licencing and permits.
- Certainty: a stable and certain framework facilitates long-term investment decisions.

A key feature of EU action on MSP consists in cross-border cooperation among EU Member States to tackle common challenges. Some precedents of cross-border cooperation initiatives have already been proposed in the context of Regional Sea conventions and intergovernmental organisations such as the Helsinki Commission (HELCOM), the VASAB (Visions and Strategies Around the Baltic Sea), which already in 2010 established a joint MSP working group for developing coherence between MSPs of the Baltic Sea countries, and the OSPAR Convention. The MSP Directive represents the first legal requirement for planning the sea space with a coordinated, integrated and transboundary approach. The directive requires Member States to elaborate plans for their jurisdictional waters by March 2021 taking into account the following elements:

- Involving stakeholders, i.e. participation is a fundamental building block of the directive.
- Developing cross-border cooperation.
- Applying an ecosystem-based approach.
- Using the best available data and share information.
- Taking into account land-sea interaction.
- Promoting the co-existence of activities.
- Reviewing the plans at least every 10 years.

[12] This Section builds mainly on Friess, B. and M. Grémaud-Colombier (2019). "Policy outlook: recent evolutions of maritime spatial planning in the European Union", Marine Policy. https://doi.org/10.1016/j.marpol.2019.01.017 and the references cited there.
[13] COM(2007) 575 final.
[14] COM(2008) 791 final.
[15] Directive 2014/89/EU.
[16] Directive 2008/56/EC.
[17] Other key enablers of the blue economy include data and information, research, skills, environmental protection and maritime surveillance.

The plans should map existing human activities in the corresponding marine and coastal waters and identify their most effective and sustainable future spatial development. They must take into account land-sea interactions and environmental, economic, social and safety aspects. EU Member States are required to ensure that they make use of the best available economic, social and environmental data. While all activities should be taken into account, the directive focuses on some key economic sectors such as Aquaculture, Marine renewable energy, Maritime transport and the Blue bioeconomy.

In order to support Member States in the implementation of the MSP Directive, the European Commission set-up the *EU MSP Platform* in 2016. In addition, funding to support the elaboration of MSP and pilot projects is available from various sources such as from the EMFF, Interreg projects or Horizon 2020 programme. By April 2020, five Member States (Belgium, Germany, Malta, Latvia and the Netherlands) had already adopted their plans. The rest are progressing towards the adoption by March 2021[18].

In the context of cross-border cooperation, MSP has the ambition to become region-specific rather than country-specific, given the transnational approach included in the MSP Directive. Developing a common vision for each sea basin will be the key to a sustainable Blue Economy. In the EU, such visions are being developed through the sea basin strategies (See Section 8.1).

MSP at a global level

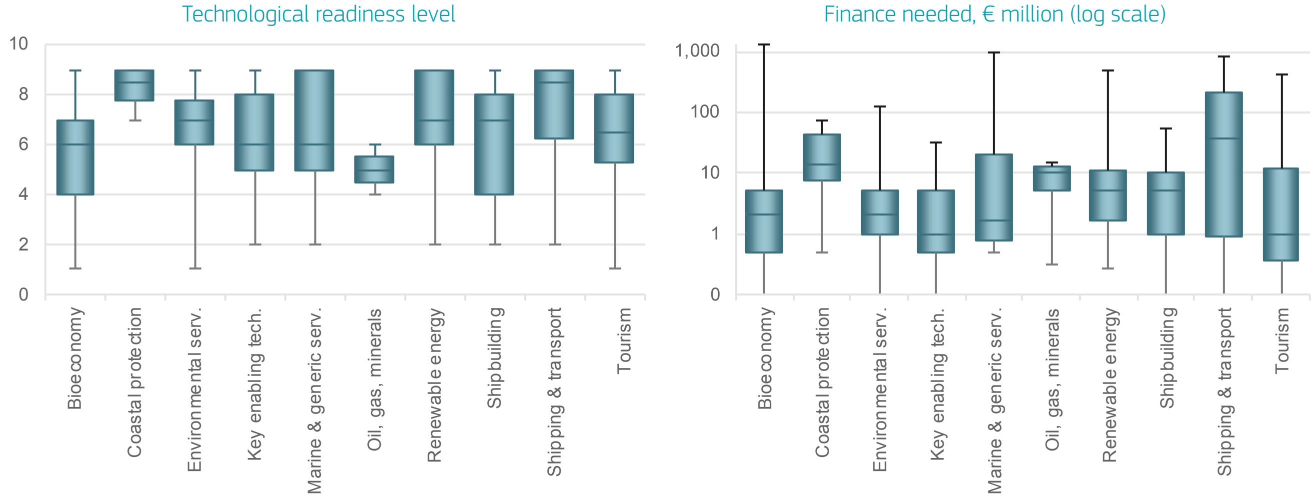
EU action on MSP does not stop at its borders. There is a widely shared understanding that the global ocean governance frameworks need to be strengthened, that pressures on the ocean need to be reduced and that the world's oceans must be used sustainably. International cooperation and common principles about the use of the marine environment is paramount given that 60% of the oceans lies beyond the borders of any national jurisdiction and is under shared responsibility. MSP has a role to play in achieving the UN 2030 Agenda for Sustainable Development, in particular Sustainable Development Goal 14 (SDG 14), i.e. life under water.

The EU has the intention of playing a leading role at global level. This is why the European Commission and UNESCO's Intergovernmental Oceanographic Commission (IOC) adopted a *Joint Roadmap to accelerate MSP processes worldwide*[19] in 2017. The roadmap signals the political commitment from both institutions in the following five priorities:

- Encouraging transboundary MSP.
- Promoting the Blue Economy in harmony with Agenda 2030.
- Stimulating Ecosystem-based MSP.
- Capacity building in all dimensions.
- Mutual understanding and communication.

The Roadmap includes 10 actions to advance the implementation of Maritime Spatial Planning worldwide. These actions are also part of the Commission and European External Action Service's Action Plan on International Ocean Governance. The objective is to achieve internationally recognised guidelines for transboundary maritime spatial planning by 2021.

Figure 2.4 Projects supported with EU research funding



Notes: The panels represents the maximum, minimum, inter-quartile and average values for the projects in each category.
Source: Survey to 470 projects receiving EU funding.

[18] For further details see: www.msp-platform.eu/msp-practice/countries.
[19] http://www.unesco.org/new/fileadmin/MULTIMEDIA/HQ/SC/pdf/Joint_Roadmap_MSP_v5.pdf.

2.3. FINANCING

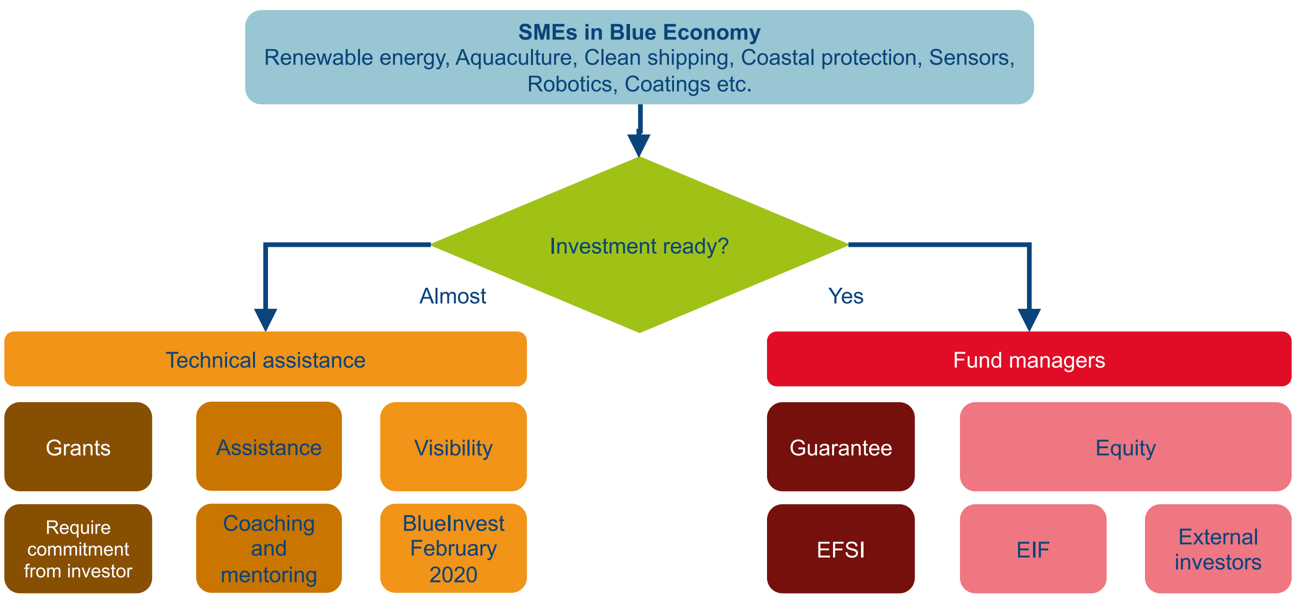
2.3.1. BLUEINVEST: HELPING FINANCE THE BLUE ECONOMY

The EU is making increasing use of mechanisms to leverage the financial support that it provides from its own funds with investment from other public or private sources. In 2014, former Commission President, Juncker, announced the Investment Plan for Europe. €21 billion in guarantees coming from the European Institutions (the EU budget and EIB own funds) leveraged a European Fund for Strategic Investment (EFSI) with a size of €315 billion (later extended to €500 billion based on €33.5 billion guarantees). Up to the end of 2019, EFSI has contributed with over €1.4 billion in funding to €8 billion worth of offshore wind projects as well as substantial support to other parts of the blue economy including port development and clean shipping.

Besides large projects like the wind farms, the EFSI also had a focus in stimulating access to finance for SMEs, which make up a substantial part of the blue economy – up to 70% of the added value in shipbuilding for instance. It is these companies that are capable of delivering the innovations needed to compete on the global market and meet the growing demand for low-emission, environmentally friendly products and services. A survey of projects supported through the EU's research programmes, particularly the parts of it dedicated to supporting small and medium enterprises, and an appeal to maritime clusters and accelerators led to a pipeline of about 500 projects. The largest sectors were the Blue bioeconomy and Renewable energy; a broad category covering ideas to make aquaculture more efficient or more kind to ecosystems or to produce new products such as nutraceuticals. But there were many others; some of which useful for a wide variety of applications in the blue economy such as underwater robotics, ocean observation or anti-biofouling coatings. Most of the products or services were at a technology readiness level of between 4 "technology validated in lab" to 8 "system complete and qualified" with financing demands of up to €10 million. An analysis of the business plans of these companies revealed a number that were ready for the market and others that, with a small push, would be (Figure 2.4).

In this context, the European Commission and the European Investment Fund (EIF) decided to set up a ***BlueInvest Platform*** for SMEs in 2019. This encompassed a package of measures including coaching for investment readiness, and grants up to €22 million in 2019 and €20 million in 2020, for the final steps of the new business plans (e.g. demonstration, certification, marketing etc.). In line with the EU's move towards leveraging its support, the grants were made conditional on letters of intent from investors – either from the public or the private sector. In addition, €75 million worth of liquidity from the EIF (with a 95% guarantees from EFSI) was made available in 2020 for investing equity in funds specialising entirely or mostly in the blue economy or co-investing in particular companies.

Figure 2.5 Blue Invest structure



Source: Commission Services.

The Commission proposals for the Multiannual Financial Framework 2021-2027 will build on experience gained in setting up and operating this Platform. The successor to the European Maritime and Fisheries Fund will offer more possibilities to bring in external investors. The range of measures that can be supported by financial instruments in the part managed by Member States will be increased. Grants from the part managed by the Commission can be "blended" with financial instruments, a facility that is not allowed at present. Additionally, ***InvestEU***, the successor to EFSI, will switch from purely stimulating economic recovery towards being a primary instrument to accelerate measures under the Green Deal. Since projections indicate that the blue economy will play a crucial role in meeting targets for greenhouse gas emissions and biodiversity, substantial strengthening of investment support from the EU is expected.

2.3.2. THE EUROPEAN BANK FOR RECONSTRUCTION AND DEVELOPMENT AND THE BLUE ECONOMY

The European Bank for Reconstruction and Development (EBRD) finances projects that strengthen the private sector in economies undergoing transition to a well-functioning market system. Its investment decisions are guided by six 'transition qualities', which focus on making economies competitive, well governed, green, inclusive, resilient and integrated. EBRD invest in projects in Europe and in their neighbouring countries, including central Europe, the Western Balkans, the southern and eastern Mediterranean and Central Asia.

The EBRD operates in places on the path to becoming stronger and more sustainable, democratic, open-market economies. The EBRD supports the transition process by combining investment with close policy dialogue with local and central governments, regulators, financial institutions, and representatives of civil society, as well as by providing technical assistance and advisory services using funds donated by governments and institutions. Donor funds play a vital role in ensuring the success of these activities and act as a catalyst or enabler for the Bank's investment. The EU is the largest EBRD donor.

The Bank's commitment to sustainability is articulated in the Agreement Establishing the EBRD. In its operations, the Bank sets a high standard of environmental and social benefits as well as equitable access to those benefits. It aligns its operations, country and sector strategies to support the regions where it operates in achieving their goals to deliver sustainable and inclusive economies and to help the economies fulfil their commitments to the global sustainability agenda.

In this context, the Bank is financing a series of projects in the Blue Economy such as the examples below.

Helping Poland expand its port operations

The port of Gdansk is one of Poland's most important gateways and a major hub for the South and East Baltic region. Having almost reached capacity due to the growing demand for deep-water container handling, in 2014 DCT Gdansk sought to expand its operations by building an additional terminal. The EBRD provided a loan of €31 million along other financial institutions to finance the terminal expansion. As a result, Poland has developed its intermodal logistic transport and expanded its market interactions in new sectors, it has alleviated bottlenecks and capacity constraints. The project extended the most energy efficient and cost competitive route for the region's exports, improving Poland's competitiveness in the global market and facilitating inter-regional trade. The Bank keeps supporting DCT Gdansk, having extend a new €46.25 million loan in 2019 for debt, acquisition finance and capex funding and well as helping strengthen the company's corporate governance.

Improving water services in Bulgaria

Over 220,000 residents in the region of Ruse, in Bulgaria, will benefit from better water and wastewater services in line with European standards[20].

The EBRD recently extended a loan of up to €8.7 million to the Ruse Water Supply and Sanitation Company consisting of €5.9 million of EBRD finance and €2.8 million from the EU's European Structural and Investment Funds (ESIF). The loan will be used to rehabilitate 63 km of water supply pipelines, build over 40 km of wastewater collection infrastructure and 5.5 km of water transmission main between the town of Slivo Pole and the village of Borisovo.

The investment will bring significant environmental benefits by cutting water losses and connecting the households of over 27 000 people to the sewer system or centralised wastewater treatment. It will also improve the reliability of the water utility services, including providing better quality drinking water.

Investing in Estonia's port infrastructure

The Port of Tallinn is one of the largest port companies in the Baltic States, providing services as a landlord port. In 2017 alone, it handled 10.6 million passengers and 19.2 million tonnes of cargo. Moreover, Port of Tallinn also provides ferry service between the mainland and Estonia's two largest islands as well as icebreaking and maritime support services. In 2018, following an IPO, the EBRD acquired a minority shareholding (3.6 % stake) in the company aiming at helping to boost the development of the local capital market.[21] The government of Estonia remains the company majority shareholder.

2.3.3. THE EUROPEAN INVESTMENT BANK AND THE BLUE ECONOMY

In 2019, the European Investment Bank (EIB) launched an ambitious new climate and environmental sustainability ambition and Energy Lending Policy that will affect all sectors including the Blue Economy. The EIB will stop financing of unabated fossil fuel energy projects, including natural gas, by the end of 2021. The Bank will also gradually increase the share of its financing

20 https://www.ebrd.com/news/2020/ebrd-loan-for-water-services-in-ruse-bulgaria.html.
21 https://www.ebrd.com/news/2018/ebrd-acquires-minority-shareholding-in-ipo-of-as-tallinna-sadam.html.

dedicated to climate action and environmental sustainability to reach 50% of its operations from 2025 on. In the critical decade from 2021 to 2030, the EIB Group will aim to support €1 trillion of investments in climate action and environmental sustainability.

In addition, by the end of 2020 the EIB Group will align all its financing activities with the principles and goals of the Paris agreement. Therefore, all financing that the EIB counts as climate action, as well as all its other finance, will need to be aligned with the Paris Agreement objectives. In the near future, this will be complemented by measures to ensure EIB financing contributes to a just transition for those regions or countries more affected so that no one is left behind.

In the context of the EIB's increased ambition towards climate action and environmental sustainability and recognising importance of healthy oceans in the fight against the climate change, the EIB Group has recently stepped up its support for sustainable ocean projects.

In February 2020, the European Investment Fund (EIF), part of the EIB Group, in cooperation with the European Commission launched the €75 million **BlueInvest Fund** (see Section 2.3.1 for further details). It will provide financing to underlying equity funds that strategically target and support the innovative Blue Economy. The new programme is backed by the European Fund for Strategic Investments (EFSI), the financial pillar of the Investment Plan for Europe.

The EIB launched the **Clean and Sustainable Ocean Programme**.[22] This is the over-arching programme for the EIB's current and future ocean-based initiatives and activities, also foreseeing the strengthening the EIB's technical assistance and advisory services to make clean and sustainable ocean projects more attractive and scalable for economic development. The programme includes two main components: The Clean Oceans initiative and the Blue Sustainable Ocean Strategy (Blue SOS).

Clean Oceans Initiative

At the 2018 IMF/World Bank Annual Meetings, the EIB, together with the German development bank KfW group[23] and *the Agence Française de Développement* (AFD),[24] has committed to provide up to €2 billion in lending over the period 2018-2023 to the public and private sectors for projects that reduce pollution in the oceans, with a particular focus on plastics.[25]

The initiative targets projects on rivers and coastal cities in these fields:

- **Collection, treatment, recycling and disposal of plastics and other waste** from rivers and coastal areas.
- **Improved waste management** to reduce plastics and other waste in ports and harbours.
- **Innovative projects that keep plastics out of the oceans** or develop reusable or biodegradable plastics.
- **Expanding and improving wastewater collection and treatment** to keep plastics out of rivers and oceans.
- **Urban stormwater management** systems that prevent waste and plastics from entering waterways during rains and floods.

Blue Sustainable Ocean Strategy

In 2019, the EIB launched the Blue SOS[26] to improve the health of oceans, build stronger coastal environments and boost blue economic activity.

The EIB has committed to more than double its lending to sustainable ocean projects to €2.5 billion over the period 2019-2023. This funding is expected to mobilise at least €5 billion of investments for a global sustainable Blue Economy.

To achieve this target, the EIB works with businesses, cities, governments and partners to support key sectors, such as:

- **Sustainable coastal development:** Projects that protect coasts from flooding and erosion, rehabilitate degraded coasts, restore coral reefs and improve water quality.
- **Sustainable seafood production:** Projects that help businesses produce seafood sustainably. This can include fisheries, aquaculture or the processing and preservation of seafood.
- **Green shipping:** Projects that reduce emissions in the shipping industry, such as new ships that use less energy and cleaner fuels. Also improving existing ships with green technologies that are better for the environment (See also Section 5.4.5 about Green Ports).
- **Blue Biotechnology:** Projects that support new marine biotechnology products, such as medicines, enzymes, biosensors and ingredients for food.

Project examples financed under the Blue SOS

Keeping the Netherlands flood proof

The largest loan of 2018 was awarded to the urgently needed renewal works on one of the Netherland's primary sea front flood defence structures, the so called Afsluitdijk. The EIB made €330 million available for the project, which will not only strengthen the dyke, but also will have benefits for local fauna. Special works will be carried out to create "fish passages" that will allow the re-establishment of fish migration between the sea and the interior lake.

The project consists in upgrading the 32km long dyke to withstand increasing in frequency and magnitude extreme storm surge events and sea level rise as a consequence of climate change. The reinforced dyke will continue to secure the lives of a half million of inhabitants as well as economic activities situated behind the dyke, whilst flexible water level management and the construction of fish passes will contribute to the quality of the environment (See Section 3.4 for an overview of the need of reinforcing dykes across the EU coast).

22 https://www.eib.org/en/about/initiatives/preserving-our-oceans/index.htm.
23 https://www.kfw.de/stories/environment/nature-conservation/infographic-clean-oceans/ target=.
24 https://www.afd.fr/en/war-against-plastic-sea-afd-taking-action.
25 https://www.eib.org/en/publications/the-clean-ocean-initiative.
26 https://www.eib.org/en/publications/blue-sustainable-ocean-strategys.

Highway of the seas between Sweden and Finland

The distance from the Finnish city of Vaasa to Umeå municipality in Sweden is only about 105 km.

However, it is a 10-hour long drive along the coastline of the Bothnian Gulf. Already in 1958 the cities decided that having **a direct ferry connection** was a good idea for both business and tourism, and thus, the Vaasa-Umeå line was born, covering the trip in only 4½ hours. The route ran until 2011, when dwindling passenger figures forced the commercial operator out of business.

To avoid losing their precious connection, both municipalities stepped in and acquired an old ferry to keep the service alive – and with success. Reaching over 200 000 passengers in recent years, meant that a larger, newer and above all a more environmentally friendly ship, was increasingly seen as a sensible investment. To this end, the cities founded a special purpose vehicle (SPV) to cover the costs of the new ship, at which point the EIB intervened.

The Bank will lend €70 million to the SPV, officially called "Kvarken Link Oy", for a new ice-class (as in, it can sail through ice) "RoPax" passenger/car ferry that will be built by Rauma Marine Constructions in Finland, with delivery scheduled for 2021. The ship will be about 150 metres long and will be able to comfortably transport 800 passengers According to the EIB, even if only 10 metres longer than the previous ship, it will provide an additional 40 % capacity for lorries. This has been calculated in "freight lane metres", which provide an indication of how many vehicles can theoretically fit on board. The vessel will have 1 500 lane meters, which means it can fit around 90 lorries.

In spite of the above, **the vessel will still be 40 % more fuel efficient than the previous one**, due to technological innovations. According to the EIB, the ship will sail mainly on LNG, and could sail on biogas if available, which allows to significantly reduce pollutant emissions. SOx emissions are estimated to be 15 times lower than those of a new vessel operating on conventional low Sulphur fuel, which is important both for the health of the users and for the environment.

2.4. ESTABLISHED SECTORS

Introduction

The scientific community continues to obtain additional information on the various ecosystem services as presented in the previous sections including providing a monetary valuation to some services that before could not be put into perspective in the context of the activities and services stemming from the sea. In the meantime, the established sectors continue to be a major pillar and contributor to the EU Blue Economy and it is also in these sectors where more complete, accurate and comparable data are available.

The seven established sectors considered in this report are *Marine living resources*, *Marine non-living resources*, *Marine renewable energy*, *Port activities*, *Shipbuilding and repair*, *Maritime transport* and *Coastal tourism*. Each sector is further divided into subsectors as summarised in Table 2.1. The details of what is included in each sector and subsector are explained in Annex II.

Table 2.1 The Established Blue Economy sectors and their subsectors

Sector	Sub-sector
Marine living resources	Primary production
	Processing of fish products
	Distribution of fish products
Marine non-living resources	Oil and gas
	Other minerals
Marine renewable energy	Offshore wind energy
Port activities	Cargo and warehousing
	Port and water projects
Shipbuilding and repair	Shipbuilding
	Equipment and machinery
Maritime transport	Passenger transport
	Freight transport
	Services for transport
Coastal tourism	Accommodation
	Transport
	Other expenditure

Source: Commission Services.

This chapter provides a summary of the main economic data as well as the trends and the drivers behind these for each of the established sectors, and how they interact with each other. DCF data are used for the primary sector[27] activities in the *Marine living resources* sector while for the rest of sectors, Eurostat Structural Business Statistics (SBS) data are used. In addition, data from Tourism expenditure survey and from the EU Tourism Satellite Account were used for the *Coastal tourism* sector[28]. The time series goes from 2009 to 2018. Data for 2018 are provisional (or projections in the case of the *Marine living resources* sector) and may be subject to revision in future editions. The data presented here supersede data presented in previous reports which may be different because of improvements in the methodology, revisions of the data or corrections of errors.

[27] Capture fisheries and aquaculture.
[28] For details on the compilation of data for Coastal tourism see the methodological annex.

This section provides an overview of the main economic indicators of the established sectors from an aggregated EU perspective. A detailed analysis for each of the sectors is presented in Chapter 5.

Although only the direct contribution of the Blue Economy sectors is considered here, all sectors have indirect and induced effects on the rest of the economy. For example, in *Shipbuilding and repair*, most of the value added is from upstream and downstream activities. This means that beyond its specific contribution, it has important multiplier effects on income and jobs in many sectors of the economy.

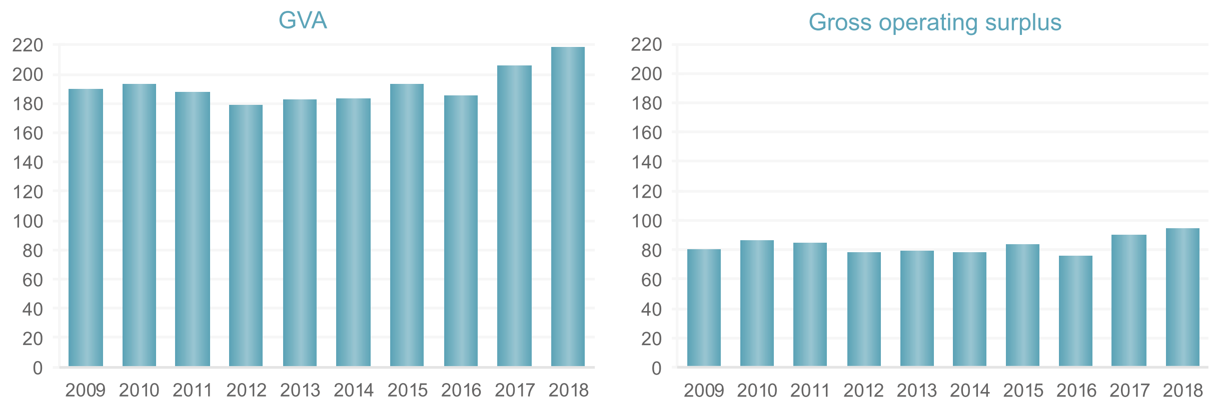
Climate change and the degradation of ecosystem conditions may increasingly impact maritime activities in the long term. Increasingly unpredictable and extreme weather conditions may force certain activities to alter or adapt to sudden changes. For example, the opening up of the Arctic route may alter sea traffic patterns in some areas.

The EU Blue Economy as a whole

The seven established sectors of the EU Blue Economy generated a gross value added (GVA) of €218.3 billion in 2018; that is, a 15 % increase compared to 2009. Gross operating surplus (profit) at €94.5 billion was 18 % higher than in 2009 (Figure 2.6), while total turnover[29] at €749.7 billion, increased by 12 % (€670.9 billion in 2009).

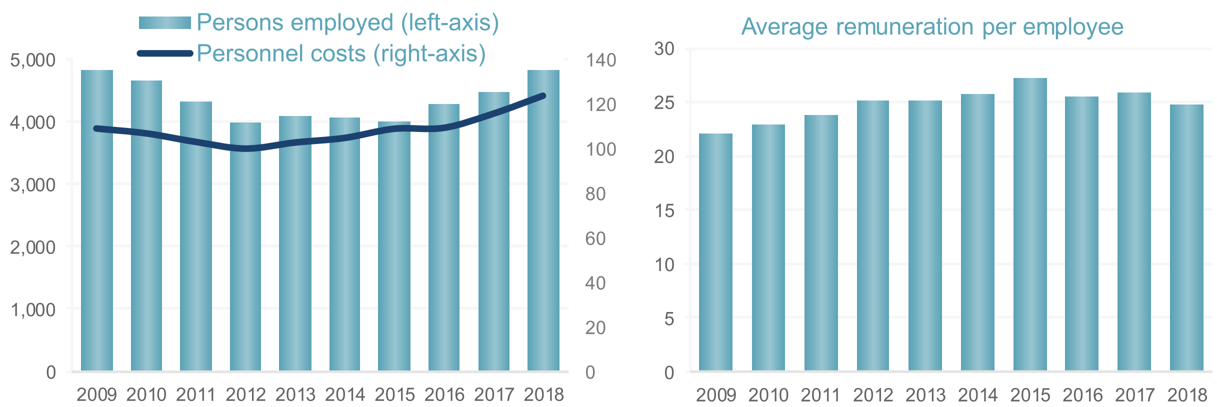
These established sectors, including the covered subsectors and their activities, directly employed almost 5 million people in 2018. Although this figure is only 1 % more than in 2009, it means that the number of jobs in the EU Blue Economy is nowadays higher than before the economic crisis and 11.6 % greater than the previous year (2017). The increase is largely driven by Coastal tourism, which saw a 20 % rise in jobs compared to 2017. Marine renewable energy (production and transmission), which is still in a strong expansion phase given that it is a relatively young sector, saw the number of persons employed increase eightfold since 2009, from 582 persons to over 4 620 persons in 2018.

Figure 2.6 Size of the EU Blue Economy, € billion



Note: Data for 2018 are provisional.
Source: Eurostat (SBS), DCF and Commission Services.

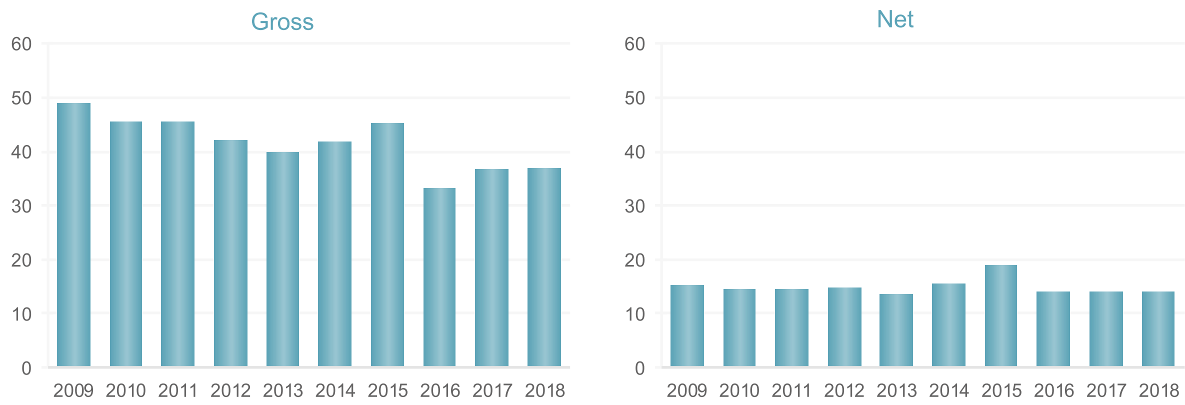
Figure 2.7 Employment (thousand people), personal costs (€ million) and remuneration (€ thousand) in the EU Blue Economy



Note: Data for 2018 are provisional.
Source: Eurostat (SBS) and Commission Services.

[29] Considering turnover can lead to double counting along the value chain since the outputs from one activity can be the inputs of another activity (i.e., intermediate consumption). This may particularly affect some sectors, such as Living resources and Shipbuilding and repair.

Figure 2.8 Investment in tangible goods in the EU Blue Economy, € billion



Note: Data for 2018 are provisional.
Source: Eurostat (SBS) and Commission Services.

Remuneration per employee for the EU Blue Economy established sectors has increased steadily since 2009, peaking in 2015 and falling slightly afterwards. However, with an average of just over €24 700 per employee, employment remuneration in 2018 was 12.4 % higher than in 2009 (Figure 2.7).

The decrease in average employment remuneration can be largely attributed to significant drops in the *Non-living resources* (-10 % compared to 2015), a well-remunerated sector that has been contracting for some years. *Coastal tourism* and *Port activities* also suffered (-5 % each). Furthermore, while the average wage decreased in several Member States from 2015 to 2018, the fall was particularly dragged by the United Kingdom where all established Blue Economy sectors suffered reductions in 2018 compared to the average in 2015, with the exception of *Marine renewable energy* (distribution and transmission).

Gross investments in tangible goods in 2018 decreased by 24.5 % compared to 2009: from €48.9 billion to €36.9 billion. As detailed further down, the decline in gross investments was mainly driven by *Non-living resources*, with investments of €19.6 billion in 2009 and €9.7 billion in 2018 (-50.5 %), in part due to the lower oil and gas prices on global energy markets which led to decreases in activity. *Maritime transport*, the largest investor in 2018 (€14.6 billion) also saw gross investments drop overall by 18 % compared o 2009.

Shipbuilding and repair reported a positive trend with overall gross investments increasing a 7.4 % compared to 2009; while gross investments in *Living resources* increased by 17 %. Yet, their contribution to the Blue Economy investments (6 % and 5 %, respectively) is still small compared to sectors with decreasing investments.

Net investments in tangible goods[30], estimated at €13.9 billion in 2018, also decreased (-7.7 %) compared to €15.1 billion in 2009, and -26.4 % compared to 2015 (€19.0 billion invested) (Figure 2.8). Despite this decrease, net investments remained positive, signalling a replacement and expansion of capital. The net investment ratio (net investment to GVA) declined, ranging from 24 % in 2009 to 22 % in 2018, peaking in 2015 at 30 %.

Main features of the established sectors

The EU **Shipbuilding and repair** industry is an innovative, dynamic and competitive sector. With a market share of around 15 % of the global order book in terms of compensated gross tonnage and 34 % in terms of value. For maritime equipment, the EU share rises to 50 %. The EU is a major player in the global shipbuilding industry, with its 300 shipyards mainly specialised in the most complex and technologically advanced civilian and naval ships, platforms and other hardware for maritime applications such as cruise ships, offshore support vessels, fishing, ferries, research vessels, dredgers and mega-yachts. The implementation of the forthcoming global and European regulation on ballast water, and sulphur and nitrogen oxide emissions, as well as actions on climate change, offer market opportunities for the European maritime equipment suppliers and shipyards.

Nonetheless, EU shipbuilding continues to face fierce international competition from countries like China and South Korea, as they try to enter European niche markets of specialised high-tech ships gas a result of the crisis and the oversupply in cargo markets.

Maritime transport plays a key role in the EU economy and trade, estimated to represent between 75 % and 90 % (depending on the sources) of the EU's external trade and one third of the intra-EU trade. Moreover, more than 410 million passengers aboard cruises and ferries embarked and disembarked in EU ports in 2018, a rise of 5.6 % from the previous year. In 2018, the total weight of goods transported to/from the main EU ports by short sea shipping (excludes the movement of cargo across oceans, deep sea shipping) was 1.8 billion tonnes.

While shipping is the most carbon-efficient mode of transportation, the size and global nature of maritime shipping makes it necessary for the industry continues to reduce its environmental impact, in particular, in the context of the European Green Deal.

The main developments in *Maritime transport* in recent years are related to the continuous increase in ship sizes for all segments (e.g. tankers and container carriers, but also cruises), which have significantly affected *Shipbuilding and repair* and *Port activities*.

[30] These figures exclude Maritime transport, Cargo and warehousing, Service activities incidental to water transportation and Coastal tourism due to the lack of data.

Table 2.2 Overview of the EU Blue Economy by sector

Persons employed *(thousand)*	2009	2011	2013	2015	2016	2017	2018
Marine living resources	591.6	572.4	563.2	561.3	570.5	570.9	573.3
Marine non-living resources	65.6	63.8	62.0	65.1	55.3	46.7	47.0
Marine renewable energy	0.6	1.3	2.6	4.0	3.6	4.0	4.6
Port activities	456.8	433.3	464.0	522.8	575.5	549.3	549.3
Shipbuilding and repair	352.5	301.6	297.5	307.1	319.4	317.3	318.3
Maritime transport	380.5	384.7	377.5	407.3	387.2	407.8	407.8
Coastal tourism	3,105.2	2,573.2	2,318.3	2,138.4	2,382.5	2,579.7	3,096.7
Blue Economy jobs	4,953	4,330	4,085	4,006	4,294	4,476	4,997
Total EU employment	*215,268*	*212,565*	*211,340*	*215,767*	*218,912*	*221,960*	*224,353*
Blue Economy *(% of EU jobs)*	2.3%	2.0%	1.9%	1.9%	2.0%	2.0%	2.2%

GVA *(€ million)*	2009	2011	2013	2015	2016	2017	2018
Marine living resources	16,949	17,706	17,528	19,497	21,076	21,100	20,966
Marine non-living resources	27,490	28,050	26,087	23,351	15,639	19,435	19,565
Marine renewable energy	79.1	277.5	461.1	965.3	948.8	1,015.1	1,089.0
Port activities	28,387	31,850	29,839	34,594	34,582	35,205	35,205
Shipbuilding and repair	13,062	13,857	13,498	14,539	15,298	17,135	17,276
Maritime transport	29,867	29,871	32,144	37,018	30,382	35,599	35,599
Coastal tourism	73,981	66,717	63,255	63,073	67,576	76,152	88,575
Blue Economy GVA	189,815	188,327	182,812	193,037	185,502	205,642	218,275
Total EU GVA	*11,113,668*	*11,852,832*	*12,193,370*	*13,291,639*	*13,401,075*	*13,771,523*	*14,207,833*
Blue Economy *(% of EU GVA)*	1.7%	1.6%	1.5%	1.5%	1.4%	1.5%	1.5%

Note: Data for 2018 are provisional or estimates and should be interpreted with caution.
Source: Eurostat (SBS), DCF and Commission Services.

The sector was particularly affected by the last global financial crisis, but has recovered to pre-crisis levels in terms of GVA and employment, since 2017.

Port activities continue to play a key role in trade, economic development and job creation. The 1 200+ seaports in the 23 coastal EU Member States, as multi-activity transport and logistic nodes, play a crucial role in the development of maritime sectors. Many ports across the EU are reducing their environmental impact while also enabling green shipping fleets. These activities will have an important role in reaching the objectives of the European Green Deal (EGD). The trend towards larger ships lead, to lower average transport costs; however, they also require new ports infrastructure and impact competition between port authorities and port operators.

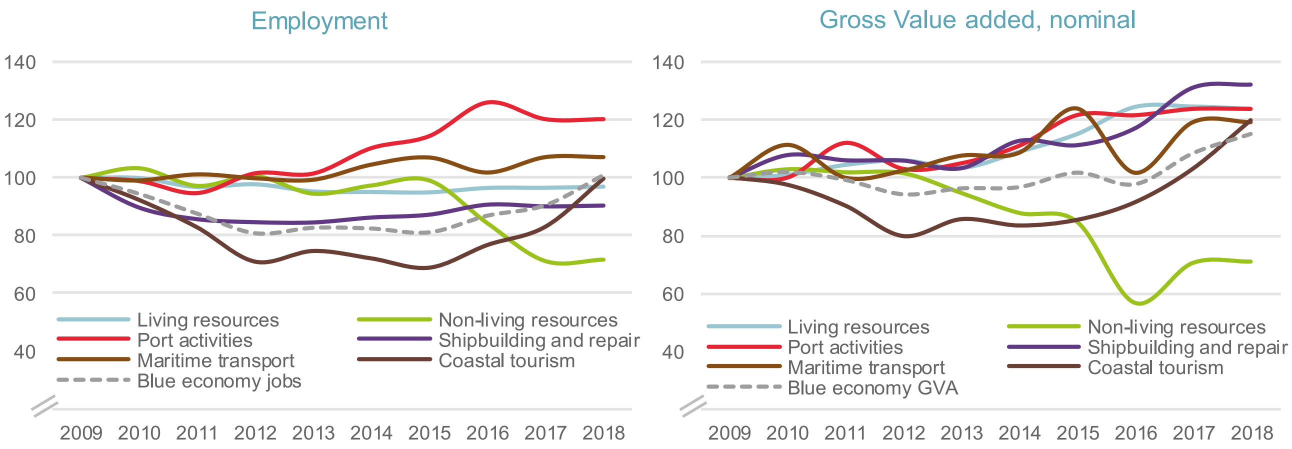
The exploitation of Europe's seas and oceans for **Marine non-living resources** has increased over the last decade and is projected to continue growing. However, the offshore *Oil and gas* sector has been in decline for some years. More than 80% of all current European oil and gas production takes place offshore, mainly in the North Sea. In early 2020, oil prices collapsed due to market concerns and the fall in economic activity following the COVID-19 pandemic. Therefore, it is expected that offshore exploitation of oil and gas will further continue to decline.

Conversely, the demand for *Other minerals* such as sand and gravel, used for construction purposes and for producing concrete, is likely to increase. Moreover, as coastal communities attempt to adapt to new pressures posed by climate change, dredging, beach nourishment and sand reclamation may intensify. Trade-offs with environmental protection will have to be taken into account.

The **Marine Renewable energy** (production and transmission) sector, is growing exponentially, albeit still encountering challenges. For instance, land-based wind farms are developing faster than their maritime counterparts. Wind energy production continues to be cheaper on land, making competition tough for developing offshore activities, particularly in view of low energy prices. The lack of electrical connections (cables/grids) is also a substantial barrier to the development of offshore wind farms, adding to investment costs. Europe has more than 90% of the world's total installed offshore wind capacity, and will continue to dominate the offshore wind market for years to come. Offshore wind in Europe is focused mainly on the North Sea, which has relatively shallow waters.

Europe continues to stand as the most-visited region, welcoming half of the world's international tourist arrivals. **Coastal tourism** plays an important role in many EU Member State economies, with a wide ranging impact on economic growth, employment and

Figure 2.9 Evolution of the EU Blue Economy by sector, Index: 2019 = 100

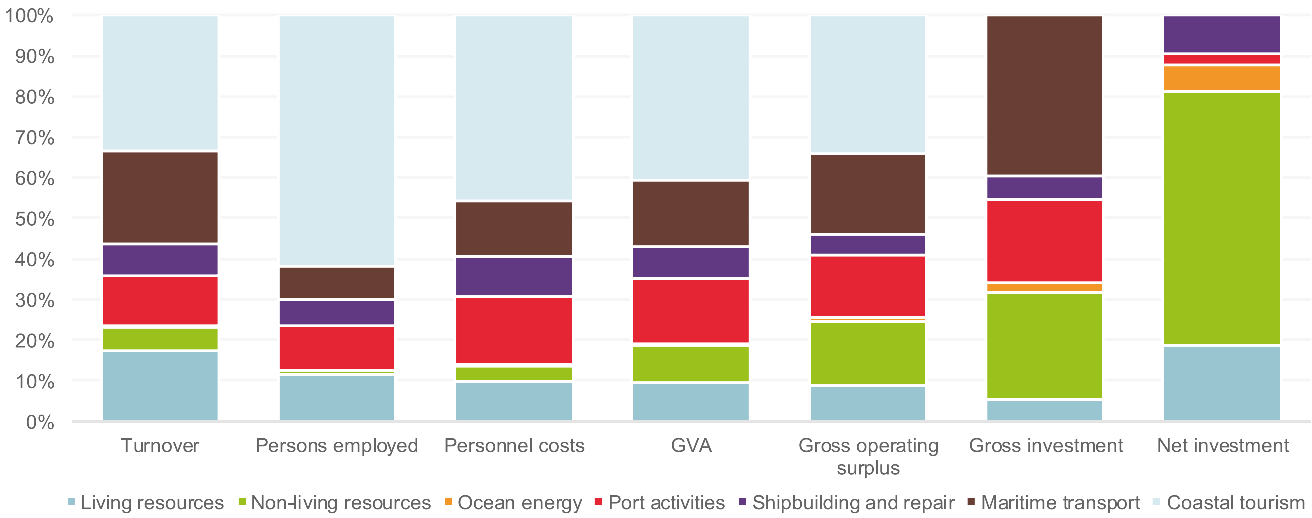


Source: Eurostat (SBS), DCF and Commission Services.

social development. In 2018, just over half (51.7 %) of the EU's tourist accommodation establishments were located in coastal areas. Visitors to coastal areas were generally higher in southern EU Member States. Coastal communities, mainly composed of SMEs and micro-enterprises, are particularly vulnerable to economic, financial and political changes. While tourism was expected to continue to grow in 2020, the outbreak of COVID-19 in Europe in February 2020 has put the tourism industry under unprecedented pressure. Due to travel restrictions imposed by MSs, there few new bookings for tourism services while at the same time, the industry is flooded with claims for refunds on cancellations and the non-performance of services. Whilst the European Commission and national governments are implementing measures in an attempt to mitigate the effects, the true extent of economic impact remains to be seen.

The **Marine living resources** sector encompasses the harvesting of renewable biological resources (*Primary sector*), their *Processing* and their *Distribution*. *Capture fisheries* production has increased and may have the capacity to do so further, in part due to the improved status of fish stocks and increased fishing opportunities, together with higher average market prices and reduced operating costs. The economic performance is expected to continue to improve as fish stocks recover and capacity continues to adapt. However, these benefits have not yet been achieved in the Mediterranean Sea basin where most fisheries have not yet moved towards sustainable fishing conditions. EU *Aquaculture* production (in volume) has stagnated over the last decades even if its value has increased. Considering the increasing demand of seafood products in the EU, it seems realistic to expect growth of in EU aquaculture products.

Figure 2.10 Economic performance and main indicators across Established sectors, 2018



Note: Gross investments are not available for coast tourism; net investments are not available for Coastal tourism, Maritime transport and most of the Port activities (available only for Construction of water projects).
Source: Eurostat (SBS), DCF and Commission Services.

The *Distribution of fish products* is increasingly concentrated in the hands of a few players. Adding value can enable producers to recover part of the value of the product, which is usually generated further down the chain.

EU production (from capture fisheries and aquaculture) covers less than 50 % of the total raw material requirements for the EU *Processing of fish products*. The processing sector is therefore dependent on global fish markets.

Evolution and comparison across established sectors

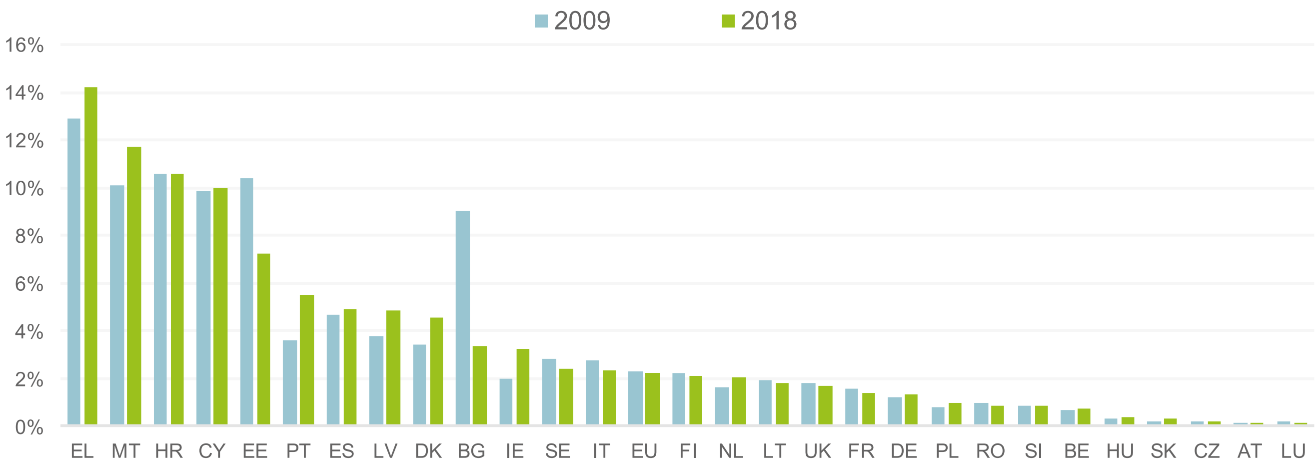
GVA data show an acceleration in the growth of all sectors from 2013 onwards except for *Non-living resources* (Table 2.2 and Figure 2.9). The GVA generated by *Coastal tourism* in 2018, the largest Blue Economy sector in the EU, increased by 19.7 % compared to 2009. *Maritime transport* and *Port activities*, the second and third largest sector, increased by 19 % and 24 %, respectively. Other sectors that contributed to growth were *Living resources* (+24 %) and *Shipbuilding and repair* (+32 %). On the other hand, *Non-living resources* dropped by almost 29 %.

Employment is recovering since 2013. With respect to 2009, the highest relative expansion was observed, in *Port activities*, *Maritime transport* and *Coastal tourism*. In *Shipbuilding and repair* as well as in *Living resources*, employment has grown with respect to the minimum observed in 2013-2014, but it has not yet recovered to 2009 levels. In *Non-living resources*, a significant declining trend is seen.

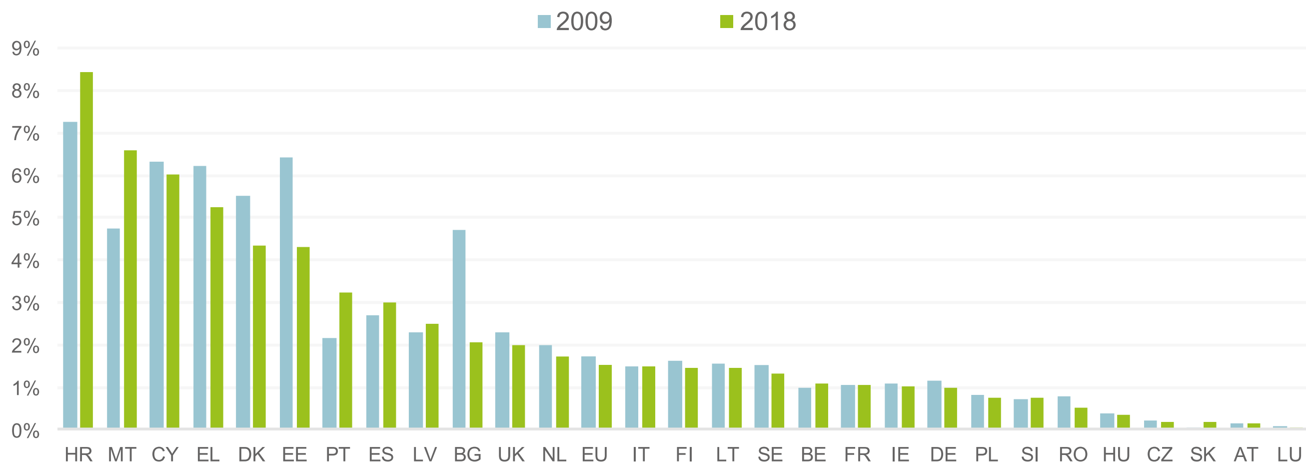
The sectors are also very different in their capital intensity. This is the case, for instance, for *Coastal tourism* compared to the *Non-living resources*. *Coastal tourism* is labour-intensive, and often run by small or medium-sized local or family businesses; it is widespread along the entire EU coastline. This is reflected in the sector making the greatest contribution to the EU Blue Economy in terms of employment, gross value added and profit

Figure 2.11 Relative size of the Blue Economy, percentage

Share of Blue jobs in national employment

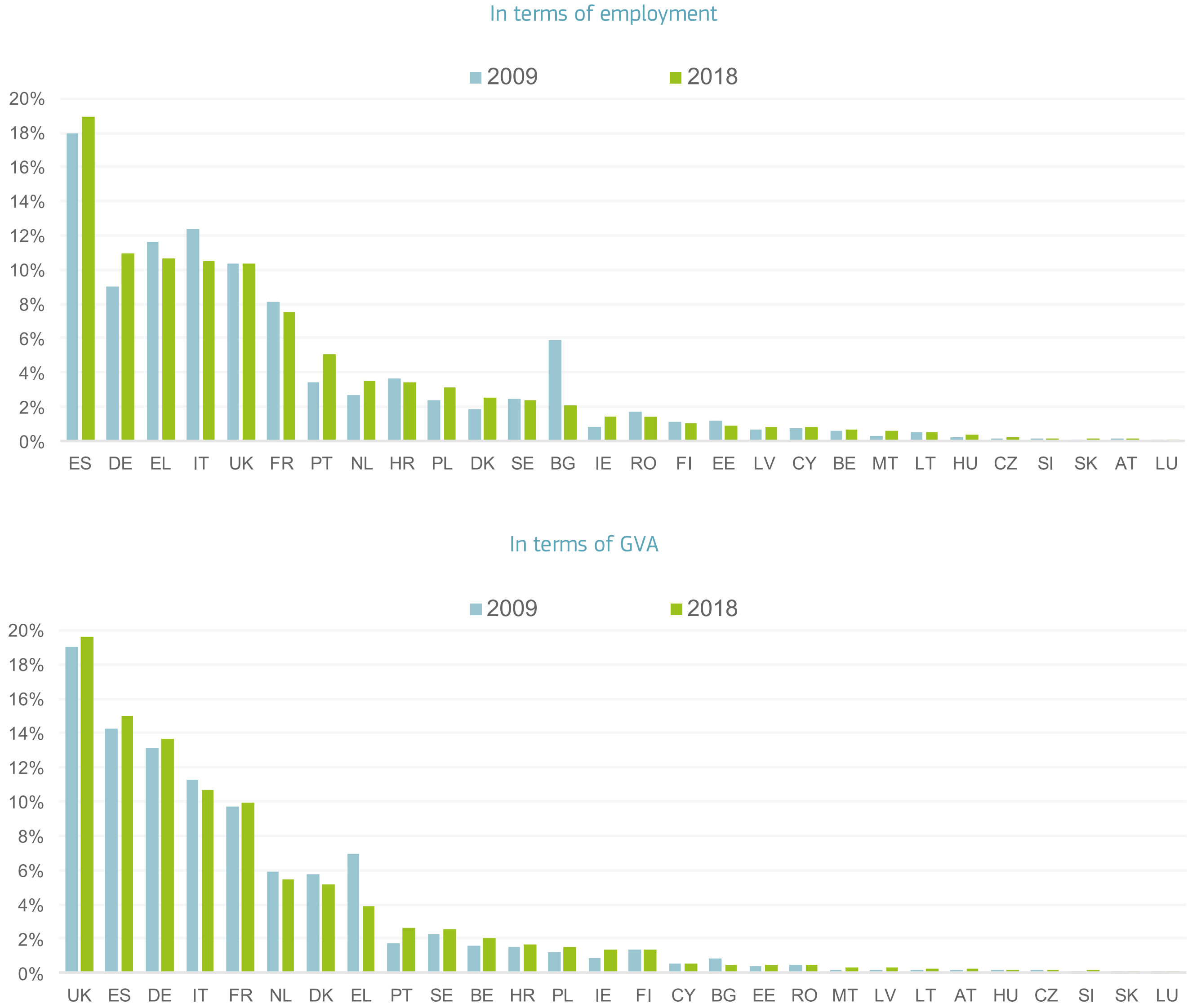


Share of Blue GVA in the national economy



Source: Eurostat (SBS), DCF and Commission Services.

Figure 2.12 National contribution to the EU Blue Economy, percentage (EU28 = 100 %)



Source: Eurostat (SBS), DCF and Commission Services

(Figure 2.10) and with its share increasing over time. However, the sector's contribution to GVA and profits are substantially lower than to employment.

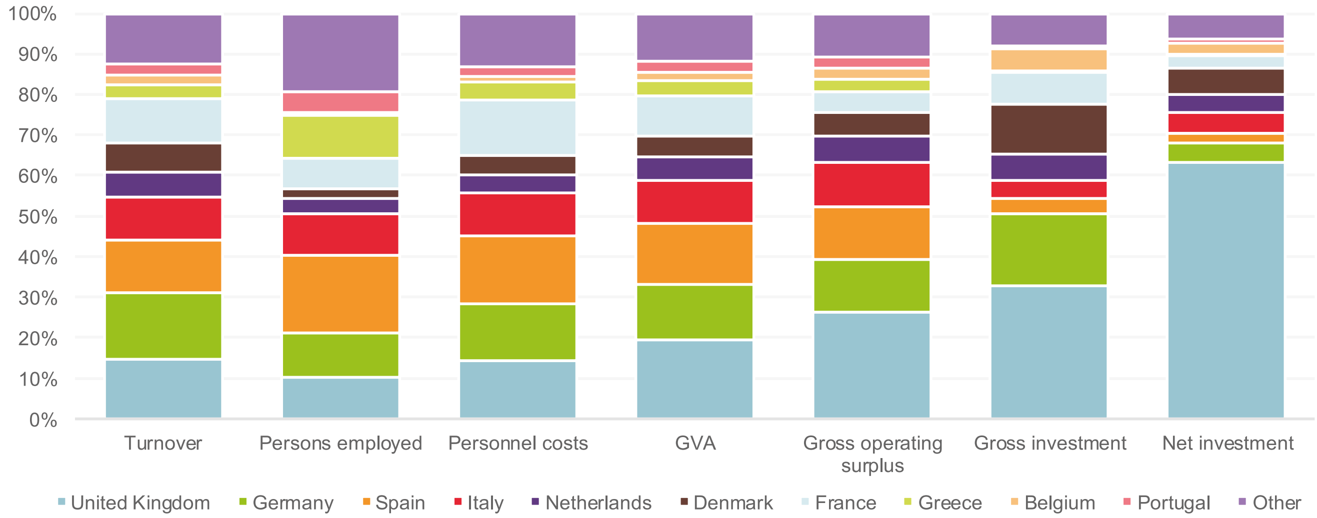
Within *Non-living resources*, the *Oil and gas* subsector is a highly capitalised industry that requires few employees per unit of output and is concentrated in a few geographical areas. The industry is generally comprised of large companies, which might have fewer direct links to local coastal communities. Consequently, this sector accounts for only a tiny fraction of employment (under 1 % in 2018) but a substantial part of overall Blue Economy-related profits. This share, however, has fallen over time from 27 % in 2009 to 16 % in 2018.

The Blue Economy established sectors across Member States

In 2018, the contribution of the established Blue Economy sectors to the overall EU economy was 2.2 % in terms of employment (down slightly from 2.3 % in 2009) and 1.5 % in terms of GVA (down from 1.7 % in 2009). The contribution varies widely across Member States. In terms of employment, shares range from 14 % in Greece to less than 0.1 % in Luxembourg and in GVA, from 8 % in Croatia to less than 0.1 % in Luxembourg (Figure 2.11).

In general, the Blue Economy exceeds 5 % of the national GVA or employment in the insular Member States or those with archipelagos: Greece, Croatia, Malta, Cyprus and Portugal. Estonia is an exception with an employment share of 7 %. Other Member States with relatively large Blue Economy sectors (contribution between 3 % and 5 % of the national GVA or employment) include Spain, Latvia, Denmark, Bulgaria and Ireland. For self-evident reasons, the Blue Economy's contribution to the national economy is very limited (below 0.4 %) in landlocked Member States (Luxembourg, Austria, Czechia, Slovakia and Hungary). Other Member States with a relatively modest Blue Economy (between 0.5 % and 1.0 % of the national economy) include Belgium, Slovenia and Romania. Three of the five largest EU economies (United Kingdom, France and Germany) are below the EU average, Italy is slightly above the average and only Spain is well above average (Figure 2.11).

Figure 2.13 Economic performance and main indicators across Member States, 2018



Note: Gross investments are not available for coast tourism; net investments are not available for Coastal tourism, Maritime transport and most of Port activities (available only for Construction of water projects).
Source: Eurostat (SBS), DCF and Commission Services.

Several Member states have seen the share of Blue jobs increase substantially compared to 2009. More evident cases include Greece, Malta, Portugal, Latvia and Denmark. On the other hand, decreases in Blue jobs are more noticeable in Bulgaria and Estonia.

In absolute terms, the five largest Member States (United Kingdom, Spain, Germany, Italy and France) are the largest contributors to the EU Blue Economy for both employment (with a combined contribution of 58 %) and GVA (a combined contribution of 69 %). Of these, only Italy has seen its share of employment and GVA decrease compared to 2009 (France has lost some ground on employment). Other countries with significant contributions in terms of either employment or GVA include Greece, Portugal, the Netherlands and Denmark (Figure 2.12).

An increase in the GVA generated by the Blue Economy established sectors can be observed in most Member States between 2009 and 2018. The most significant expansion is recorded in Ireland, Portugal and Malta (with increase of over 50 % over the last decade). Similarly, an expansion of about 30 % or more is observed in Belgium, Poland and Sweden. On the other hand, in 2018 GVA in Bulgaria and Greece had not yet recovered to the levels observed in 2009. An expansion in employment in a number of Member States can also be observed, with 2018 figures being 50 % larger than in 2009 in Ireland, Malta and Portugal, 30 % larger in Denmark, the Netherlands and Poland, and 20 % in Germany. However, in some Member States, employment has not recovered 2009 levels yet (e.g. Bulgaria, Italy, Greece, France, Croatia, Sweden and Finland) (Figure 2.11 and Figure 2.12).

The relative importance of Member States is different for each economic indicator, depending on their sectoral specialisation. For instance, the United Kingdom has a significantly larger contribution in terms of gross investment (€12.2 billion or 33 % of the EU) than in terms of employment (517 000 employees or 10 % of the EU) given the significance of the oil and gas industry. Similarly, with €2.0 billion of gross investment (mainly in ports and connected activities), Belgium contributes with 5 % to the EU total while it only employs 33 000 people in the Blue Economy (0.7 % of the EU). On the other hand, Spain, Italy and Greece are more specialised in more labour intensive sectors such as Coastal tourism or Living resources and their contribution to the EU Blue Economy is larger in terms of employment than in terms of GVA or gross investment (Figure 2.13).

2.5. COVID-19: INITIAL REFLECTIONS ON THE IMPACTS AND EARLY RESPONSE

The outbreak of COVID-19 reached the EU in late February 2020, which led to most EU Member States implementing strict closures and confinement measures. The extent of the impact and the subsequent economic crisis will be heterogeneous across the Blue Economy sectors and activities, and will depend very much on the duration, and the specific national exit strategy. This section tries to highlight the initial effects and the early response of EU to the crisis summarising the main measures put in place by the EU.[31]

As other regions and countries around the world, the EU and its MSs have put in place a comprehensive economic policy response to help mitigate the impacts of the COVID-19 crisis. These include **coordinated actions** taken at the EU level and at the Member States level. Among others: the application of the general escape clause on **EU fiscal rules** so that national budgets can support the economy and respond in a coordinated manner to the impact of the COVID-19 pandemic; the **use of the EU budget** with €65 billion from the ESIF Funds. In terms of **monetary policy**, the ECB launched a €750 billion Pandemic Emergency Purchase Programme. As for **financial stability**, supervisory authorities have provided guidance to financial institutions on the interpretation and application of the regulatory requirements in the current exceptional circumstances and about the possibility of releasing capital buffers.

Additional crisis response instruments are also being agreed to **prepare the ground for recovery**: the Commission has proposed further temporary **flexibility in the use of EU funds** to effectively mobilise the EU budget. **Emergency support** to reinforce healthcare systems will be provided by the re-activation of the Emergency Support Instrument, endowed with at least €2.7 billion from EU budget resources. The **EIB has been strengthened** with a pan-European guarantee fund of €25 billion, which could support €200 billion of financing for companies with a focus on SMEs. The precautionary lines of the EU **safety nets** such as the European Stability Mechanisms (ESM) for the Euro area Member States with a firing capacity of €500 billion and the Balance of Payments Facility has been adapted to be used by Member States, as needed. **SURE** is a temporary loan-based instrument for financial assistance agreed for the duration of the emergency; endowed with up to €100 billion, it will be particularly aiming at supporting Member States to protect employment. Work has started on the creation of a **Recovery Fund** that prepares and support the recovery, providing funding through the EU budget to programmes designed to kick-start the economy in line with European priorities. The next EU **Multiannual Financial Framework (MFF)** still under discussion, will likely be adapted to reflect the new economic situation and outlook so that it may play a central role in the economic recovery. Work is ongoing on a broader **Roadmap and an Action Plan to support the recovery** of the European economy through high quality job creation and reforms to strengthen resilience and competitiveness, in line with a sustainable growth strategy and the European Green Deal. The Roadmap for Recovery is based on the principles of solidarity, cohesion and convergence and will be articulated around four key areas of action: a fully functioning Single Market, an unprecedented investment effort, acting globally, and a functioning system of governance. The Roadmap will be accompanied by a **Recovery Fund** commensurate with the challenges faced by the EU economies. At the time of writing, the draft Roadmap is being finalised by the European Commission and is expected to be adopted by the European Council in June 2020.[32]

[31] The cut-off date is 7 May 2020.

[32] Insights and updates on the general EU response to the corona virus crisis can be consulted at: https://ec.europa.eu/info/live-work-travel-eu/health/coronavirus-response_en.

Table 2.3 Preliminary assessment of the impact of the COVID-19 economic crisis on the Blue Economy

Sector	Size	Initial impact	Recovery path
Established sectors			
Marine living resources	Medium	Strong	Lagged
Marine non-living resources	Small	Medium	Prompt
Marine renewable energy	Nascent	Strong	Prompt
Port activities	Medium	Strong	Prompt
Shipbuilding and repair	Small	Medium	Lagged
Maritime transport	Medium	Strong	Prompt
Coastal tourism	Very large	Strong	Very lagged
Emerging sectors			
Blue bioeconomy	Small	Strong	Prompt
Ocean energy	Nascent	Small	Prompt
Desalination	Nascent	Small	Prompt
Maritime defence	Small	Small	Prompt
Cables	Nascent	Small	Prompt
Research and Education	Nascent	Small	Prompt
Marine observation	Nascent	Small	Prompt

Source: Commission Services.

While these general measures will support the Blue Economy activities, concrete measures have also been undertaken to specifically tackle the Blue Economy sectors and activities, particularly the living resources sector. The Commission published an information note and factsheet to give Member States information on EU measures to cushion the impact on the living resources sector and other Blue Economy sectors:[33]

- Under the proposed Coronavirus Response Investment Initiative (CRII+), €65 billion have become available from the EU's structural funds from the 2014-2020 period. This includes unspent money available under the EMFF around €2 billion (see below). Available funds from the European Social fund will be available to blue economy sectors too. The €1 billion EFSI guarantees to stimulate €8 billion for financial relief to SMEs and mid-cap companies also in blue economy sectors.
- On 20 March the European Commission adopted [34] a temporary State aid framework to enable Member States to provide relief to economic operators hit by the crisis. The new Temporary Framework allows state aid up to a level of €120,000 per undertaking active in the fishery and aquaculture sectors. The Temporary Framework enables Member States to make support available, in the form of grants or tax advantages, to operators facing a sudden shortage or unavailability of liquidity. The Commission has put in place procedures to enable very swift assessment and decision-making. The impact of these measures on coastal areas goes well beyond the fisheries and aquaculture sectors. Also companies in the wider blue economy – from biotech to tourism – will benefit, as worsening economic conditions and restrictions on movement will be felt across the Union over the next period. Aid can be granted until 31 December 2020 to undertakings that face difficulties as a result of the Coronavirus outbreak. These aid measures are fully in line with the EU's common fisheries policy. Aid is not applicable to activities explicitly excluded from the de *minimis* aid in the fishery and aquaculture sector.
- Under existing EMFF rules, a range of options exist for the fisheries sector, the aquaculture sector, community-led local development and fisheries local action groups, marketing and processing related measures.

On 17 April, the European Parliament, with the Council following, adopted the Commission's initiative to modify the European Maritime and Fisheries Fund (EMFF)[35] to help mitigate the impact of coronavirus on the fisheries and aquaculture sectors.

Part of the Coronavirus Response Investment Initiative Plus, these exceptional measures include support for the temporary cessation of fishing activities due to coronavirus, financial compensations to aquaculture farmers and to processing enterprises, specific measures for the outermost regions and support to producer organisations for the storage of fishery and aquaculture products. Additional amendments to the EMFF Regulation allow for a more flexible reallocation of financial resources within the operational programmes of each Member State and a simplified procedure for amending operational programmes with respect to the introduction of the new measures. Operations supported under the temporary coronavirus-related measures will be retroactively eligible as of 1 February 2020 until 31 December 2020.

At the time of writing, it is too soon to accurately assess the impact that the COVID-19 crisis will have on the individual Blue Economy sectors. However, it is likely that some sectors will suffer more than others. According to a preliminary assessment based on the information available in early April, the sectors expected to suffer greater impacts and have a slower recovery are: *Coastal tourism*, *Shipbuilding and repair* and *Marine non-living resources*. Sectors expected to suffer severe initial impacts but which are expected to benefit from a rather fast recovery are: *Maritime transport*, *Port activities*, *Marine renewable energy* and *Blue Bioeconomy*. Finally, most of the emerging sectors are expected to suffer minor impacts and show a prompt recovery (Table 2.3).

[33] Insights and updates on the EU response to the corona virus crisis in the domain of fisheries and aquaculture can be consulted at: https://ec.europa.eu/fisheries/coronavirus-response-fisheries-and-aquaculture_en

[34] Communication from the Commission — Temporary framework for State aid measures to support the economy in the current COVID-19 outbreak, 19 March 2020, OJ C 91I, 20.3.2020, p. 1-9, as amended by Communication from the Commission C(2020) 2215 final of 3 April 2020 on the Amendment of the Temporary Framework for State aid measures to support the economy in the current COVID-19 outbreak, OJ C 112I, 4.4.2020, p. 1–9, and Communication from the Commission C(2020) 3156 final of 8 May 2020 on the Amendment of the Temporary Framework for State aid measures to support the economy in the current COVID-19 outbreak, OJ C 164, 13.5.2020, p. 3–15.

[35] REGULATION (EU) 2020/560 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 23 April 2020 amending Regulations (EU) No 508/2014 and (EU) No 1379/2013 as regards specific measures to mitigate the impact of the COVID-19 outbreak in the fishery and aquaculture sector.

CHAPTER 3

CLIMATE CHANGE AND OTHER HUMAN IMPACTS ON OCEANS

Worldwide, humans are increasingly exploiting both land and the ocean and affecting ecosystems, the environment and the earths' climate. Human activities such as burning fossil fuels (for transportation, electricity and heat) and deforestation and farming livestock are responsible for almost all the atmospheric greenhouse gas increases over the last centuries[36]. This adds enormous amounts of greenhouse gases to those naturally occurring in the atmosphere, increasing the greenhouse effect and climate change. Greenhouse gases in the atmosphere warm the earth because they absorb energy (in the form of radiation) that normally would escape to outer space. Many of these gases occur naturally, but human activity is increasing the concentrations of some of them in the atmosphere, in particular: carbon dioxide (CO_2), methane, nitrous oxide, and fluorinated gases. CO_2 is the greenhouse gas most commonly produced by human activities and it is responsible for 64 % of human-made global warming[37].

Global warming has already reached around 1.0°C above pre-industrial levels, primarily through emissions of CO_2 and other greenhouse gases[38]. The global ocean has warmed unabated since 1970 and has taken up more than 90 % of the excess heat in the climate system[39]. The ocean's absorption of CO_2 has led to ocean acidification, which harms marine life by reducing the presence of calcium carbonate, which is the building block for skeletons and shells.

Climate change affects all regions around the world. Ice sheets and glaciers worldwide have lost mass, contributing to an acceleration in global sea-level rise[40]. Extreme weather events, such as heavy rainfall, floods, heatwaves, and droughts, are occurring more frequently and more intensely. This will lead to decreasing availability of essential resources, such as reduced water availability and quality in some regions[41].

Economic activities can also affect marine ecosystems in a very wide range of ways: from fishing and its impacts on the benthos and marine populations, to oil spills, eutrophication, agriculture with nitrate pollution, marine pollution and plastics. These pressures on marine ecosystems can undermine the full potential of the benefits that can be obtained from the them and any Blue Economy activities, which are at least partly dependent on them. The interdependences between Blue Economy activities and the marine ecosystems are analysed in section 4.3. This chapter focuses on specific pressures: climate change and pollution.

In particular, this chapter explores the impacts of marine activities in terms of greenhouse gas emissions and the role of the ocean in regulating the earth's climate and mitigating climate change. The chapter continues by investigating the impacts of climate change on the ocean, such as its effect on the fisheries and aquaculture sector and the increase of floods that will require coastal protection and adaptation. Finally, the impact of pollution and litter, in the Oceans (including plastics) is also analysed. Thus, this chapter builds up on last year's Blue Economy report works on coastal protection to mitigate climate change and the economic impact of marine litter and plastic.

[36] IPCC, 2018: Global Warming of 1.5°C.An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty. Masson-Delmotte, V., et al. (eds). Chapter 1 of this report finds that human activities have led to around 1°C of warming, while other factors (such as volcanic eruptions and solar activity) account for less than +/-0.1°C..

[37] European Commission. 2020. Causes of climate change. https://ec.europa.eu/clima/change/causes_en.

[38] IPCC. (2018).

[39] IPCC 2019) Special Report on the Ocean and Cryosphere in a Changing Climate. Pörtner, H.-O., et al., (Eds.).

[40] IPCC (2018). Summary for Policymakers of IPCC Special Report on Global Warming of 1.5°C approved by governments. Available at: https://www.ipcc.ch/2018/10/08/summary-for-policymakers-of-ipcc-special-report-on-global-warming-of-1-5c-approved-by-governments/.

[41] European Commission. 2020. Climate change consequences. https://ec.europa.eu/clima/change/consequences_en.

3.1. GREENHOUSE GAS EMISSIONS AND THE BLUE ECONOMY

Greenhouse gases (GHGs) are the main contributor to global warming and climate change. Climate change is expected to result in more frequently heat waves, forest fires and droughts in Southern and Central Europe. While, Northern Europe will become significantly wetter, and winter floods could become common[42].

EU Member States have to monitor and report on the various greenhouse gases in their national emissions inventories[43]. Main greenhouse gases are: carbon dioxide, methane, nitrous oxide, nitrogen trifluoride, and sulphur hexafluoride; and numerous hydrofluorocarbons and perfluorocarbons that exist. Greenhouse gases are not all equal. Each greenhouse gas differs significantly in terms of the impact that it has on the warming of the earth. The impact of a greenhouse gas on global warming is also called the global warming potential. Two factors largely determine the global warming potential of a greenhouse gas: The lifetime of a greenhouse gas (i.e. how long the gas can remain present in the atmosphere); and the radiative efficiency (i.e. how much energy the gas can absorb)[44]. Global warming potentials allow the standardisation of all greenhouse gasses. The global warming potential of carbon dioxide is used as a reference point of measure, and is standardised to 1. Global warming potentials are commonly used to convert the impact of each greenhouse gas to a Carbon dioxide equivalent (CO_2e) (Table 3.1) The global warming potentials that are being used for accounting are based on the fourth assessment report of the IPCC[45].

Table 3.1 Global warming potential of greenhouse gases

Greenhouse gas	Global warming potential
Carbon Dioxide (CO_2)	1
Methane (CH_4)	25
Nitrous oxide (N_2O)	298
Sulphur hexafluoride (SF_6)	22,800
Nitrogen trifluoride (NF_3)	17,200
Hydrofluorocarbons (HFCs)	124 – 14,800
Perfluorocarbons (PFCs)	7,390 – 12,200
Chlorofluorocarbons (CFCs)	4,750 – 14,400
Hydrochlorofluorocarbons (HCFCs)	77 – 2,310

Source: IPCC fourth assessment report, chapter 2.

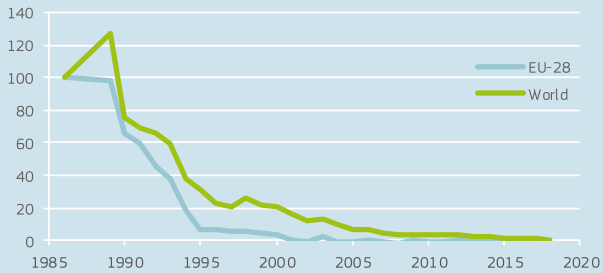
The most important GHG by far is CO_2, accounting for 81.3% of total EU-28 emissions in 2017. In 2017, EU-28 CO_2 emissions were 3.5 billion tonnes, which was 21.3% below 1990 levels and 14% lower than in 2008[46].

BOX 3.1: OZONE-DEPLETING SUBSTANCES AND THE MONTREAL PROTOCOL

The ozone layer prevents the most harmful wavelengths of ultraviolet light (UV light) from passing through the Earth's atmosphere. Ozone depletion and the ozone hole generated worldwide concern over increased cancer risks and other negative effects. These concerns led to the adoption of the Montreal Protocol in 1987.

The Montreal Protocol focuses on the global phase-out of damaging greenhouse gases and ozone-depleting substances (ODS), namely chlorofluorocarbons (CFCs) and hydrochlorofluorocarbons (HFCs). Since its entry into force in 1989, the EU was able to reduce its consumption of ODSs by 100% in 2002; and with a global reduction of 99.67% as of 2018 (Figure 11)[47]. In 2016, the Montreal Protocol was amended (the Kigali Amendment) to enshrine a phase-out for hydrofluorocarbons. It was agreed that both developed and developing countries would reduce their consumption and production of HFCs over the next three decades. Under the amendment, HFC consumption may be no more than 90% of its 2019 baseline, and no more than 15% in 2036[48].

Figure 3.1 Consumption of ozone-depleting substances,% compared to 1986 levels

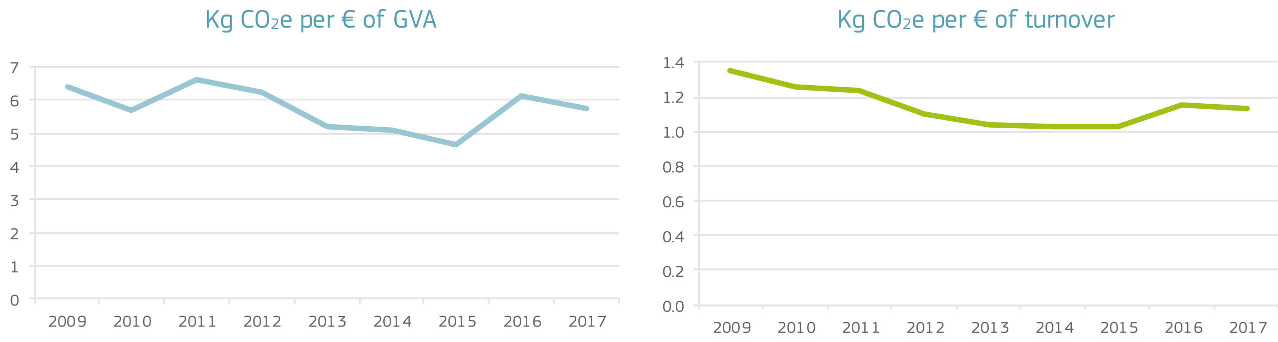


Source: European Environment Agency (2020).

Under the Paris Agreement, global efforts are being made to stem the worlds' overall greenhouse gas emissions, including reducing anthropogenic greenhouse gas emissions to net zero this century (climate neutrality) in order to meet the Agreement's goal of limiting the global mean temperature increase to well below 2°C above pre-industrial levels, and to pursue efforts to limit the increase to 1.5°C. The Paris pledge of the EU and its Member States (known as its Nationally Determined Contribution – NDC) consists of reducing domestic GHG emissions to at least 40% below 1990 levels by 2030. However, the EU is in the process of adopting more ambitious emissions reductions. In December

42 European Commission. 2020. Climate change consequences. https://ec.europa.eu/clima/change/consequences_en.
43 In the EU, Member States carry out the monitoring of national greenhouse gas emissions in accordance with the Regulation on a mechanism for monitoring and reporting greenhouse gas emissions and for reporting other information at national and Union level relevant to climate change (Regulation 525/2013).
44 The global warming potentials that are based on the 100-year global warming potential of greenhouse gases, extracted from chapter 2, section 2.10 of the IPCC fourth assessment report (2007).
45 Considering the best available science available at the time of the Regulation (525/2013).
46 European Commission (2019). Fourth Biennial Report from the European Union Required under the United Nations Framework Convention on Climate Change (Decision 2 CP.17). C(2019)8832. Eurostat. 2018. Greenhouse gas emission statistics — air emissions accounts. Available at: https://ec.europa.eu/eurostat/statistics-explained/pdfscache/30599.pdf.
47 European Environment Agency. 2020. Production and consumption of ozone-depleting substances in Europe. [https://www.eea.europa.eu/data-and-maps/indicators/production-and-consumption-of-ozone-3/assessment].
48 European Environment Agency. 2019. Emissions and supply of fluorinated greenhouse gases in Europe. [https://www.eea.europa.eu/data-and-maps/indicators/emissions-and-consumption-of-fluorinated-2/assessment-2].

Figure 3.2 Greenhouse gas emitted by the EU's water transport sector



Source: Commission Services based on Eurostat Eurostat (2020) and the EU Blue Economy Report (2019).

2019, the European Council endorsed the objective of achieving a climate-neutral EU by 2050[49], building on the *Clean Planet for All* Communication of the European Commission and the IPCC Special Report on 1.5°C. As part of the European Green Deal, the Commission intends to propose an increase to the EU's 2030 target to at least -50% and towards -55% compared to 1990 levels, in a responsible way[50].

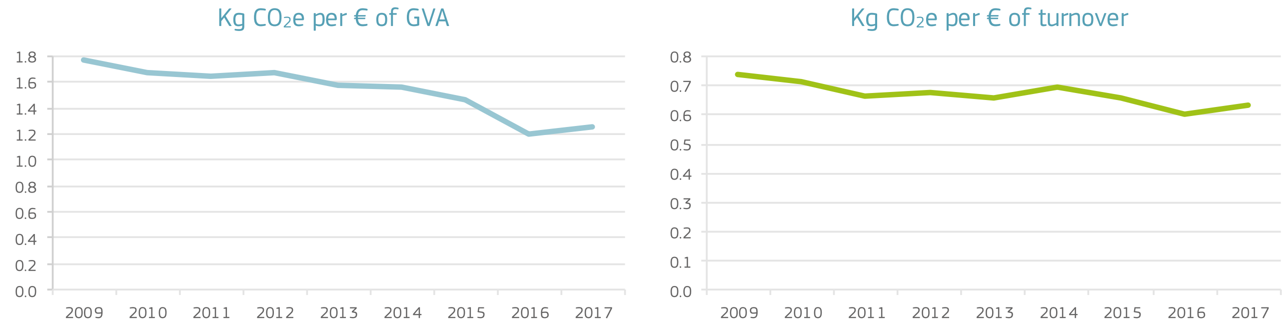
These developments happen on the backdrop of an EU that has already been on a path towards climate neutrality through economic transformation and modernisation. Between 1990 and the end of 2018, greenhouse gas emissions in the EU dropped by 23%, while the economy grew by 61%[51]. Even if the reduction of greenhouse gas emissions in Blue Economy sectors has often been less drastic, they also demonstrate that economic output has been decoupled from greenhouse gas emissions. Shipping currently represents 3-4% of global CO_2 emissions and could reach 10% by 2050 if no action is taken. Even if, as a result of the financial crisis, the shipping industry has been operating at much lower speeds, resulting in considerable efficiency gains.. In order to ensure that the shipping industry will contribute its fair share to realising the temperature target of the Paris Agreement, the Marine Environment Protection Committee (MEPC) of the UN's International Maritime Organisation (IMO) in April 2018 agreed on an initial strategy to reduce greenhouse gas emissions from international shipping. The initial strategy includes, in particular. the ambition to peak GHG emissions as soon as possible, and reduce emissions by at least 50% by 2050 compared to 2008. The strategy represents an important first step and although the EU advocated higher ambition levels, it pushes for the swift implementation of the strategy through meaningful and robust reduction measures, both for the short and long term. The strategy also recognises the need to consider the impacts of measures on states, including developing countries and in particular small developing islands states and least developed countries, and to address any disproportionately negative impacts if those were to occur. In the same spirit the EU funded a €10 million capacity-building project for climate change mitigation managed by the IMO[52].

For the EU's water transport sector, which covers both inland water transport and coastal water transport, corresponding to NACE H50, the gross value added (GVA) of inland water transport has increased by 8.4% (from €20.7 billion to €22.4 billion) from 2009 to 2017. According to Eurostat, during the same period, greenhouse gas emissions in terms of CO_2e decreased by 2% (from 132 million tonnes to 129 million tonnes)[53]. This represents a decrease of 9.6% of CO_2e per unit of GVA (Figure 3.2, left-hand panel). This trend is in concert with the turnover (gross premium written) of the EU's water transport sector. Between 2009 and 2017 turnover for the sector has increased by 17.3% (from €97.6 billion to €114.3 billion) while greenhouse gas emissions (CO_2e) per unit of turnover decreased by 16.4% (Figure 3.2, right-hand panel). However, the CO_2 emissions from EU related maritime transport activities remain substantial. The first data obtained from the EU system to monitor, report and verify CO_2e emissions from ships over 5000 gross tonnage showed that they emitted more than 138 million tonnes of CO_2e into the atmosphere in 2018[54].

The EU's capture fisheries and aquaculture sector (*Primary sector* subsector in the *Living resources sector*, corresponding) has also played its part. Between 2009 and 2017, the GVA of the fisheries and aquaculture sector increased by 41.5% (from €4.7 billion to €6.6 billion). During the same period, greenhouse gas emissions in terms of CO_2e increased by just 0.5% (from 8.31 million tonnes to 8.35 million tonnes)[55]. This represents a decrease of 29% of CO_2e per unit of GVA (Figure 3.3, left-hand panel). This downward trend in greenhouse gas emission intensity also occurred in terms of turnover. Between 2009 and 2017 turnover in the *Primary production* subsector increased by 17% (from €11.3 billion to € 13.2 billion) while emissions per unit over turnover decreased by 14.1% (Figure 3.3, right-hand panel).

49 European Council Conclusions, 12 December 2019.
50 The European Green Deal. European Commission communication COM(2019) 640 final.
51 For more information, see: https://ec.europa.eu/clima/policies/strategies/progress_en.
52 European Commission (2019). https://ec.europa.eu/transport/modes/maritime/news/2018-04-13-imo-agreement-co2_en
53 Source Eurostat (online data code: env_ac_aeint_r2).
54 Sept 19 data from https://mrv.emsa.europa.eu/#public/emission-report.
55 Source Eurostat (online data code: env_ac_aeint_r2).

Figure 3.3 Greenhouse gas emitted by the EU's *Primary sector* (*Capture fisheries* and *Aquaculture*)



Source: Commission Services based on Eurostat (2020) and the EU Blue Economy Report (2019).

3.2. THE ROLE OF THE OCEANS IN CLIMATE REGULATION, CARBON SEQUESTRATION AND CLIMATE CHANGE MITIGATION

3.2.1. OCEANS IN CLIMATE REGULATION

The ocean plays a major role in regulating the Earth's climate by redistributing and absorbing heat and by removing CO_2 from the atmosphere. In the open ocean, the 'biological carbon pump' results in the transfer of around 10 GT of carbon per year from near-surface waters to the ocean interior, driven by the combination of photosynthesis by phytoplankton and downward transfer of particulate carbon through a variety of processes[56]. The amount of absorbed and sequestered carbon depends on multiple factors, such as the amount of nutrients and light phytoplankton have for their activity. Many of these factors depend on the physical structure of the ocean (e.g. how strongly stratified the different water layers are), which is largely influenced by the interactions with the atmosphere (mostly through heat and momentum transfer). A recent analysis[57] estimates that up to one third of the anthropogenic CO_2 emissions for the atmosphere are taken up by marine ecosystems. This physical structure is expected to be altered in the future because of the changing atmospheric conditions, so the amount of primary production taking place in our future seas and oceans is also likely to change. The magnitude of this change is uncertain and, most probably, region-dependent.

The primary production rate (PPR) happening in open-sea regions is difficult to measure *in-situ* so typically, estimates are made from remote sensing (satellite) colour imagery and modelling (observation, analysis and forecasts at EU and global scale available at the Copernicus marine Service[58]). Nowadays, numerical models are also used to simulate how phytoplankton behaves and incorporate carbon in the euphotic (with light) layer of the oceans and seas. Such models can also make predictions and simulations for alternative future scenarios (e.g., regarding global change and/or management options).

The global ocean has taken up more than 90% of the excess heat in the atmosphere and has absorbed 20-30% of anthropogenic CO_2 since the 1980s[59]. This has already contributed to a number of impacts such as a doubling in the frequency of marine heatwaves and increased acidity of the ocean, which makes the water more corrosive for marine organisms that build their shells and structures out of mineral carbonates, such as corals, shellfish and plankton. These climate-change stressors occur alongside other human-driven impacts, such as overfishing, excessive nutrient load (eutrophication), and plastic pollution, with implications for fisheries and livelihoods in coastal communities. Hence, the speed and intensity of the future risks and impacts from ocean change critically depend on future greenhouse gas emissions.

3.2.2. BLUE CARBON SEQUESTRATION IN THE EU MEDITERRANEAN SEA

A sophisticated Regional Earth System Model (RESM) developed at the JRC for simulating the conditions of the Mediterranean Sea (the Marine Modelling Framework, MMF[60]) has been used to make estimations of the PPR taking place on EU jurisdictional waters within the Mediterranean basin. The PPR values estimated by the MMF model within the Mediterranean are almost identical to satellite values for present day conditions (2003-2018), indicating that the model accurately captures the magnitude and spatial distribution of this ecosystem process in the Mediterranean Sea.

56 IPCC. (2019). Special Report on the Ocean and Cryosphere in a Changing Climate.
57 Basu, S., Mackey, K.R.M., 2018. Phytoplankton as Key Mediators of the Biological Carbon Pump: Their Responses to a Changing Climate. Sustainability 10, 869.
58 The operational PPR and other plankton products are operationally produced by Copernicus in all EU sea basins and at global scale with 4 time frames: past 20 year analysis, real time observation, 5 day forecast and climate projections. Copernicus also produces at global scale 3 CO_2 products: surface flux, surface partial pressure and fugacity of CO_2 directly delivering information on carbon sink. Available at: Copernicus Ocean state report #2: https://marine.copernicus.eu/science-learning/ocean-state-report/ocean-state-report-2nd-issue/. More information at: www.marine.copernicus.eu.
59 IPCC. (2019).
60 Stips, A. et al. 2015. Towards an integrated water modelling toolbox. European Commission, Luxembourg.

From this total PPR occurrence, it is possible to estimate how much carbon is sequestered from the atmosphere and transferred to the deep ocean by applying statistic relationships based on field data measurements[61]. This provides an estimation on how much carbon is being effectively isolated from the atmosphere by the action of primary producers in the ocean. The MMF estimates the following sequestration of carbon for each of the EU MS within the Mediterranean Sea (in million tonnes per year): Italy, 13.2; Spain, 10.2; Greece, 6.25; France, 3.6; Cyprus, 0.92; Malta, 0.67 and Croatia, 0.34.

Finally, this sequestered carbon can be expressed in monetary terms by giving a 'value' to remove carbon from the atmosphere. Establishing a value for the removed carbon is, however, complex. There are myriads of market-price estimates for CO_2 that span from about €30 per tonne to about €600 per tonne depending on the trade systems considered and the region concerned. However, a more advanced approach is to use the '*tutelary value of carbon*' as defined by the Quinet Commission in 2009 and revised in 2019. This value reflects the willingness of society to avoid extra pollution of the atmosphere in the context of carbon neutrality and global change abatement actions (e.g., the Paris Climate Agreement). This value is not fixed in time but is rather assumed to be changing according to the realised CO_2 concentration in the atmosphere and the expected impacts an extra tonne of carbon emitted will have (i.e., the '*social cost of carbon*' as expressed by Nobel laureate W. Nordhaus)[62]. Recent estimates[63] put this tutelary value at about €100 per tonne for 2018, €250per tonne in 2030 and €775 per tonne in 2050. These values are expected to increase in successive evaluations as they depend on the state of knowledge, the level of CO_2 emissions and the willingness to abate these emissions. Therefore, these values are used as lower bounds of future carbon values.

The OECD proposed €30 per tonne as the benchmark value of the low-end estimate of carbon costs today[64]. When applying the €30 per tonne to the sequestration estimates provided by the MMF, a value of approximately €1.65 billion per year for EU MSs in the Mediterranean Sea can be estimated. Instead, when applying the tutelary value per carbon tonne, the estimated value of this ecosystem service grows to approximately €5.5 billion per year. Thus, despite the high uncertainties, estimates indicate that the value of carbon sequestered in the EU MSs in the Mediterranean Sea is between €1.65 billion and €5.5 billion per year[65]. The distribution of this ecosystem service is, of course, not homogeneous, e.g. Italy, France and Spain present much larger values.

Climate change scenarios can be used in combination with the MMF[66] to make simulations about how this ecosystem service is likely to change into the future. Changes in the medium term have been explored (corresponding to the 2040-2050 decade) under two different IPCC scenarios; RCP4.5 (a middle point scenario) and RCP8.5 (a worst case scenario). According to the trend of the tutelary value described above, for 2020 a tonne of CO_2 should have a value about €156 per tonne and for the decade 2040 – 2050 will have a value of about €600 per tonne. Two different comparisons were made, the first one considers the same value per tonne of CO_2 now and in the 2040s decade, while in the second scenario the expected change in the tutelary value for the future is considered (Figure 3.4).

Applying a non-changing tutelary value of CO_2 (Figure 3.4) for all EU MSs the estimated value of the carbon sequestration service will increase in the future for both climate scenarios, with an overall rise of approximately €620 million per year. In this case, the largest increase is obtained for Greece following the already described regional changes of PPR for the Mediterranean Sea[67]. If, on the contrary, the time-varying tutelary value approach described above is considered, the increase of the overall value of this service is much larger, approximately €18 billion per year. There are also some regional differences in the distribution of the increase for Spain as it is for instance much larger (in proportion) than using the fixed price approach (Figure 3.4).

The reasons for the increase in PPR (and carbon sequestration) are linked to the weakening of the vertical stratification in the future scenarios due to more intense evaporation, lack of freshwater inputs and hence, increase of surface salinity in the overall Mediterranean basin[68]. These results are in line with the increasing productivity trend already observed for the Mediterranean Sea[69]. However, this is a regional response to climate change provoked by the particular configuration of the Mediterranean Sea, the impacts for other EU regional seas is yet to be evaluated.

61 For example: Eppley, R.W., Peterson, B.J., 1979. Particulate organic matter flux and planktonic new production in the deep ocean. Nature 282, 677-680; Buesseler, K.O. et al. 2007. Revisiting Carbon Flux Through the Ocean's Twilight Zone. Science 316, 567-570.

62 William D. Nordhaus (2017). Revisiting the social cost of carbon. Proceedings of the National Academy of Science, 114 (7),1518-1523.

63 Quinet Commission (2019). La Valeur de l'Action pour le Climat, Report of the Commission headed by Alain Quinet, France Stratégie, February 2019.

64 OECD (2018), Effective Carbon Rates 2018: Pricing Carbon Emissions Through Taxes and Emissions Trading, OECD Publishing, Paris, https://doi.org/10.1787/9789264305304-en.

65 For instance, the value can be informed by the cost of alternative mitigation that it replaces. If ocean sequestration replaces a mitigation option that would cost 200€/tonne of CO_2 mitigated, then the economic value of the mitigation service provided by the ocean ecosystem is 200€/tonne of CO_2. An alternative way of valuing this ecosystem service is to look for estimates of the economic damage caused by the avoided emission of one tonne of CO_2. This concept is called the social cost of carbon (SC-CO_2), and the subject of much uncertainty and debate in economics. Estimates range from as low as 1€/tonne of CO_2 (EPA, 2018) to 400€/tonne of CO_2 and more. See Ricke, Drouet, Caldeira and Tavoni (2018) Country-level Social Costs of Carbon. Nature Climate Change 8, 895–900. https://www.nature.com/articles/s41558-018-0282-y.

66 For example: Macías, D. et al. 2018a. Deep winter convection and phytoplankton dynamics in the NW Mediterranean Sea under present climate and future (horizon 2030) scenarios. Sci. Reports 8, 6626; Macías, D. et al. 2018. Hydrological and biogeochemical response of the Mediterranean Sea to freshwater flow changes for the end of the 21st century. Plos One 13, e0192174.

67 Macías, D. et al. 2015. Productivity changes in the Mediterranean Sea for the twenty-first century in response to changes in the regional atmospheric forcing. Frontiers in Marine Science 2 (79).

68 For a more detailed explanation see: Macías et al (2015).

69 Druon, J.-N. et al. 2019. Satellite-based indicator of zooplankton distribution for global monitoring, Nature Scientific Reports 9:4732.

Figure 3.4 Estimated values of the sequestered carbon, € million / year

Source: Commission Services

3.3. ECONOMIC IMPACTS OF CLIMATE CHANGE ON EUROPEAN FISHERIES AND AQUACULTURE

The CERES project (Climate Change and European Aquatic Resources)[70] provides a cause-and-effect understanding and management responses on how climate change will influence European fish and shellfish resources and the economic activities that depend on them[71]. More than 150 participants from 26 institutions in 15 countries took part in this project. Partners included national research laboratories, universities, industry members from the aquaculture and fisheries sector and other stakeholders. Focusing on the most commercially valuable fish and shellfish, the project provides further knowledge and has helped develop tools needed for adaptation planning in marine and inland waters to better anticipate the consequences of climate change. Long-term management plans will need to take into account the potential future impacts of climate change on aquatic living resources and the human communities that depend on them. The project identified not only the risks and the opportunities but also the uncertainties, i.e. information needed to enhance climate resilience and support the development of sustainable management and governance systems in these Blue Economy sectors.

Scenarios for future development

The future economic situation of the European fishing fleets and aquaculture farms was estimated within scenarios that defined future political, economic, social, technological, legal and environmental (PESTLE) changes. Four contrasting scenarios were developed: World Markets (WM), National Enterprises (NE), Global Sustainability (GS) and Local Stewardship (LS)[72] and the PESTLE elements refined through consultation with industry partners and stakeholders.

Economic consequences of climate change on European fisheries

CERES used six different bioeconomic models to estimate the mid-century (2050) profitability of ten fisheries operating in different European waters from the southern Arctic Ocean to the Eastern Mediterranean Sea[73] (Table 3.2). A profitability baseline

[70] The CERES project is fund under the EU Horizon 2020 programme and runs from 2016 to 2020. For further details, see https://ceresproject.eu/.
[71] There is another project funded under the EU Horizon 2020 programme with a similar thematic: Climefish. The project ClimeFish simulates the growth of the most important and the less resilient cultured and wild-caught fish and shellfish species in Europe, also testing d RCP4.5 and the 8.5 IPCC scenarios. For more information, see: https://climefish.eu
[72] See Annex 3.3 for further details.
[73] The models examined the economic outcomes for 30 fleet segments, including a wide diversity of fleets (e.g. highly industrialised and artisanal,

was calculated from present day fish distributions, fuel and fish prices, management plans including spatial closures, and fuel efficiencies. The change in future profitability was projected using climate-driven changes in the productivity and/or distribution of fishery target species and future economic and management developments assumed in the four CERES scenarios.[74].

The projected change in economic performance (or 'catch opportunity' in the Norwegian and Barents Sea) in 2050 varied considerably among fleets and CERES scenarios tested but some consistent drivers were observed. In general, however, most fishing fleets examined will likely need to adapt to changes in prices and management (e.g. through changes in fishing behaviour or technological innovation) before needing to adapt to climate-driven changes in distribution and productivity of their target species.

Environment: By 2050, shifts in the distribution or productivity of fish were not predicted to be the main driver of changes in profitability. Many fishing fleets, such as the North Sea demersal fishery, could readily adapt to these biological changes to maintain their current profitability.[75]

Economics: In accordance with expectations, the future development of fuel and fish prices were strong drivers of profitability (Table 3.2). While fleets have some flexibility in selecting different fishing areas, adjusting to changes in costs (fuel) and revenues (fish) is much more difficult. In the future, increasing the efficiency of fishing (fuel-saving fishing strategies or technological improvements on board) will be important for both pelagic and demersal fisheries. Increased fuel efficiency will be particularly important for demersal trawl fisheries where fuel is usually the main operating cost (due to dragging fishing gear at the bottom).

Legal and Policy: The effect of changing management targets depends on the current situation of the fishery. Increasing the exploitation rate leads to larger catches in lower trophic levels species such as mesopelagic fish and mesozooplankton (*Calanus Finarmchius*) in the Norwegian and Barents Seas, which are currently not exploited or harvested at a very low rate, respectively. For the other fisheries, it had little to slightly negative impacts on their economic performance[76]. Where fish stocks are managed using Total Allowable Catch, the distribution of national quotas follows the principle of relative stability where each country receives a fixed percentage of the EU quota. The situation is different in the Mediterranean where very few stocks are managed with quotas and countries regulate their fisheries mostly based on limiting fishing effort. Changes in the distribution of target species will require changes in quota distribution among countries and/or fishing fleets (e.g. within EU or among EU and third countries) for effective, climate-ready fisheries management.

Economic consequences of climate change on European aquaculture

Typical farms combining all relevant details of regional production systems were defined for the economic assessment of climate change impacts on Europe's most important aquaculture species[77] and applied as a baseline for farm-level predictions. The mid-century (2050) profitability for rainbow trout, carp, Atlantic salmon, sea bass, sea bream and blue mussel farms in each of the four CERES scenarios was compared to present-day operating earnings (Figure 3.5). Production systems ranging from traditional ponds and organic production up to large, innovative farms and industrial-scale production were included. The projections considered future developments of feed cost relevant for finfish production, trends for future energy costs and market returns combined with assumptions on potential future subsidies and marketing options.

Sea bass, salmon and best-practice trout farms were projected to be the most profitable in the future, whereas farms for the other species, on average, experienced substantial reductions in profit. Often, the size of losses or gains in profit was scenario-dependent. For example, German carp farms were only profitable under the National Enterprise (NE) and Local Stewardship (LS) scenarios (Figure 3.5) due to future differences in local marketing options. Profit losses for carp farms under World Markets (WM) and Global Sustainability (GS) scenarios, however, were enhanced by the elimination of subsidies under these scenarios.

Future developments occurring under the WM scenario were the most favourable and increased farm profits followed by the LS and NS scenarios. In contrast, almost 80 % of the farms examined were less profitable than today under the GS scenario. In general, the combination of market returns and feed costs determined the future profitability of fish farms. Although both fish price and feed costs increased in the future, the GS scenario had relatively less increase in fish price due to its assumptions of population growth rate, income, international trade, agricultural expansion and technological change that influence world food prices[78].

Low profitability was observed in the GS scenario (RCP4.5) but the costs of technological investment associated with adapting to climate change impacts (not included in the analysis) are also be expected to be low. In contrast, more severe climate impacts and greater investment in technological solutions would be needed in WM and NE (RCP8.5). Changes in harvest weight and feed conversion ratio (FCR) induced by environmental change also had a high impact on future profitability. Apart from environmental / biological impacts, the ability to buffer future price developments and additional investments depended on the profit margin of individual farms. Farms that were predicted to be unprofitable in all four scenarios in 2050 had a similar present-day profit margin of around 7 % (based on operation earnings). Farms with a present-day profit margin between 11 and 31 % had

exploiting either pelagic or demersal fish, using either passive or active fishing gear).

74 CERES did not include ancillary, downstream economic activities of fishing such as processing.

75 Changes in distribution are more severe under RCP8.5 in 2100 and these were not tested.

76 Nash, R. D. M., Drinkwater, K. F., and Hjøllo, S. S. 2019. Management Scenarios under Climate Change – A Study of the Nordic and Barents Seas. Frontiers in Marine Science, 6.

77 Lasner T, Brinker A, Nielsen R, Rad F (2017) Establishing a benchmarking for fish farming – Profitability, productivity and energy efficiency of German, Danish and Turkish rainbow trout grow-out systems. Aquaculture Research 48(6): 3134-3148.

78 Popp J, Befeki E, Duleba S, Oláh J (2018) Multifunctionality of pond fish farms in the opinion of the farm managers: the case of Hungary. Reviews in Aquaculture: http://doi.wiley.com/10.1111/raq.12260.

Table 3.2 Relative effect of the different factors on the economic performances of the fisheries

	Region	Environmental	Economic		Legal	Technological	Political
Pelagic Fisheries	Norweg. & Barents Sea	P					
	Baltic Sea						
	North Sea	P	Fu	Fi			
	North East Atlantic	P	Fu	Fi			
	Bay of Biscay	P					
	W. Mediterranean Sea	P	Fu	Fi			
Demersal Fisheries	Norweg. & Barents Sea	P					
	Baltic Sea						
	North Sea	D	Fu	Fi			MSP
	Aegean Sea	P	Fu	Fi			

Most negative			No effect			Most positive	No data

Notes: Factors as defined in CERES scenarios. P: climate drive productivity; D: climate driven spatial distribution; Fu: Fuel price; Fi: Fish prices; MSP: increasing area closures due to marine spatial planning. The legal factor considers an increase in exploitation rate. In the Norwegian and Barents Sea, the potential catch is used as proxy for profitability.
Source: CERES Project.

Figure 3.5 Change in profitability by 2050 for a typical farm

Species	Country	Production (t)	Activity	MS	NE	GS	LS
Sea bass	Spain	1,224	Netcage				
Rainbow trout	Germany	500	Raceway RAS				
	Germany	100	Raceway				
	Germany	8	Pond/Raceway				
	Denmark	700	Raceway RAS				
	United Kingdom	360	Raceway				
	Denmark	150	Pond				
Salmon	Norway	3,680	Netcage industrial				
	Ireland	1,560	Netcage organic				
Carp	Germany	5	Pond				
	Germany	20	Pond				
	Poland	90	Pond				
	Poland	190	Pond				
Blue mussel	Denmark	900	Longline				
	Netherlands	1,118	Bottom				

>+100%	+80-100%	+60-80%	+40-60%	+20-40%	+0-20%	-0-20%	-20-40%	-40-60%	-60-80%	-80-100%	<-100%

Notes: Profitability is estimated based on future prices of fish feed, energy costs and fish price (returns). Scenarios: WM: World Markets; NE: National Enterprise, GS: Global Sustainability, LS: Local Stewardship.
Source: CERES project.

either decreased or increased profitability in 2050 depending on the scenario. Farms with present-day profit margin of over 30% increased their future profits in all of the four scenarios. Combined with depreciation and opportunity costs of these typical farms as well as potential price variation, a comprehensive picture of future prospects can be provided.

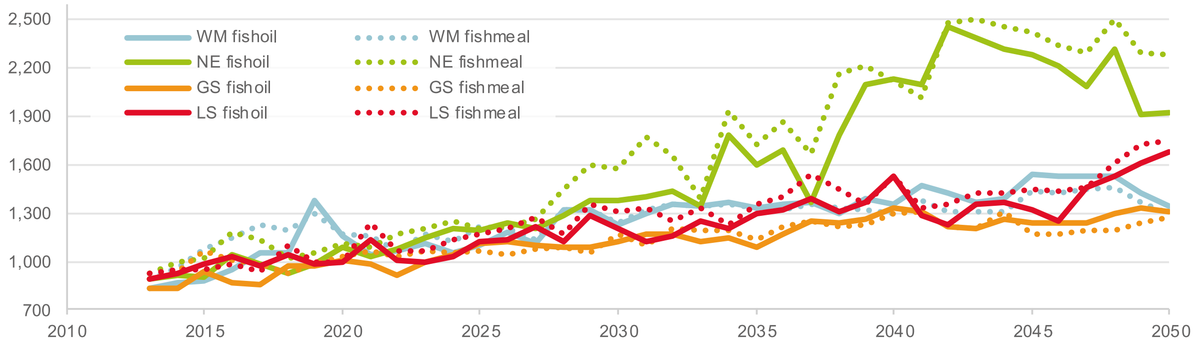
Economic consequences of climate change on fish meal and fish oil prices

Europe's finfish aquaculture sector relies on fishmeal and fish oil (FMFO) to provide a healthy diet of protein, omega-3 fatty acids and other essential nutrients to its farmed finfish. FMFO feed is produced from wild-caught small pelagic fish (SPF) from across the globe, particularly catches of anchovy along the Peruvian and Chilean coasts. In 2018, the EU imported approximately 50% of its total feed. Any reductions in the catch of SPF due to climate change will increase FMFO prices and decrease aquaculture farm profits. Using a network economics model accounting for 80% of the global production and consumption of FMFO[79], CERES projected FMFO prices under the four CERES scenarios to 2050 to help gauge the level of exposure of Europe's aquaculture farms to climate change.

In 2050, prices per tonne of fishmeal and fish oil (€2 282 and €1 921, respectively) were highest in the NE scenario followed by the LS scenario (Figure 3.6). The GS scenario produced the lowest and most stable fishmeal and fish oil prices (€1 269 and €1 306 respectively). World Markets prices in 2050 were slightly higher than GS but showed more variability and generally higher prices through time. A combination of large (poleward) shifts in fish stocks, a growing human population consuming increased levels of seafood, and (assumed) lower global cooperation leads to high prices in the NE scenario. Low prices in the GS scenario

79 Mullon C, Steinmetz F, Merino G, Fernandes JA, Cheung WWL, Butenschön M, Barange M (2016) Quantitative pathways for Northeast Atlantic fisheries based on climate, ecological-economic and governance modelling scenarios. Ecol Modell 320:273–291. https://doi.org/10.1016/j.ecolmodel.2015.09.027.

Figure 3.6 Average prices for fishmeal and fish oil through 2050 across the four CERES scenarios.



Source: CERES project.

stem from more moderate levels of latitudinal shifts in SPF stocks, human population growth and seafood demand and increased cooperation in global trade. 'Demand flexibility', accounting for the presence of substitutes or alternatives to FMFO, also explains some of the price differences among the scenarios. Demand flexibility was assumed to be low (few alternatives) in the NE and LS scenarios and higher (more alternatives) in the World Markets (WM) and GS scenarios.

The FMFO projections provide a catalyst for the design and implementation of climate adaptation strategies. A variety of strategies are already underway including variation in quota/effort management for SPF stocks, especially during the *El Niño* years, which will contribute to resilience to climate change in the future. Other strategies include the use of fish trimmings and other by-products by fishmeal and fish oil producers to reduce the need for whole fish, moving towards a more circular economy. Alternative ingredients such as soy, insect protein and algae oil offering potential substitutes to FMFO are also being explored. Differences among scenarios underscore the importance of effective cooperation among countries in reducing the economic impacts of climate change on both the fisheries and aquaculture sectors. FMFO prices are most stable and increase slowest in the GS scenario, which represents a more a cooperative global society better equipped to moderate the supply and demand of goods including alternative feed. The GS scenario also assumes that society reduces carbon emissions and implements mitigation measures to capture carbon, reducing global warming by 2100 and helping maintain the productivity of SPF stocks.

Solutions

In discussions with stakeholders in both the aquaculture and fisheries industries, CERES identified a large number of management measures and options available for transformative adaptation, measures that not only reduce negative effects but that enhance potential opportunities stemming from climate change. These measures include prevention, adaptation, control and compensation. Aquaculture has shown to have a greater variety of innovation measures compared to fisheries. This reflects the fact that aquaculture is subject to more controls and also has more scope for technological advances (in engineering, siting, infrastructure and related to the biology of its farmed fish and shellfish) to cope with the adverse consequences of climate change.

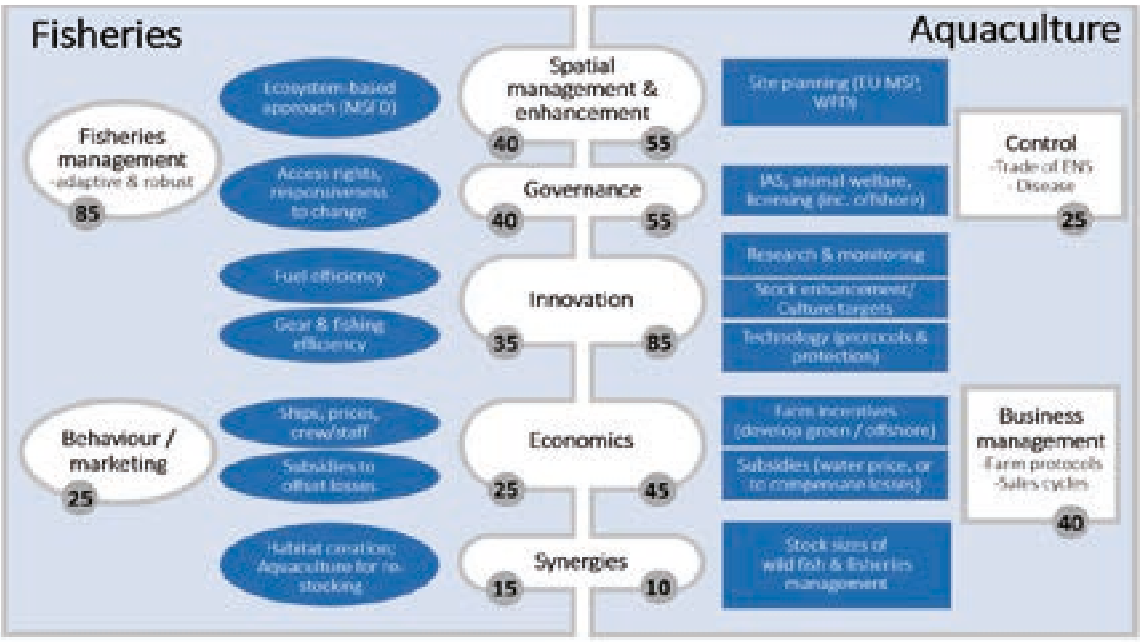
Three compensation measures were identified including compensating the users, the resource (fish and shellfish) and the environment (habitats). A second type of compensation raised by stakeholders was that for the resource, i.e., compensating the stock being fished or farmed. This will involve breeding and restocking and release programmes for suitable species. The third type of compensation, of enhancing the environment by recreation and restoration was raised but is of less relevance in the present context.

A summary of adaptation measures needed in light of the ongoing and projected changes in the climate, highlights both similarities and differences between fisheries and aquaculture. An integrated approach, encompassing both top-down demands (by governance) and bottom-up responses (by stakeholders) and covering technology, economics, governance and societal and industrial behaviours, is required to tackle the challenges posed by climate change to both sectors (Figure 3.7). The rigorous conceptual analysis of risk and opportunity assessment and management used by CERES helps to determine suitable adaptation actions. It also showed current and future directions and interactions of legislation at the global, the European and the national levels. Finally, it considered management measures against cumulative and in-combination effects of the various aquatic pressures[80].

A methodological annex briefly clarifying some of the assumptions and methodologies used in producing this section can be found in the methodology section of the report (see Annex 3.3)

[80] Lonsdale, J. A., Nicholson, R., Judd, A., Elliott, M., & Clarke, C. (2020). A novel approach for cumulative impacts assessment for marine spatial planning. Environmental Science & Policy, 106, 125-135.

Figure 3.7 Measures needed for transformative adaptation of the fisheries and/or aquaculture sectors in light of ongoing climate change.



Notes: Measures stem from stakeholder dialog within 24 'Storylines' (12 region- and sector-specific examples for fisheries and aquaculture). For each measure (white symbols), the number is the percentage (%) of applicable Storylines.
Source: CERES Project

3.4. CLIMATE CHANGE ADAPTATION COSTS: PROTECTING EUROPE'S COASTS AGAINST RISING SEA LEVELS

Around one third of the EU population lives within 50 km of the coast. Damage from coastal flooding in the EU currently amounts to €1 billion annually, which is equivalent to around 0.01% of current EU GDP. France is the country currently experiencing the most damage (€0.2 billion annually). Around 72 000 people in the EU are exposed to coastal flooding every year.

Extreme sea levels in EU could rise by as much as one meter or more by the end of this century. Without mitigation and adaptation measures, annual damage from coastal flooding in the EU could increase sharply to almost €814 billion by 2100, with at least 3 million EU citizens affected by coastal flooding. Around 95% of these impacts could be avoided through moderate mitigation and by raising dykes where human settlements and economically important areas exist along the coastline. The extent to which adaptation can lessen the effects of coastal flooding and at what cost (and benefits) is a sensitive issue. This investment strategy is analysed in this section.

3.4.1. EU COASTAL FLOOD RISK AND PROTECTION MEASURES

The coastal zone is an area of high interest. At present, more than 200 million European citizens live near coastlines, stretching from the North-East Atlantic and the Baltic to the Mediterranean and Black Sea[81]. Coastal areas often host important commercial activities and also support diverse ecosystems that provide important habitats, protection against sea level rise and sources of food. Coastal zones are particularly vulnerable to climate change due to the combined effects of sea level rise due to global warming and potential changes in the frequency and intensity of storms due to extreme weather events. Global mean sea level has increased by 13-20 cm since pre-industrial times[82]. This process has accelerated since the 1990s[83] and the rise after 1950 can be explained by global warming[84]. This has already contributed to coastal recession[85] and has made Europe's coasts more sensitive to coastal hazards. The continued rise in sea levels along Europe's coastlines in view of global warming could result in unprecedented coastal flood losses if no additional coastal protection and risk-reduction measures are implemented.

There exists a range of possible adaptation measures to increase the resilience of future coastal societies to flooding. These include natural (dunes) and artificial (dykes) structures, beach nourishment, forecasting and warning systems, flood proofing of infrastructures, and a retreat from high-risk areas. Accommodating

[81] For details about the distribution of population across Sea Basins, see the EU Blue Economy Report 2019, p. 114.
[82] Kopp, R. E. et al. (2016) Temperature-driven global sea-level variability in the Common Era. Proceedings of the National Academy of Sciences 113, E1434, doi:10.1073/pnas.1517056113.
[83] Watson, C. S. et al. (2015).Unabated global mean sea-level rise over the satellite altimeter era. Nature Clim. Change 5, 565-568, doi:10.1038/nclimate2635
[84] Slangen, A. B. A. et al. (2014). Projecting twenty-first century regional sea-level changes. Clim. Change 124, 317-332, doi:10.1007/s10584-014-1080-9.
[85] Mentaschi, L., Vousdoukas, M. I., Pekel, J.-F., Voukouvalas, E. & Feyen, L. (2018). Global long-term observations of coastal erosion and accretion. Scientific Reports 8, 12876, doi:10.1038/s41598-018-30904-w.

flood hazards is an option, which involves making infrastructure less sensitive to flood damage. Nature-based solutions have recently gained attention as they can be more effective, low-cost and environmentally sustainable ways to protect and maintain coastlines[86]. Mangroves and sea grass attenuate waves, while water flow and flooding[87] reduce storm-water runoff, and help build-up coasts by contributing to the processes that generate, trap, and distribute sediment across shorelines[88]. In a similar manner, reefs can also reduce shoreline erosion[89].

Despite the multiple co-benefits of nature-based solutions, estimates of their costs, and long-term performance are lacking. Moreover, many of the tested approaches (e.g. reefs, mangroves) have limited applicability in Europe. Along developed coastlines, hard protection measures are currently the only strategy with demonstrated effectiveness against coastal extreme events and sea level rise. Dyke or seawall reinforcement has been the most common practice for decades, despite the fact that hard protection can affect the landscape in a negative way, increase erosion, reduce amenity value and result in more catastrophic events in case of failure. A possible alternative strategy is relocating dwellings and infrastructure in order to reduce coastal flood risk, but relocation is often challenging due to technical issues or public opposition. Moreover, the nature of some critical assets, like ports and power plants, is directly linked to their presence close to the sea, and therefore their relocation is particularly challenging.

The present chapter focuses only on the cost effectiveness of raising the height of flood defences using traditional approaches. It assumes that the cost variation of implementing alternative solutions would lie within the uncertainty intervals of the present cost estimates[90].

3.4.2. IMPACT ESTIMATES WITHOUT CLIMATE CHANGE ADAPTATION

The coastal hazard analysis projects a very likely increase of the European average 100-year extreme sea level of 34–76 cm under a moderate mitigation scenario, and of 58–172 cm under a high emissions scenario[91]. Sea level rise is the main driver of this strong increase, yet in many regions in Europe there is also a contribution of intensified coastal storms.

At present, coastal flood losses in the EU amount to €1 billion/year (expressed in 2015 € values), and each year about 72 000 EU citizens are exposed to coastal inundation[92]. France is the country with the highest current exposure to coastal flooding, both in terms of losses and people exposed. Flood risk is projected to increase strongly in the EU with global warming. In the absence of further investments in coastal adaptation, annual coastal flood losses for the EU are projected to grow to €18.9 billion and €32.3 billion by mid-century for Representative Concentration Pathways RCP4.5 and RCP8.5, respectively (Table 3.3). In the second half of this century, the rise in coastal flood risk further accelerates and by 2100 annual coastal flood losses are projected to reach €1 36.9 billion and €814 billion, respectively. Therefore, the moderate mitigation scenario would reduce the economic damages by more than 80 % compared to the high emission scenario. The total number of people exposed to coastal flooding in Europe is projected to rise to between 1.2 and 3.1 million people per year by 2100 under RCP4.5, and RCP8.5, respectively (Table 3.4). Coastal flood risk will increase in all EU MS that have a coastline, with France, Italy and Denmark showing the highest absolute increase in coastal flood impacts towards the end of the century. For some countries, coastal flood losses at the end of this century could amount to a considerable share of their GDP, especially under a high-emissions pathway (RCP8.5), most notably in Cyprus (4.9 %), Greece (3.2 %), Denmark (2.5 %), Ireland (1.8 %) and Croatia (1.8 %).

At any specific point in time, impacts under the high emissions scenario are always larger than under the moderate mitigation scenario, and they grow much faster with time under the high-emissions pathway. This indicates that climate change mitigation is effective in reducing future coastal flood risk.

3.4.3. COSTS AND BENEFITS OF ADAPTATION

The costs and benefits of raising dykes show high spatial variability between coastal segments. Overall, benefits exceed costs for 23.8 % and 32.3 % of the European coastline segments under a moderate mitigation and high emissions scenario, respectively (Table 3.5). Thus, present natural or hard shoreline protection is economically optimal for 76 % and 67 % of the European coastline, under a moderate mitigation and high emissions scenario, respectively. No economic motivation for increased protection can be related to several factors, like natural barriers with steep morphology that sufficiently protect against a projected extreme sea level rise. In sparsely populated coastlines, benefits (avoided damage) are low because of the limited exposure. Also, long and complex coastlines imply higher dyke construction costs, hence lower benefit to cost ratio (BCR) values, such as in many parts of Finland, Sweden, Estonia, and Croatia. Most of the Baltic is experiencing an uplift and therefore relative sea level rise is lower compared to other parts of Europe, implying also lower future losses and potential benefits of adaptation for a significant part of Finland and Sweden. The presence of human settlements renders rapid adaptation economically profitable, with benefits tending to outweigh costs in areas where population density is larger than 500 people per km^2. In urbanised and economically important areas the benefits tend to be several times the costs.

86 Temmerman, S. et al. (2013). Ecosystem-based coastal defence in the face of global change. Nature 504, 79, doi:10.1038/nature12859.
87 Thomas, R. E. et al. (2014). Physical modelling of water, fauna and flora: knowledge gaps, avenues for future research and infrastructural needs. J. Hydraul. Res. 52, 311-325, doi:10.1080/00221686.2013.876453.
88 Lentz, E. E. et al. (2016). Evaluation of dynamic coastal response to sea-level rise modifies inundation likelihood. Nature Clim. Change 6, 696–700, doi:10.1038/nclimate2957.
89 McAdoo, B. G. et al. (2011). Coral reefs as buffers during the 2009 South Pacific tsunami, Upolu Island, Samoa. Earth-Science Reviews 107, 147-155, doi:10.1016/j.earscirev.2010.11.005.
90 For details about the methodology, see the Annex.
91 Vousdoukas, M. I. et al. (2018). Global probabilistic projections of extreme sea levels show intensification of coastal flood hazard. Nature Communications 9, 2360, doi:10.1038/s41467-018-04692-w.
92 Vousdoukas, M. I. et al. (2018). Climatic and socioeconomic controls of future coastal flood risk in Europe. Nature Climate Change, doi:10.1038/s41558-018-0260-4.

Table 3.3 Expected Annual Damage (EAD), from coastal flooding in 2100, € billion

Member State	Scenario		
	Baseline	Moderate Mitigation	High Emissions
BE	0.0	4.5	20.7
BG	0.0	0.1	0.6
CY	0.0	1.4	12.5
DE	0.1	6.0	38.8
DK	0.0	8.9	84.6
EE	0.0	0.1	0.6
ES	0.1	9.4	53.0
FI	0.0	0.3	6.2
FR	0.2	40.4	266.0
EL	0.1	4.9	20.8
HR	0.0	0.9	2.5
IE	0.1	14.5	89.1
IT	0.1	15.3	70.3
LT	0.0	0.2	0.4
LV	0.0	0.1	0.2
MT	0.0	0.0	0.0
NL	0.0	20.7	77.5
PL	0.1	2.3	9.3
PT	0.1	2.2	8.7
RO	0.0	0.1	2.8
SE	0.0	4.2	46.2
SI	0.0	0.7	2.9
EU27	1.0	136.9	814

Source: Commission Services based on The EU Blue Economy Report 2020

Table 3.4 Expected Annual Population Exposed (EAPE) to coastal flooding in 2100, thousand people

Member State	Scenario		
	Baseline	Moderate Mitigation	High Emissions
BE	0.5	0	5
BG	0.6	2	3
CY	3.0	10	16
DE	2.0	31	113
DK	1.0	101	433
EE	0.1	0	1
ES	8.1	216	489
FI	0.5	3	57
FR	3.5	180	504
EL	10.7	100	175
HR	9.2	36	49
IE	3.1	122	306
IT	12.7	312	624
LT	1.3	4	5
LV	0.2	0	1
MT	0.0	0	0
NL	0.6	1	10
PL	9.9	21	53
PT	2.6	16	40
RO	0.5	2	4
SE	0.5	47	211
SI	2.4	12	19
EU27	73	1,214	3,117

At country level, Belgium is the country with the highest percentage of coastline where benefits exceed costs (85 % and 95 %, under moderate mitigation and high emissions scenario, respectively), followed by France (58 %, 66 %), and Italy (53 %, 59 %) (Table 3.5). These are also countries with some of the highest expected BCRs, varying within 16.6-25.8, 10.5-24.8, and 9.7-16.4, respectively (range expresses variation among scenarios; Table 3). Other countries with high BCR values are the Netherlands (Expected BCR between 21.1 and 34.3), Cyprus (11.1-15.6), Ireland (8.8 and 18.7), and Greece (9-11) (Table 3.5). On the lower end of the analysis is Malta, for which the expected country level BCR is the lowest in Europe: 1.6-1.7, depending on the scenario. Other countries with low BCR values are Bulgaria (expected BCR equal to 2-2.1), Lithuania (2-2.1), Latvia (1.8-2.1) and Croatia (1.9-2.3). Since the Fossil fuel based development combines strong increase in Extreme Sea Levels (ESLs) with socio-economic growth, the resulting BCRs are higher, for some countries over double compared to the other scenario (e.g. France, Ireland, Sweden, Denmark, and Finland). The mean expected BCR for Europe is 8.3 (likely range: 6.1-17.5) and 14.9 (12.3-29.6), under moderate mitigation and high emissions, respectively.

The estimated average annual investment for further dyke improvements in the EU during this century (over period 2020-2100, without discounting) is €1.1 billion/year for the moderate mitigation and €1.8 billion/year for the high emissions scenario, with the latter being larger due to additional protection needed against higher extreme sea levels (Table 3.6 and Figure 3.9). Country level adaptation costs depend on the value of assets and the coastline length, with France (€269-385 million/year), Italy (€180-261 million/year), and Germany (€125-230 million/year) facing the highest projected costs (Table 3.6). Other countries with substantial costs for dyke reinforcement are Ireland, Spain, Greece and the Netherlands (above €40 million/year).

Considering only the locations where further protection is economically beneficial, the additional average coastal defence height needed in Europe is 90 and 100 cm under the moderate mitigation and high emissions scenario, respectively (Table 3.6). Country average values vary from a minimum of 42 cm (Malta) to a maximum of 2.8 m (Belgium).

When benefits and costs are analysed at NUTS2 regions, raising dykes mostly benefits the areas with urban centres. The BCR of regions are mapped in Figure 3.8, and they give an indication of how much the benefits exceed the adaptation costs for the region, once the benefits and costs of the coastal segments where adaptation is economically beneficial are aggregated to the regional level. High BCR values do not necessarily imply that the entire regional coastline should be protected because the cost-benefit analysis is made at the segment level. The regional (as well as the country and EU) BCR value therefore is more an indication to assess the degree to which some regions (or countries/EU) experience gains in terms of avoided damage much greater than the incurred adaptation costs. Adaptation comes with far stronger economic benefits in Puglia, IT (BCR 17 and 49 under Sustainability and Fossil fuel based development, respectively), Murcia, ES (15 and 37), Loire, FR (8 and 44), Languedoc-Roussillon, FR (10 and 42), and Basque region, ES (13 and 33).

POINTS FOR CONSIDERATION

EU coastal zones will severely be exposed to the effects of climate change. Extreme sea levels in Europe could rise by as much as one metre or over by the end of this century, and will very likely continue to rise in the future.

If no climate action is taken, global warming will result in an unprecedented rise in coastal flood impacts.. Rising sea levels,

Table 3.5 Percentage of the country's coastline where further protection is economically beneficial.

Member State	% no adaptation		Country BCR	
	moderate mitigation	high emissions	moderate mitigation	high emissions
BE	85.0	95.0	16.8	25.8
BG	5.4	8.9	2.0	2.1
CY	22.9	27.5	11.1	15.6
DE	22.1	43.0	3.6	6.2
DK	22.8	48.3	3.0	6.9
EE	0.5	1.5	2.1	2.5
ES	46.9	56.2	8.1	15.2
FI	2.1	16.5	1.7	3.3
FR	58.3	66.3	10.5	24.9
EL	10.7	12.8	9.0	10.6
HR	8.3	10.4	1.9	2.3
IE	18.7	28.6	8.9	18.6
IT	52.6	59.1	9.7	16.4
LT	4.9	9.8	2.1	2.0
LV	3.2	3.2	2.1	1.8
MT	6.7	13.3	1.6	1.7
NL	40.1	40.8	21.1	34.5
PL	24.6	30.7	3.9	4.5
PT	32.7	43.5	6.7	9.1
RO	3.3	16.4	2.4	2.1
SE	11.7	23.4	5.4	10.9
SI	50.0	50.0	3.7	6.0
EU27	**23.8**	**32.3**	**8.3**	**14.9**

Notes: the last two columns show the country level benefit to cost ratio (BCR) with adaptation only in the coastal segments where it is economically beneficial.
Source: Commission Services based on The EU Blue Economy Report 2020

Table 3.6 Annual costs per country of raising the dykes where adaptation is economically beneficial (average over period 2020-2100) and corresponding country-level average increase in dyke height.

Member State	Annual cost of protection (€ million, undiscounted)		Dyke height increase (m)	
	Moderate mitigation	High emissions	Moderate mitigation	High emissions
BE	32.0	32.9	2.8	3.4
BG	1.1	2.4	0.6	0.7
CY	8.3	12.6	0.8	1.0
DE	125.5	229.6	1.4	1.4
DK	90.2	224.1	0.9	1.0
EE	0.8	1.5	1.4	1.0
ES	93.1	148.7	0.6	0.8
FI	6.2	43.0	0.8	0.8
FR	269.7	385.0	0.9	1.1
EL	46.2	65.0	0.7	0.8
HR	8.9	14.4	0.5	0.6
IE	75.5	135.3	0.9	1.0
IT	180.3	260.9	0.7	0.9
LT	1.6	2.5	1.2	1.0
LV	0.3	0.9	0.8	1.3
MT	0.2	0.5	0.3	0.4
NL	64.7	56.3	1.5	1.3
PL	37.7	49.7	1.6	1.7
PT	26.2	37.0	1.0	1.0
RO	0.8	6.1	0.6	0.9
SE	27.4	91.6	0.7	0.9
SI	8.7	9.3	2.1	2.3
EU27	**1,106.2**	**1,808.4**	**0.9**	**1.0**

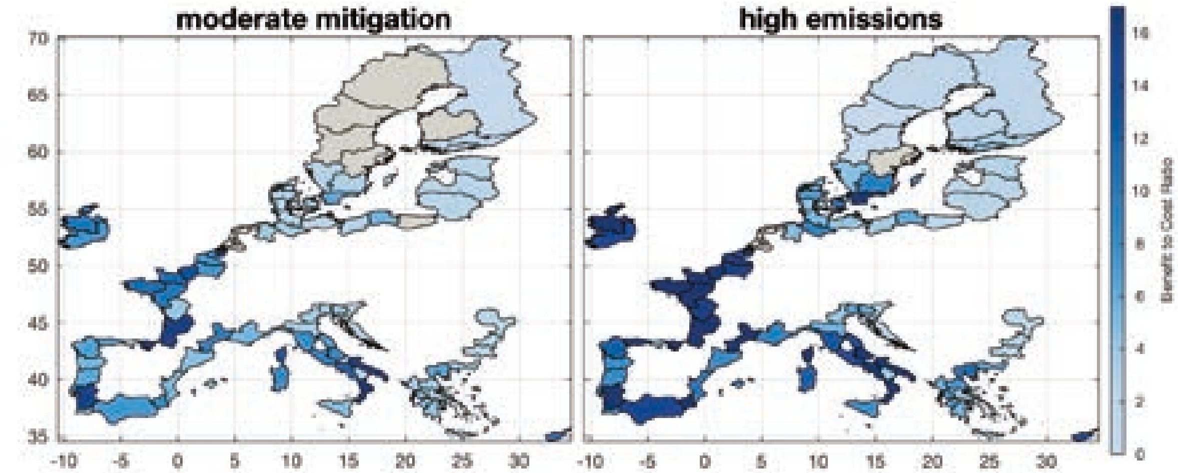
Source: Commission Services based on The EU Blue Economy Report 2020

more intense coastal storms and global warming are the key drivers of the rise in coastal flood risk, while the absolute magnitude of the impacts is further amplified by the projected rise in economic activity in coastal areas. In this context, this analysis indicates that:

Climate change mitigation is effective in reducing future coastal flood risk in the EU. The projected impacts by 2100 under a moderate mitigation scenario are less than 20% of those without climate mitigation. Even in the case of mitigation, the rise in coastal flood losses could be so pronounced that where human life may be at high density and at risk, the use of hard defence elements may be all too necessary.

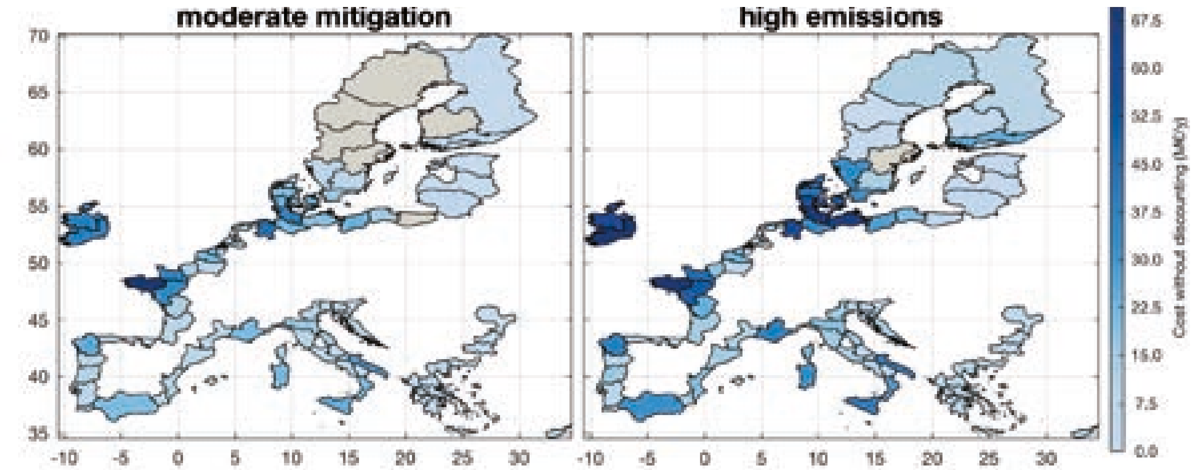
Adaptation by strengthening protection measures along EU coastlines is highly cost-effective to reduce future coastal impacts. Rising dykes could prevent up to 98% of economic damage by the end of the century and nearly 700 000 fewer EU citizens would

Figure 3.8 Benefit to cost ratios per NUTS2 region



Notes: Grey colours express areas where the present protection provides sufficient protection.
Source: Commission Services based on The EU Blue Economy Report 2020

Figure 3.9 Average annual costs of adaptation, € million per year per NUTS2 region



Notes: Grey colours express areas where the present protection provides sufficient protection.
Source: Commission Services based on The EU Blue Economy Report 2020

be exposed to coastal flooding. The average annual undiscounted investment from now until the end of the century would be lower than €2 billion/year, while the annual undiscounted benefit (avoided flood damage) in 2100 would be nearly €800 billion/year (for the high emissions scenario), as summarised in Figure 3.10 and Figure 3.11.

Applying optimal protection in economic terms will leave European citizens exposed to coastal flooding where the avoided damage does not outweigh the costs. Therefore, designing adaptation measures to rising extreme sea levels and storm surges on the basis of economic criteria alone may not be the optimal strategy. Shoreline length applies a critical control on the costs of dyke improvements. In areas with highly fractal coastlines, like Finland and Sweden, costs could be substantially reduced by installing defences further inland, without following the shoreline shape in all its detail.

Strategic foresight: The projections and results from this analysis call for the development of coastal regions to be planned integrating the impacts of rising sea levels. In this context, Maritime Spatial Planning can offer a coherent framework to combine both hard defence and nature-based solutions integrated alongside a continuous, iterative and dynamic planning process that is based on the best available evidence (including environmental impact and risk assessments, scientific data, sectorial information and local knowledge).

Nature-based solutions: This study focuses only on the costs and benefits of hard measures protection. Nature-based solutions have shown the capacity to mitigate erosion and flood risk under current sea levels, yet there is no solid evidence about their effectiveness to protect European coastal communities against the expected rise in sea level extremes. However, this does not exclude the parallel implementation of more sustainable environmental practices to enforce the physical and ecological resilience of coastal zones.

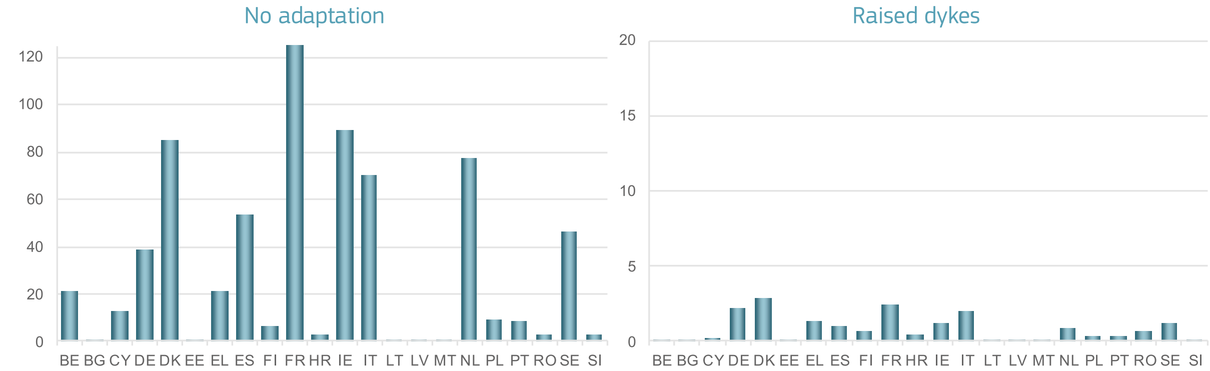
Dealing with uncertainty and different policy objectives: Future projections of coastal hazards, as well as dyke costs, come with uncertainty. The above assesses the adaptation option that optimises the benefits vs. costs considering the most likely case.

Figure 3.10 EU-27 annual damages and population exposed to coastal flooding in present and by 2100 under two emissions scenarios, with and without adaptation respectively.

	Today	High emissions		Moderate mitigation	
		No adapt	Adapt	No adapt	Adapt
Damages (€ billion/year)	1.0	814	18	137	6
People exposed (million/year)	0.07	3.1	0.7	1.2	0.4

Notes: For adaptation, dykes are raised to a level of protection that maximizes their economic benefit. High emissions correspond to RCP8.5 combined with socioeconomic projections from SSP5 (fossil-fuelled development). Moderate mitigation corresponds to RCP4.5 combined with AAP1 (sustainability).
Source: Commission Services based on The EU Blue Economy Report 2020

Figure 3.11 Flood damage under a high emissions scenario in 2100, € billion per year



Notes: Value for France without adaptation: €266 billion a year.
Source: Commission Services based on The EU Blue Economy Report 2020

However, stakeholders may opt for a more conservative criterion and optimise adaptation investments in view of high-end, less probable future scenarios, under which flood impacts might be higher. Such a choice might result in higher adaptation costs, but would also imply fewer risks for future generations, as the analysis would prioritise protection against the rarer and more catastrophic events.

Benefits for our future generations: Sea levels are projected to increase long after 2100 and likely at an accelerating rate. Hence, although the impact and cost-benefit analysis is limited up until 2100, adaptation measures taken now could also lower flood risk during the 22nd century and beyond. Considering longer time spans, the benefits of raising dyke heights for future generations are therefore much higher than estimated herein.

A methodological annex briefly clarifying some of the assumptions and methodologies used in producing this chapter can be found in the methodology section of the report (see Annex 3.3)

3.5. MARINE POLLUTION

Marine pollution, as a side effect from human activities, is threatening the health of the marine environment and the use of the seas for commercial and recreational activities. Indeed, pollution is also one of the main drivers for the loss of marine biodiversity. The Biodiversity Strategy[93] aims to halt the loss of biodiversity and ecosystem services in the EU and help stop global biodiversity loss by 2020. A new post 2020 strategy and a zero pollution action plan are currently being developed and includes reverting marine biodiversity loss.

Marine pollution concerns different types of pollutant input to the Seas, such as chemical and toxic substances (including oil spills and sulphur pollution), plastics and nutrients, but also underwater noise and other inputs from energy. The EU MSFD[94] defines marine pollution as the direct or indirect introduction into the marine environment, as a result of human activity, of substances or energy, including human-induced marine underwater noise, which results or is likely to result in deleterious effects such as harm to living resources and marine ecosystems, including loss

[93] COM(2011)244. *Our life insurance, our natural capital: an EU biodiversity strategy to 2020.* Communication from the Commission to the European Parliament, the Council, the Economic and Social Committee and the Committee of the Regions. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52011DC0244.

[94] EU 2008 MSFD — DIRECTIVE 2008/56/EC of 17 June 2008 establishing a framework for community action in the field of marine environmental policy (Marine Strategy Framework Directive).

of biodiversity, hazards to human health, the hindering of marine activities, including fishing, tourism and recreation and other legitimate uses of the sea, impairment of the quality for use of sea water and reduction of amenities or, in general, impairment of the sustainable use of marine goods and services.

The MSFD, in connection with the WFD provides a framework for the management of marine pollution. Within the EU Circular Economy Package, a Communication on the EU Strategy for Plastics in a Circular Economy provides the framework for protecting the environment from plastic pollution whilst fostering growth and innovation[95]. Originating from the EU's Plastic Strategy, in 2019 the EU adopted new EU-wide rules targeting the 10 single-use plastic products most often found on Europe's beaches and seas, as well as lost and abandoned fishing gear[96].

Thus, pollution can occur as an intentional disposal of chemicals and waste, e.g. through waste water outlets, waste mismanagement, littering, or dumping. The introduction can be direct, from ships or other activities at sea, as well as from coastal or inland sources, transported by rivers to the sea. The discarding of litter into the seas has been recognised as a threat to the environment and to the undertaking of human activities[97]. Also, long-range airborne introduction of contaminants, e.g. pesticides and microplastics, through deposition and atmospheric wash-out contribute to the pollution of the marine environment.

Different pollution types have different sources, environmental pathways and impacts. The introduction of persistent, toxic chemical substances, which can bioaccumulate, eventually leads to high contamination levels even if the emissions occur at low concentration levels, e.g. through atmospheric input or from diffuse sources. These include heavy metals, POPs (Persistent Organic Pollutants) and other chemical substances of concern. Eutrophication is most often caused by human activity like farming and other activities that can lead to fertilizer run off into aquatic systems due to an overabundance of nutrients. A communality of different types of marine pollution is the role of the Seas and Oceans as final sinks, where re-concentration and accumulation of pollutants, including litter and chemical contaminants can occur. Different types of pollution can be interlinked, as e.g. plastic material often contain additives (such as plasticisers, colorants, etc.) thereby constituting an additional pathway for these substances to enter the marine environment.

The relation between the economy and marine pollution is complex, as economic activities may result in pollution, while pollution also hinders economic activities. The factors to be considered include costs for prevention, clean-up, reduction or cessation of pollution, costs causing socioeconomic harm and the harm to wildlife and human wellbeing, which often cannot be expressed in monetary terms.

In order to support informed decisions and sustainable economic developments, to foster innovation and to protect the marine environment, public authorities need data which are comparable, of sufficient coverage (temporal and spatial) and of adequate quality ("fit-for-purpose"). This concerns data on environmental occurrences, sources, pathways and impacts of pollution on environment, such as production volumes, consumption, losses and the respective costs associated with the different elements of the product life cycles.

3.5.1. THE EU CHEMICALS AND PLASTICS INDUSTRY

In 2018, the European chemicals industry sold chemicals worth €565 billion. Of the total production, 25.4 % were petrochemical products, 27.2 % were speciality chemicals, including paints and inks, crop protection products, dyes and pigments, and 21.3 % were plastic, synthetic rubber and man-made fibres[98].

In 2017, in the EU-28, Norway and Switzerland, the total demand for plastic amounted to about 51 million tonnes, divided among the packaging sector (39.7 %), the building and construction sector (19.8 %), the automotive sector (10.1 %), the electrical and electronics sector (6.2 %), the households, leisure and sports sector (4.1 %), the agriculture sector (3.4 %) and other sectors (16.7 %), according to Plastics Europe. The European plastic industry is made up of about 60 000 companies, with a turnover of close to €355 billion in 2017, which offer direct employment to over 1.5 million people. About 64 million tonnes of plastic were produced in the EU-28, Norway and Switzerland in 2017[99].

Industrial sectors directly linked to marine activities and potentially contributing to pollution include shipping, marine resource exploitation such as offshore oil and gas extraction, tourism, coastal industries, fishing and aquaculture. While often the relation between production and losses is unknown, certain materials are produced to be used in marine environment. According to estimations, between 4.8 and 12.7 million metric tonnes of lost plastic waste enter the marine environment every year[100].

3.5.2. COSTS RELATED TO MARINE POLLUTION

Potential impacts on the marine environment from the production, use and disposal of chemicals, including anthropogenic polymers and the products can be direct but also indirect, e.g. through the impact of CO_2 emissions and the non-sustainable use of natural resources. Likewise, economic sectors relying on clean and healthy seas as a resource for production, harvesting and recreation suffer negative direct and/or indirect impacts. A sustainable blue economy aims to avoid the pollution caused through the production and use of chemicals (and related products). It also seeks to facilitate the transition towards a circular economy in the context of the European Green Deal.

For the analysis of present costs, expenses, and loss of benefits, which are supported by society and related to the anthropogenic degradation of the marine environment, the four following categories may be useful:

95 EU. (2018). Plastics Strategy Communication — A European Strategy for Plastics in a Circular Economy {SWD(2018) 16 final}.
96 Directive (EU) 2019/904 of the European Parliament and of the Council of 5 June 2019 on the reduction of the impact of certain plastic products on the environment.
97 EU. (2018). Staff working document: SWD (2018)254: COMMISSION STAFF WORKING DOCUMENT IMPACT ASSESSMENT Parts 1-3.
98 CEFIC. (2020) Cefic Facts & Figures.
99 EEA. (2019). The plastic waste trade in the circular economy doi: 10.2800/220248.
100 Jenna R Jambeck, et al. (2015). Plastic waste inputs from land into the ocean, Science 347(6223):768-771, DOI 10.1126/science.1260352.

- Opportunity costs (i.e. loss of benefits due to environmental degradation)
- Mitigation costs: aimed at protecting the human population and ecosystems against the negative effects from environmental degradation (e.g. beach cleaning).
- Prevention costs, and other costs related to reducing pollutant emissions and dispersion (e.g. waste water treatment plants, changes in agriculture processes etc.)
- Transaction costs: aimed at improving coordination levels (e.g. pollution monitoring, control, communication, etc.)

As an example, UN Environment estimated the total natural capital cost to marine ecosystems from plastic littering damage to be at $13 billion per year[101] globally.

3.5.3. DATA ON MARINE POLLUTION

The implementation of the Marine Strategy Framework Directive[102] has led to an increased availability of data on contaminants, nutrients, underwater noise and marine litter in the EU. A common set of priority contaminants has been agreed through the EU Water Framework Directive[103] and specific substances stemming from human activities in the marine environment have been identified[104]. Top beach litter items in Europe were identified (see Figure 3.12) from a pan-European data collection exercise[105]. The first baselines on marine beach macro litter[106] have been derived and enable the quantitative prioritisation of efforts as well as the verification of the successful implementation of measures. An average of 58 litter items per 100 m coastline related to single-use plastics and 22 litter items per 100 m coastline related to fisheries of a total of 149 litter items per 100 m coastline as averages from 1 472 beach litter surveys in EU, indicate the magnitude of the problem and provide information on specific litter items enabling prioritisation in measures for reduction.

As regards underwater noise, the work implemented at the EU and the regional levels through the Technical Group on Noise, focused on monitoring issues and was closely related to activities undertaken in Regional Seas Conventions (RSC). Such work included the publishing of monitoring guidance for underwater noise in European Seas[107]. It also comprises the setting up of a register of loud impulsive noise and the development of a joint monitoring programme for continuous noise in the North and Baltic Seas.

The need for availability of large scale databases providing harmonised datasets on marine pollution has been recognised and the EMODNET chemistry module is providing a data portal for this very purpose.

Currently, data on industrial losses and waste stream leakages continues to be difficult to access, due to the lack of legislation for identification, quantification and reporting. While there is information on the different types of waste treatment (Figure 3.13), losses are not reported.

Figure 3.12 The most common litter types and beach litter composition in the EU

Source: European Commission (2018): A European Strategy for Plastics in a Circular Economy (SWD(2018) 16 final).

Case study: initiatives addressing plastics and micro-plastic pollution

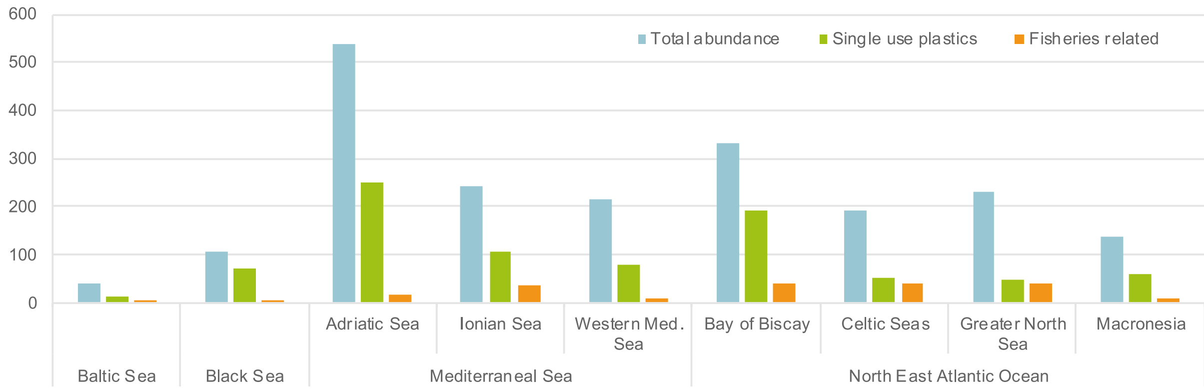
Ongoing research and innovation in national and regional programmes financed through the smart specialisation include a few initiatives directly focusing on micro-plastic pollution. This should be attributed to the novelty of micro-plastics research that has not yet evolved to market-oriented solutions. To highlight the challenge, potential and opportunity in plastics and micro-plastics pollution prevention, three examples are presented, which developed certain practical solutions that could lead to measurable impacts. All three cases have benefited from support from EU financing and programmes.

Overview of ERDF operations targeting micro-plastic pollution (2014 to 2019)

Out of the more than 120 000 operations co-funded by the ERDF from 2014 to 2019 across EU regions, 161 tackle plastic or micro-plastic pollution (directly or not)[109]. In total, this represents an EU contribution of €54 million. The average ERDF operation is at €336 000 with projects holders (beneficiaries) coming from public research organisations to private, large or small, companies (Figure 3.14).

101 UNEP. (2014). Valuing Plastics: The Business Case for Measuring, Managing and Disclosing Plastic Use in the Consumer Goods Industry.
102 EU. (2008). MSFD – Directive 2008/56/EC of 17 June 2008 establishing a framework for community action in the field of marine environmental policy (Marine Strategy Framework Directive).
103 EU. (2000).
104 Tornero, V., Hanke, G. (2016a). Chemical contaminants entering the marine environment from sea-based sources: a review with a focus on European seas. Marine Pollution Bulletin 112, 17-38. Tornero, V., Hanke, G. (2016b). Identification of marine chemical contaminants released from sea-based sources: A review focusing on regulatory aspects. JRC Technical Report EUR 28039. Luxembourg (Luxembourg): Publications Office of the European Union; doi:10.2788/258216.
105 Addamo A.M., Laroche P., Hanke G. (2017). Top Marine Beach Litter Items in Europe, EUR 29249 EN, Publications Office of the European Union, Luxembourg, ISBN 978-92-79-87711-7, doi:10.2760/496717.
106 Hanke G. et al. (2019). EU Marine Beach Litter Baselines, EUR 30022 EN, Publications Office of the European Union, Luxemburg. ISBN 978-92-76-14243-0, doi:10.2760/16903.
107 https://ec.europa.eu/jrc/en/publication/eur-scientific-and-technical-research-reports/monitoring-guidance-underwater-noise-european-seas-part-ii-monitoring-guidance.
108 Hanke G. et al. (2019).
109 The selection of the relevant operations is based on keywords search in the titles and operations' descriptions using the main keyword "plastic" or "micro-plastic" combined another one such as "waste", "pollution", "textile", "packaging", "recycled", "bio".

Figure 3.13 The median abundance (items/survey) of litter types on beaches in EU in 2015-2016[106]



Notes: "Ionian sea" includes the Central Mediterranean Sea; "Bay of Biscay" includes the Iberian Coast; "Great North Sea" includes the Kattegat and the English Channel.
Source: JRC (2019). EU Marine Beach Litter Baselines.

BOX 3.2: INITIATIVES ADDRESSING PLASTICS AND MICRO-PLASTICS POLLUTION

The Great Bubble Barrier

The Great Bubble Barrier[110] is a Dutch start-up company that developed an innovative bubble barrier for removing plastics from rivers and canals. A bubble curtain created by pumping air into water redirects micro and macro debris toward a point where it can be removed from the water. It is compatible with wildlife, shipping or other uses of water bodies. A full assessment of microplastic capture is currently being carried out. The technology represents European innovation that will have an impact on keeping plastics out of the environment. The company received EU funding support from different sources (Climate KIC, SME instrument).

PlanetCare

PlanetCare[111] is a Slovenian start-up company that began with the targeted development of filtering solutions aimed at stopping fibre pollution from clothes and textile washing. Synthetic fibres are a major contribution to micro-plastics in the Oceans. In 2019 PlanetCare began the sale of its retrofit filter for domestic washing machines. Through its return-and-reuse scheme for used cartridges the solution is fully circular and fibres are safely removed from the environment. PlanetCare benefited from the Climate KIC programme and is actively involved in the circular economy priority of the Slovenian smart specialisation strategy as well as in extensive international collaboration with European academic and public institutions, NGOs and other stakeholders. The activity is aligned with the demonstration pilot project "Decarbonising Slovenia: A Deep Demonstration of a Circular, Regenerative and Low-Carbon Economy" supported by the EIT Climate KIC, EIT Raw Materials and JRC.

CLAIM[112]

Within the H2020 project "Cleaning Litter by Developing and Applying Innovative Methods in European Seas – CLAIM"[113] a novel photo-catalytic technology is developed using inexpensive zinc-oxide nano-coating that can harness sunlight to degrade micro-plastics into harmless products. The solution is inexpensive compared to alternatives and has proved effective on polyethylene. This is just one of five technologies under development within the project (including filtration, a floating boom, a mobile pyroliser and a plastic debris monitoring device).

The dispersed geographical localisation of projects is explained by the two following main determinants:

- Funding availability. In the context of cohesion policies, there is a more ERDF key funding availability in regions with an inverse proportion in relation to their level of economic development.
- The presence of territorial assets such as companies and/or universities in the field.

The combination of these two factors allows for the identification of some European regions investing in projects related to plastic and micro-plastic pollution using ERDF funding. Regions from Poland, Slovakia, Czechia and Spain represent the largest part of projects. However some 'hotspots' appear in the Netherlands, Italy, the UK and in Ireland (Figure 3.15)

Some of the most important and emblematic projects funded by ERDF, include three to be flagged (each of them receiving more than €3 million of ERDF contribution). The first project implemented by a company based in the region of Silesia (South of Poland) aims

[110] https://thegreatbubblebarrier.com.
[111] https://www.planetcare.org. See also: https://s3platform.jrc.ec.europa.eu/-/jrc-supports-the-project-aiming-at-decarbonising-slovenia-a-deep-demonstration-of-a-circular-regenerative-and-low-carbon-economy.
[112] For more information and R&D projects on the marine litter side see: https://ec.europa.eu/programmes/horizon2020/en/h2020-sections-projects.
[113] https://www.claim-h2020project.eu.

to develop an innovative technology for the recovery of polymer based materials for industrial film production. The second and the third are implemented by Slovak SMEs, and aim to produce PET flakes from non-processed plastic waste and invest in an Industrial R&D Centre for the recovery of the problematic types of plastic waste respectively.

The range of activities and sectors concerned by plastic and micro-plastic pollution financed by the ERDF is broad. A few of these are listed below:

- The creation and development of new bio-based materials to replace plastics (e.g. the Lithuanian project Biokompozito aiming to develop an experimental technology for the production of bio-based plastic);
- The improvement of recycling processes (e.g. the Czech project using thermoplastic adhesive to reuse sandwich packing materials);
- The improvement of the packaging design (e.g. the Interreg project on developing and strengthening cross-sectoral linkages among actors in sustainable bio-composite packaging innovation systems in a Central European circular economy);
- Plastic pollution coming from textile production (e.g. the Spanish R&D project on new textile and plastic waste materials to develop plastic tops with a high content of recycled plastic material with higher technical properties);
- Plastic pollution coming from the agricultural sector (e.g. the Polish project on the development of an innovative facility for the recovery and recycling of plastic packaging of hazardous substances, especially plant protection products).

3.5.4. THE MANAGEMENT OF MARINE POLLUTION

The management of pollution should consider a precautionary principle. Often, potential risks are unknown and subject to a "tragedy of the commons" with the marine environment being particularly sensitive to this. Hence, sources and pathways must be analysed in order to identify the origin of pollution.

Remediation of marine pollution appears almost always impossible. Once emitted into the marine water bodies any approach to reverse the process through remediation and clean-up procedures at large scale is unrealistic. Therefore, preventive measures are crucial. The MSFD requires that quantities or composition of marine litter do not cause harm to the coastal and marine environment; it created the evidence basis for the adoption of the Directive on Single Use Plastics (SUP), which aims to reduce the impact on the marine environment from single use plastic products and from plastic fishing and aquaculture gear. The SUP Directive as well as EU activities on microplastics are follow-up actions of the 2018 Strategy for Plastics adopted by the Commission, which introduced an integrated approach to the production, use and environmental impacts from plastic and products containing it, including an international dimension.

Addressing marine pollution requires holistic and large scale policy frameworks, at a regional, national, and global level, due to the transboundary nature of pollution, spreading by air or ocean currents. The quantitative evidence of harm and of precautionary approaches, require sound scientific data of impact and pollutant occurrence. While the impact of pollution can be delayed and unexpected, synergetic effects can also occur across different types of pollution.

The elements of such assessments include the monitoring of contaminants in the different environmental matrices, such as sediment, water column and biota. Marine Macro Litter (over2.5 cm in largest dimension[114]) is monitored on beaches, in the water surface layer and on the seabed. Selected species are monitored for impact through ingestion and entanglement[115].

In January 2019, ECHA proposed a wide-ranging restriction targeting intentionally added microplastics in products placed on the EU/EEA market, to avoid or reduce their release into the environment[116]. The proposal is estimated to cut down emissions by at least 85 % and prevent the release of 400 000 tonnes of microplastics over the 20-year period following its introduction[117]. Furthermore, besides the reduction of secondary microplastics deriving from the physical degradation of larger items, the input of particles from tyre abrasion or fibres from textiles for instance, has also been recognised.

Impact of measures on production sectors

Measures aiming at the reduction of marine litter are currently re-shaping industries related to production, use and disposal of items known to be a predominant part of marine litter[118]. These include the production and use of single-use plastic and fishery related items, but also infrastructural measures, such as adjustment of port reception facilities and waste management logistics.

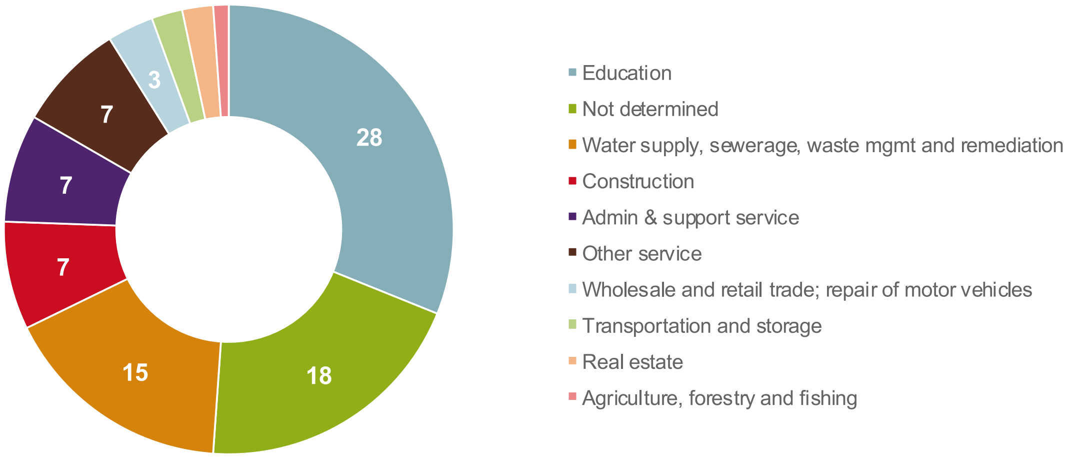
While the use of bio-based materials and, under certain defined conditions "bio-degradable" materials, is being discussed, their use must be preceded by a thorough analysis of their impact not only on the environment, but also on related activities, e.g. in food production.

Transboundary aspects of marine pollution

As the marine environment is connecting countries through ocean currents, the impact of marine pollution can occur even far from its origin. International cooperation at different levels is therefore essential. Besides collaboration within the EU, it requires action

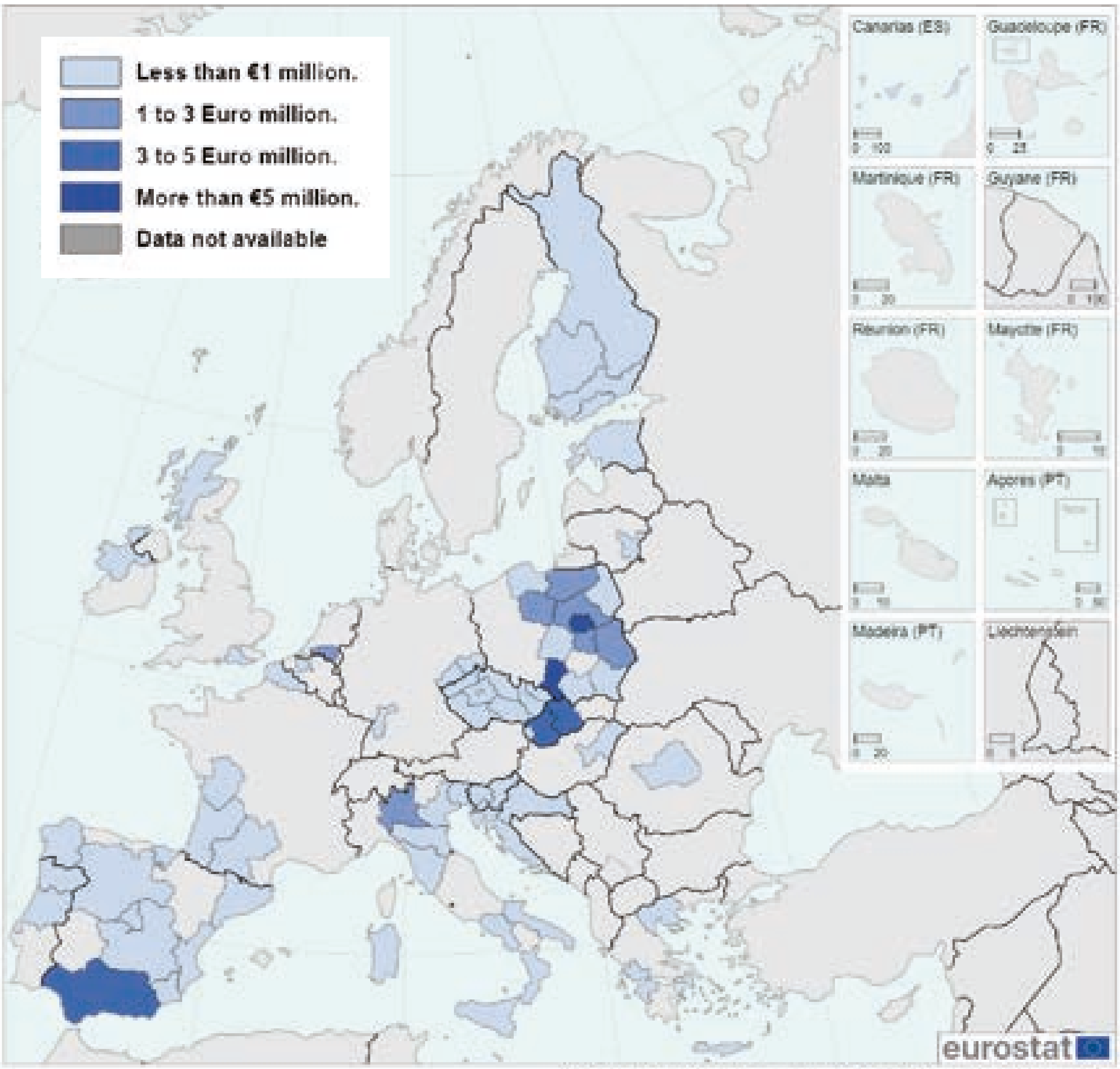
[114] Lusher, A., Hollman, P., & Mendoza-Hill, J. (2017). Microplastics in fisheries and aquaculture: status of knowledge on their occurrence and implications for aquatic organisms and food safety. FAO Fisheries and Aquaculture Technical Paper, (615).
[115] The European Union has put in place rules to provide society with environmental benefits that include clean water, breathable air and a healthy nature. Environmental compliance assurance describes all the ways in which public authorities promote, monitor and enforce compliance with such rules. It is part of environmental governance. More information at: https://ec.europa.eu/environment/legal/compliance_en.htm.
[116] ECHA. Reducing microplastic emissions by 400 000 tonnes over the next 20 years. https://newsletter.echa.europa.eu/home/-/newsletter/entry/reducing-400-000-tonnes-of-microplastic-emissions-over-the-next-20-years.
[117] ECHA. The problem with microplastics. https://chemicalsinourlife.echa.europa.eu/the-problem-with-microplastics.
[118] Hanke G. et al (2019) EU. 2019. Directive on reduction of impact of certain plastics 2019/904/EU.

Figure 3.14 Beneficiaries of projects related to plastic or micro-plastic pollution by activity, 2014-2019, percentage



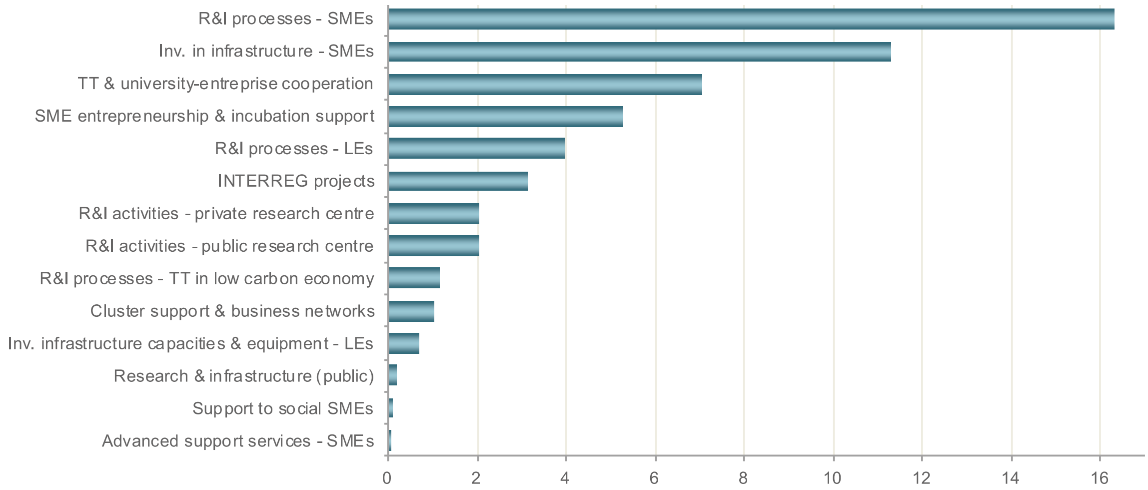
Source: JRC ERDF beneficiaries' database (2019).

Figure 3.15 ERDF funding related to plastic and micro-plastic pollution, 2014-2019, € million



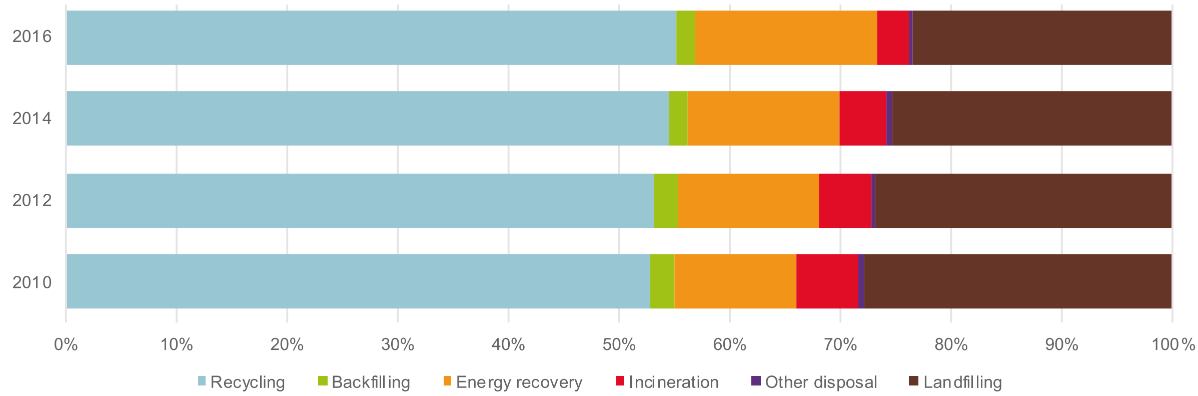
Notes: Classification based on NUTS 2016, level 3. Administrative boundaries: © EuroGeographics © UN-FAO © Turkstat. Cartography: Eurostat — GISCO, 03/2019.
Source: JRC ERDF beneficiaries' database (2019).

Figure 3.16 ERDF funding by categories of intervention, 2014-2019, € million



Notes: TT: Technology Transfer; R&I: Research and Innovation; Inv.: Investment; LEs: Large Enterprises; SMEs: Small and Medium Enterprises.
Source: JRC ERDF beneficiaries' database (2019)

Figure 3.17 Treatment rates for domestically generated waste in the EU-28, percentage



Notes: Major mineral wastes are excluded.
Source: Commission Services based on Eurostat

with the neighbouring Regional Sea Conventions and at a UN level. An understanding of the current based movements of litter is therefore essential[119].

While the seas are linked through their pattern of currents, markets are linked through the streams of raw materials, products and waste. Thence, the type and amount of imported/exported materials should be subject to regulations and controls in order to understand how markets are linked and how the tools of the circular economy might be better employed at an EU scale and beyond, in order to promote a sustainable economy.

Furthermore, the export/import of plastic waste is a matter of concern. Waste materials move around Europe and beyond, either as undesired discarded material, or as a valuable secondary resources. This becomes an increasingly important matter inside the EU, as it move towards the cessation of waste exports outside its borders.

Overall, the increased protection of the environment and the progress towards a circular economy provide challenges but also opportunities as new industries and technologies emerge. Economic indicators, waste indicators and environmental parameters need to be monitored in order to provide feedback and accompany the implementation process of sustainable circular economy and environmental protection. While the EU provides a consolidated framework for the implementation of such provisions, global collaboration is needed to achieve large scale coverage[120].

[119] Macias, D., Cozar, A., Garcia-Gorriz, E., Gonzalez, D., Stips, A. 2019. Surface water circulation develops seasonally changing patterns of floating litter accumulation in the Mediterranean Sea. A modelling approach. Marine Pollution Bulletin, 149.

[120] UN. (2019). United Nations Environment Assembly of the United Nations Environment Programme Fourth session Nairobi, 11–15 March 2019, Ministerial declaration of the United Nations Environment Assembly at its fourth session, UNEP/EA.4/HLS.1.

CHAPTER 4

MARINE NATURAL CAPITAL AND ECOSYSTEM SERVICES

The marine natural capital is the ocean's stock of natural assets, which include living and non-living resources, and is the source of marine ecosystem services. Marine ecosystem services are the benefits that people obtain from marine ecosystems, and thus they support human well-being. The Blue Economy comprises the marine and maritime economic activities that indirectly and directly use resources from the sea (See Chapter 1). Ecosystems can provide a higher amount of services when they are healthy, and so they can also provide more benefits for people. In this context, this chapter discusses the importance of the services provided by healthy, resilient and productive marine environments. The chapter also attempts to describe a methodology for assessing the economic value of marine ecosystem services for Blue Economy activities, which indicate the value that could be at stake when the sustainability of ecosystem is endangered.

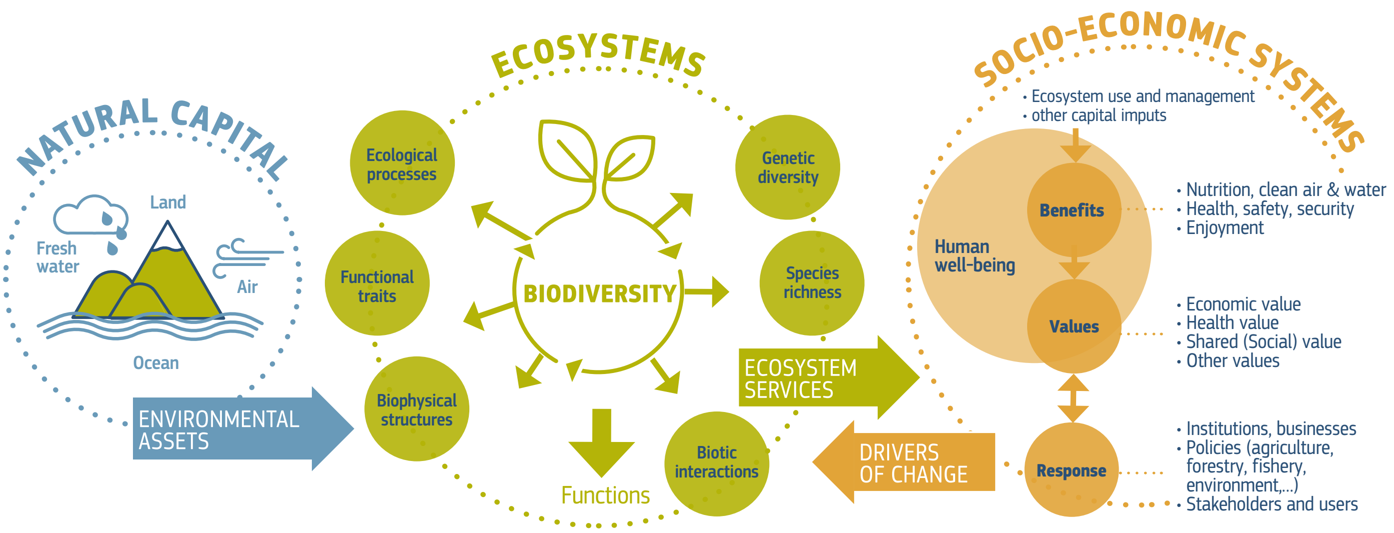
4.1. NATURAL CAPITAL: DEFINITION AND POLICY CONTEXT

Natural Capital is a part of wealth that encompasses the world's stocks of natural assets, which include living and non-living resources from land, air, freshwater and oceans. From that natural capital, people tap into a wide range of ecosystem services that make human existence and well-being possible in terms of food, water and materials; public health, and better socio-economic systems (Figure 4.1). Reducing human impacts (e.g. climate change, pollution, habitat degradation and conversion, over-exploitation and introduction of invasive alien species) on the ecosystems and improving their condition, helps preserve the environment as future capital in social, economic and financial terms and their continuous capacity to provide ecosystem services.

It is therefore, paramount to integrate the concept of natural capital into decision-making, known as the Natural Capital Approach. It proposes a mean for identifying and quantifying natural resources and associated ecosystem goods and services that can help integrate ecosystem-oriented management with economic decision-making and development[121]. Adopting the natural capital approach encourages the establishment of links between environmental and economic concepts and policy areas including health and education[122],[123].

The EU recognises the European seas and oceans as key-players for the economy, reconciling economic growth and improving livelihoods and social inclusion between maritime sectors[124]

Figure 4.1 Ecosystems services, from natural capital to benefits to society



Source: Commission Services

121 Voora, V.A., Venema, H. D. 2008. "The Natural Capital Approach. A Concept Paper. International Institute for Sustainable Development. Manitoba, Canada. 85pp.
122 Austen, M.C. et al. 2019."Valuing Marine Ecosystems — Taking into account the value of ecosystem benefits in the Blue Economy". Coopman, J., Heymans, J.J., Kellett, P., Muñiz Piniella, A., French, V., Alexander, B. [Eds.] Future Science Brief 5 of the European Marine Board. Ostend, Belgium. 32pp. ISBN: 9789492043696 ISSN: 4920-43696 DOI: 10.5281/zenodo.2602732.
123 In this context, it is also fundamental to increase the public awareness and encourage the responsible and informed behaviour towards the ocean and it resources (known as Ocean Literacy), as well as incorporate into national educational programmes. For further details, see for instance, Santoro, F. et al. 2017. "Ocean Literacy for All – A toolkit". IOC Manuals and Guides, 80. IOC/UNESCO & UNESCO Venice Office, Paris.136pp. ISBN: 9789231002496.
124 Further information in Maritime Spatial Planning (MSP) https://ec.europa.eu/maritimeaffairs/policy/maritime_spatial_planning_en. See also Section 2.2.3.

and to reconcile economic development with the conservation of marine ecosystem services. The environmental condition of European seas and oceans affects their capacity to provide ecosystems services and, consequently, also impacts the EU Blue Economy either directly or indirectly. The importance of ecosystem services and the significant impact on human economy and well-being in general is also recognised by the World Economic Forum. Indeed, in its latest *Global Risk Report*[125], the top most likely risks were environmental and linked to ecosystem services: 1) extreme weather, 2) climate action failure, 3) natural disasters, 4) biodiversity loss and 5) human-made environmental disasters. Moreover, three of these are also among the risks with the highest potential impact: climate action failure, biodiversity loss and extreme weather.

In this context, the EU has already adopted several policies with ambitious targets and actions, seeking to protect the marine environment and biodiversity across Europe more effectively, such as:

- The Biodiversity Strategy[126], aiming to halt the loss of biodiversity and ecosystem services in the EU and help stop global biodiversity loss by 2020. It reflects the commitments taken by the EU in 2010, within the international Convention on Biological Diversity (CBD). A new post 2020 strategy is currently being developed with targets to be met by 2030, including several goals to revert marine biodiversity loss;
- The Marine Strategy Framework Directive[127], aiming to achieve a sustainable use of the European seas and to protect the marine ecosystem and biodiversity upon which human health and marine-related economic and social activities depend (see section 2.2.2). One of the objectives is to maintain or achieve Good Environmental Status (GES) of the EU's marine waters by 2020. It provides support to the global commitments within the United Nation 2030 Agenda for Sustainable Development[128], to meet the Sustainable Development Goals *Life Below Water* (SDG 14);
- The Common Fisheries Policy (CFP)[129], ensuring that fishing and aquaculture are environmentally, economically and socially sustainable and that they provide a source of healthy food for EU citizens.
- The Maritime Spatial Planning Directive[130], highlighting the need to manage EU waters more coherently, and working across borders and sectors to ensure that human activities at sea take place in an efficient, safe and sustainable way (see Section 2.2.3 for further details);
- The 7th Environmental Action Programme (7th EAP)[131], stepping up EU efforts to protect the natural capital, stimulate resource-efficient, low-carbon growth and innovation, and safeguard people's health and wellbeing, while respecting the Earth's natural limits;
- The Habitat[132] and Bird[133] Directives (HBD), in particular for several marine habitats and species and the implementation of protective measures that ensure their conservation status.
- The Water Framework Directive (WFD)[134], establishing a framework for the protection of inland surface waters, transitional waters, coastal waters and groundwater, with the objective to achieve and maintain Good Ecological Status and Good Chemical Status for the coastal and transitional waters;
- The Bathing Water Directive (BWD)[135], which aims to preserve, protect and improve the quality of the environment and to protect human health by adopting adequate containment measures in the release of microorganisms in marine-coastal waters

Loss of biodiversity directly affects the carrying capacity and resilience of marine ecosystems. This jeopardises the ability of marine ecosystems to support healthy flora and fauna and to provide a variety of ecosystem services that support livelihoods, whether through fishing, aquaculture, tourism, or other activities. The consequences for continued socioeconomic progress can therefore be direct and serious on the ecosystems[136]. The opportunity cost of not reaching the 2020 EU Biodiversity Strategy target established was estimated at up to €50 billion a year in 2015[137]. Marine ecosystems and biodiversity are declining across the EU, and maintaining healthy marine habitats and sustainable resources, for example the capacity of carbon sequestration by marine habitats and their contribution to the climate regulation or a fair standard of living for fish stocks, is also essential for the long-term viability of the Blue Economy sectors.

125 World Economic Forum (2020) The Global Risk Report. 2020. Available at: http://www3.weforum.org/docs/WEF_Global_Risk_Report_2020.pdf.
126 COM(2011)244. Our life insurance, our natural capital: an EU biodiversity strategy to 2020. Communication from the Commission to the European Parliament, the Council, the Economic and Social Committee and the Committee of the Regions. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52011DC0244.
127 Directive 2008/56/EC of the European Parliament and of the Council of 17 June 2008 establishing a framework for community action in the field of marine environmental policy (MSFD). https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32008L0056.
128 A/RES/70/1. Resolution adopted by the General Assembly on 25 September 2015 Transforming our world: the 2030 Agenda for Sustainable Development. https://sustainabledevelopment.un.org/.
129 Regulation (EU) No 1380/2013 of the European Parliament and of the Council of 11 December 2013 on the Common Fisheries Policy, amending Council Regulations (EC) No 1954/2003 and (EC) No 1224/2009 and repealing Council Regulations (EC) No 2371/2002 and (EC) No 639/2004 and Council Decision 2004/585/EC. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32013R1380.
130 Directive 2014/89/EU of the European parliament and of the council of 23 July 2014 establishing a framework for maritime spatial planning (MSP). https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv:OJ.L_.2014.257.01.0135.01.ENG%20.
131 Decision No 1386/2013/EU of the European Parliament and of the Council of 20 November 2013 on a General Union Environment Action Programme to 2020 'Living well, within the limits of our planet'. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32013D1386.
132 Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:31992L0043.
133 Directive 2009/147/EC of the European Parliament and of the Council of 30 November 2009 on the conservation of wild birds. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32009L0147.
134 Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32000L0060.
135 Directive 2006/7/EC of the European Parliament and of the Council of 15 February 2006 concerning the management of bathing water quality and repealing Directive 76/160/EEC. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32006L0007.
136 Haines, R. et al. 2018. "Study on the Benefits of MPAs". Publications office of the European Union, Luxembourg. 93pp. ISBN:9789290023782.
137 European Commission (2015). Mid-term Review of the EU Biodiversity Strategy to 2020. Report from the Commission to the European Parliament and the Council, Mid-term Review of the EU Biodiversity Strategy to 2020, 2.10.2015, European Commission, Brussels.

4.2. HUMAN ACTIVITIES INTERACTIONS WITH NATURAL CAPITAL

Maritime activities are dependent on the natural capital (either abiotic, biotic or both) held in Europe's seas. The importance of using this capital sustainably is vital so that marine ecosystems and their services can be maintained, and hence also, the human activities that depend on them. A greater range of pressures are exerted on marine ecosystems through the human indirect use of abiotic natural capital in their activities (e.g. Non-living resources) than in direct ones (e.g. Living resources).[138] This is a key point of concern since the *Living resources* depend on good environmental and ecosystem conditions, while activities using *Non-living resources*, as well as land-based activities, cause pressures on marine ecosystems but are mostly not dependent on their state (Table 4.1).

According to the latest MSFD reporting, each of the main human activities may exert multiple pressures on the marine environment and its ecosystems (Figure 4.3). Blue Economy sectors, but also land-based activities (notably agriculture and urban/industrial settlements), cause a range of widespread pressures across Europe's seas. Pressures from human activities on marine habitats and species are found in 93 % of Europe's marine area. However, it is important to distinguish well-managed activities from non-adequately managed activities. The highest potential of combined effects from multiple pressures are found along coastal areas, in particular, in the North Sea, Southern Baltic Sea, Adriatic and Western Mediterranean regions. The most extensive combined effects in shelf areas occur in the North Sea, parts of the Baltic Sea and the Adriatic Sea.[139]

4.3. MARINE ECOSYSTEM SERVICES: AN OVERVIEW

The oceans play an essential role in the Earth's systems and in supporting human existence and well-being. For instance, the water cycle, carbon cycle and climate regulation depend on the physical, chemical and biological processes of the oceans. Maintaining these cycles and the processes in balance is also key for the services that the oceans provide to humanity, including direct and indirect human daily needs and other benefits.

The Millennium Ecosystem Assessment (MEA), called for by the United Nations had the objective to assess the consequences of ecosystem change for human well-being and to provide sound scientific evidence for actions needed to enhance the conservation and sustainable use of those systems and their contribution to human well-being[140]. MEA (2005) succinctly defined the Ecosystem Services as "the benefits humans derive from nature", and as well as the Common International Classification of Ecosystem Services (CICES)[141] grouped such services into three general categories: *provisioning services* — benefits obtained directly from the ecosystem (e.g. food, water, minerals, energy etc.); *regulating and maintenance services* — benefits obtained from the regulation of ecosystem processes (e.g. climate regulation, carbon sequestration, coastal protection etc.); and *cultural services* – non-material benefits obtained directly from the ecosystem (e.g. aesthetic, recreational, psychological and spiritual benefits, etc.)[142]. While the ecosystem services system classification offer a way of understanding the indirect effects of decisions that affect the natural environment on human and social welfare, a thorough understanding of ecosystem functioning and how these functions provide benefits is needed in order to determine the change in services flow that might occur following a disturbance to the ecosystem[143].

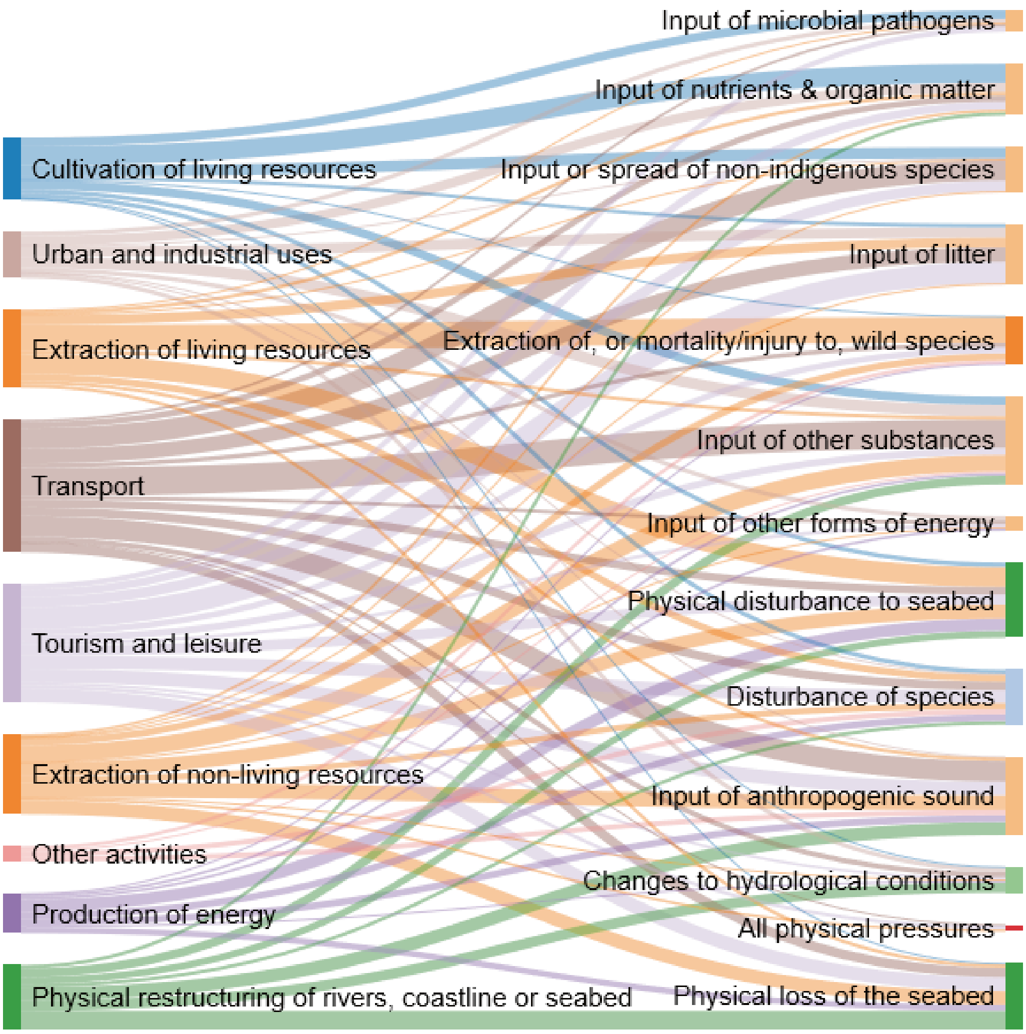
Table 4.1 Dependence and pressure of human activities on natural capital

Blue Economy sector	Main dependence on:		Main pressure on:	
	Marine abiotic natural capital	Marine biotic natural capital	Marine abiotic natural capital	Marine biotic natural capital
Marine living resources	X	X		X
Marine non-living resources	X		X	X
Marine renewable energy	X		X	X
Port activities	X		X	X
Shipbuilding and repair			X	
Maritime transport	X		X	X
Coastal tourism	X	X		X

Source: Commission Services

[138] European Environmental Agency. 2015. Marine Messages Our seas, our future — moving towards a new understanding. Available at: https://www.eea.europa.eu/publications/marine-messages.
[139] ETC/ICM Technical Report 4/2019 Multiple pressures and their combined effects in Europe's seas, see https://www.eionet.europa.eu/etcs/etc-icm/products/etc-icm-report-4-2019-multiple-pressures-and-their-combined-effects-in-europes-seas
[140] MEA Millennium Ecosystem Assessment. 2005. "Ecosystems and Human Well-being: Synthesis". Island Press, Washington, DC. 156pp. ISBN:1597260401.
[141] Potschin, M., Haines-Young, R. 2011. Ecosystem services: Exploring a geographical perspective. Progress in Physical Geography 35(5): 571-574.
[142] Liquete, C. et al. 2013. "Current status and future prospects for the assessment of marine and coastal ecosystem services: a systematic review". PLoS ONE 8(7): e67737. DOI: 10.1371/journal.pone.0067737.
[143] Norton, D., Hynes, S., Boyd, J. 2018. "Valuing Ireland's Coastal, Marine and Estuarine Ecosystem Services". EPA Research Report No 239. EPA Publications, Wexford. 67pp. ISBN:9781840957600.

Figure 4.2 Human activities and pressures affecting the state of the marine environment



Notes: the size of the curves corresponds to the frequency of the linkage activity-pressure being reported, but does not differentiate between well-managed activities (e.g. the use of less noisy ships for maritime transport, the direct discharge of well-treated wastewater at sea, etc.) from non-adequately managed ones.
Source: Commission Services

The hierarchical and flexible structure built on the three main ecosystem services categories is an ideal classification system for the assessment of ecosystem services[144]. However, the *marine ecosystem services are still relatively less well explored*[145]. The complexity of the marine ecosystem itself led to an inadequate knowledge of the distribution of communities and habitats, and on the ecosystems function that they provide, with consequent scarcity of marine spatial data relating to marine ecosystem services[146]. Furthermore, gaps have been also identified in a 1) systematic and integrated monitoring of biodiversity and ecosystem functioning to assess status, trends and identification of potential tipping points, and 2) the influence of interacting indirect and direct drivers on biodiversity and ecosystem services provisioning in various contexts and spatial scale[147].

[144] Maes, J. et al. 2013. "Mapping and Assessment of Ecosystems and their Services. An Analytical Framework for Ecosystem Assessments under Action 5 of the EU Biodiversity Strategy to 2020". Publications office of the European Union, Luxembourg. 60pp. ISBN:9789279293696.
[145] Brouwer, R. et al. I. 2013. "A Synthesis of Approaches to Assess and Value Ecosystem Services in the EU in the Context of TEEB". University Amsterdam, Institute for Environmental Studies. 144pp.
[146] Townsend, M. et al. 2014. "Overcoming the challenges of data scarcity in mapping marine ecosystem service potential". Ecosystem Services 8: 44–55.
[147] PBES (2019). Summary for policymakers of the global assessment report on biodiversity and ecosystem services of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services. S. Díaz, et al. (eds.). IPBES secretariat, Bonn, Germany. 56 pp.

4.4. MARINE ECOSYSTEM SERVICES AND BLUE ECONOMY

There is a clear interaction between marine ecosystem health and the Blue Economy. Blue economy activities may stem from marine ecosystem services not only directly (e.g. the *Food provisioning* services supports directly *Capture fisheries* and *Aquaculture* and the *Water storage and provisioning* services supports directly *Desalination*) but also indirectly (e.g. the *Processing of fish products* and the *Distribution of fish products* depend indirectly of a series of ecosystem services such as *Food provisioning*, *Water purification* or the *Life cycle maintenance*).

Ecosystems are extremely complex systems of living organisms interacting with the non-living components in their environment. These biotic and abiotic components of the ecosystem are linked together through nutrient cycles, energy flows and other cycles such as the water cycle and carbon cycle. These high levels of complexity are also translated into the interaction between ecosystem services and the Blue Economy. Indeed, one ecosystem service may support several human activities. For instance, the services of *Water purification* supports a number of Blue Economy sectors such as *Marine living resources*, *Blue bioeconomy*, *Coastal tourism* and *Waste management*. At the same time, each Blue Economy sector may stem from a variety of ecosystem services. For instance, *Coastal tourism* may only thrive thanks to the combination of a number of ecosystem services such as *Water purification*, *Air quality regulation*, *Coastal protection*, *Life cycle maintenance*, *Biological regulation* and *Symbolic and aesthetic values*. An overview of this interaction is summarised in Table 4.2.

Human activities may aim at reinforcing the ecosystems and their long-term sustainability. However, in general, human activities and the Blue Economy tend to exert key pressures on marine ecosystem conditions that threaten their Good Environmental Status (GES) and therefore jeopardise their capacity to provide services and wellbeing. Among others, these key human pressures include:

- Input or spread of non-indigenous species.
- Over-exploitation and over-extraction of marine resources, or mortality/injury to, wild species
- Input of nutrients and organic matter.
- Physical loss or disturbance to seabed.
- Changes to hydrological conditions.
- Input of contaminants, litter and hazardous substances.
- Input of anthropogenic sound and other forms of energy.

The combination of these pressures may lead to harmful effects such as ocean acidification or habitat loss and, in general, endanger the equilibrium of marine ecosystems. Overall, the capacity of human activities to obtain value and wellbeing from the Blue Economy depends on the Good Environmental Status of the marine ecosystems.

4.5. MEASURING AND ACCOUNTING MARINE ECOSYSTEM SERVICES

Nature offers material/market as well as immaterial/non-market goods and services. The economic value of such goods and services goes beyond the actual use of nature to encompass also non-use values as well as the different value types associated with nature (Figure 4.3)[148]. The Common International Classification of Ecosystem Services (CICES) is a standardised classification system for the environmental-economic assessment, with a hierarchical structure providing information in relation to the development of typologies for describing ecosystem services, the standards describing economic products and activities. Besides the consistency among CICES and MEA classifications, there are broad equivalences between CICES and the classifications done by The Economics of Ecosystems and Biodiversity (TEEB), a global initiative focused on *making nature's values visible*, and The Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES), an intergovernmental organisation established to improve the interface between science and policy on issues of biodiversity and ecosystem services. The common international classification would help integrate environmental accounts with national accounts[149].

The 7th Environment Action Program (7th EAP) and the EU Biodiversity Strategy 2020 includes objectives to develop natural capital accounting (NCA) in the EU, with a focus on ecosystems and their services. Furthermore, a recent Horizon 2020 project MAIA (Mapping and Assessment for Integrated ecosystem Accounting) aims to mainstream natural capital and ecosystem accounting (NCA) in EU Member States (MS)[150]. It is important to note that NCA methods and metrics are still evolving with many gaps still to fill[151] and the challenges in the marine ecosystems give NCA still an experimental status. In this context, an international expert committee recently set up a technical guidance on ocean accounting[152]. Ecosystem accounting complements the system of national accounts (SNA), where the role of natural capital is completely absent. The use of satellite accounts allows to integrate natural capital accounting into the SNA. In satellite accounts, the SNA core statistical framework is applied to adapted outputs designed to meet specific/crosscutting uses, in this case environmental issues. The System of Environmental-Economic Accounting (SEEA) proposed and supported by the United Nations[153] provides methodological guidelines for setting up satellite accounts concerning natural capital. Specifically, the UN SEEA EEA (Experimental Ecosystem Accounting) target accounts reflecting the role of ecosystems and their services[154]. The Knowledge and Innovation Project on an Integrated system for Natural Capital and ecosystem services Accounting (KIP INCA) was set up by the European Commission (including DG Environment, DG Research and Innovation, JRC and Eurostat) and the European Environment Agency. The project's objective is to design and implement

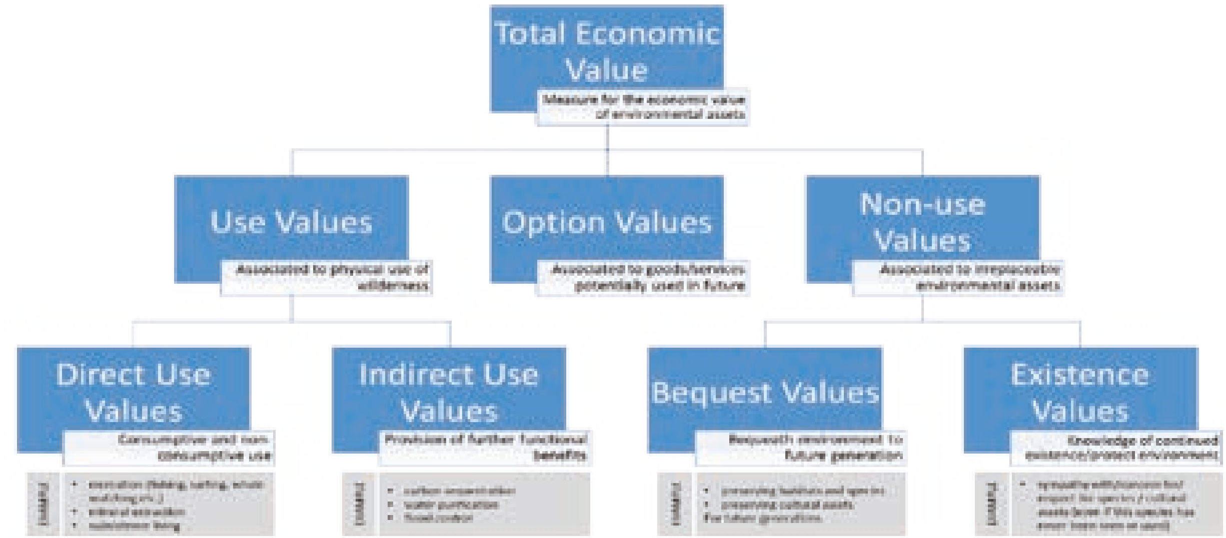
[148] Haines et al. (2018).
[149] Further information in www.cices.eu.
[150] Further information in http://maiaportal.eu/home/
[151] Maxwell, D. 2015. Valuing Natural Capital: Future Proofing Business and Finance. Sedition Publishing Ltd | Oxford, UK.100pp
[152] Global Ocean Accounts Partnership. 2019. Technical Guidance on Ocean Accounting for Sustainable Development. United Nations, 1st edition, 158pp.
[153] United Nations. 1993. "Integrated Environmental and Economic Accounting, Interim version". New York, United Nations. 182pp
[154] United Nations. 2017."Technical Recommendations in support of the System of Environmental-Economic Accounting 2012– Experimental Ecosystem Accounting". New York, United Nations. 192pp.

Table 4.2 Overview of the interaction between marine ecosystem services and the Blue Economy lue of nature

Ecosystem Service			Blue Economy	
Section	**Category**	**Flow**	**Sector or subsector**	**Dependency**
Provisioning services	Food provision	Fisheries	Primary sector	Direct
			Processing of fish products	Indirect
			Distribution of fish products	Indirect
			Shipbuilding and repair	Indirect
			Household	Direct
		Aquaculture production	Aquaculture (fish/shellfish)	Direct
			Aquaculture (algae)	Direct
			Processing of fish products	Indirect
			Distribution of fish products	Indirect
	Water storage and provision (abiotic)	Water for human consumption	Desalination	Direct
	Biotic materials and biofuels	Biomass or biotic element for non-food purpose	Ocean energy	Direct
			Marine living resources	Direct and Indirect
			Marine non-living resources	Direct and Indirect
			Blue bioeconomy	Direct
Regulating and maintenance services	Water purification	Bio and physicochemical processes for waste and pollutant removal	Marine living resources	Direct and Indirect
			Blue bioeconomy	Direct
			Coastal tourism	Direct and Indirect
			Waste management	Direct
	Air quality regulation	Air pollutants concentration in the lower atmosphere	Coastal tourism	Direct and Indirect
			Marine living resources	Direct and Indirect
			Blue bioeconomy	Direct
	Coastal protection	Erosion prevention, protection against floods, hurricanes	Maritime defence	Indirect
			Household	Direct
			Coastal tourism	Direct
	Climate regulation	Greenhouse gases: uptake, storage and sequestration of CO_2	All sectors	Direct and Indirect
	Weather regulation (abiotic)	Influence on local weather conditions as thermo-regulation and humidity	Maritime transport	Direct
			Maritime defence	Indirect
			Marine renewable energy	Direct
			Ocean energy	Direct
	Ocean nourishment	Nutrient regulation	All (polluting) sectors	Direct and Indirect
		Soil formation (abiotic)	Marine non-living resources	Direct
			Desalination	Direct
	Life cycle maintenance	Biological and physical support habitat maintenance	Marine living resources	Indirect
			Coastal tourism	Direct
			Marine non-living resources	Indirect
			Global society	Direct
		Biological and physical support nursery maintenance	Marine living resources	Direct and Indirect
			Global society	Direct
	Biological regulation	Biological control of pests may affect commercial activities and human health	Marine living resources	Direct and Indirect
			Coastal tourism	Direct
Cultural services	Symbolic and aesthetic values	Exaltation of senses end emotions by seascape, habitats and species	Coastal tourism	Direct
	Recreation and tourism	Fish catching for non-commercial purposes	Coastal tourism	Indirect
		Opportunities for nature-based relaxation and amusements	Coastal tourism	Direct
			Art	Direct
	Cognitive effects	Mimicking nature	All sectors	Direct and Indirect
			Research and innovation	Direct
Abiotic flows	Abiotic mean	Abiotic status of matter and resources	Maritime transport	Direct
			Marine renewable energy	Direct
			Ocean energy	Direct
			Marine non-living resources	Direct

Source: Commission Services

Figure 4.3 Total economic value of nature



Source: Commission Services

an integrated accounting system for ecosystems and their services in the EU by testing and further developing the technical recommendations provided by the UN SEEA EEA[155]. KIP INCA builds on the EU initiative on Mapping and Assessment of Ecosystems and Services (MAES), which aims to map and assess ecosystems and their services in the EU[156], and supports the second phase of MAES that focuses on the valuation of ecosystem services and integrate them into accounting and reporting systems in an upcoming report by 2020)[157].

The accounting format used for ecosystem services are the supply and use tables, which report annual flows of goods and services between different units in the system (see Figure 4.3 and for marine systems and Figure 4.4 for supply-use table). In ecosystem services satellite accounts:

- The supply table shows the flow of each service provided by different ecosystem types. In the case of marine ES, we refer to "transitional waters", "continental shelf" and "open ocean";
- The use table shows the flow of each ecosystem service to the different user. In the case of marine ES, we might refer mainly to the fisheries and tourism sectors, households and global society.

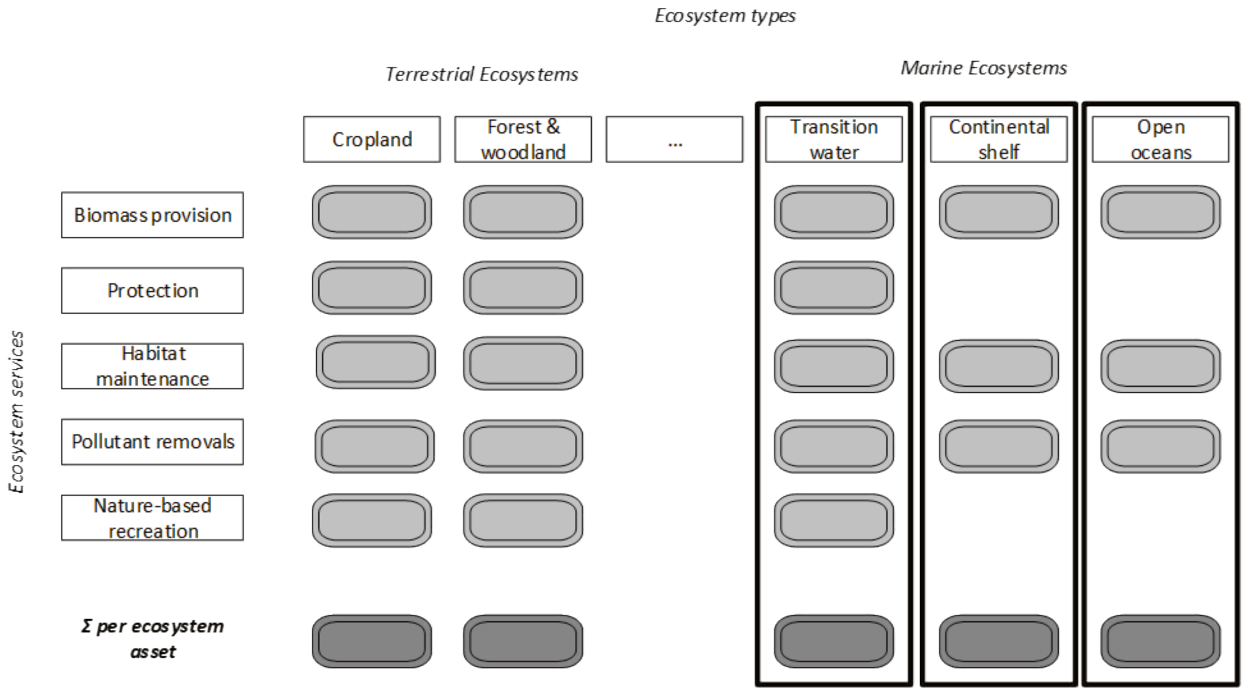
Table 4.3 Ecosystem Services and related accounting groups

Ecosystem Services	Accounting Group	Correspondence with CICES	Correspondence with TEEB
Food provision: Fisheries	Source: provision	Provisioning	Provisioning
Food provision: Aquaculture production	Source: provision	Provisioning	Provisioning
Habitat maintenance as final service for global society	Source: suitability	Regulating and maintenance	Habitat
Nursery maintenance as inter-ecosystem flow	Source: suitability	Regulating and maintenance	Habitat
Coastal protection	Buffer	Regulating and maintenance	Regulating
Water purification	Sink	Regulating and maintenance	Regulating
Global climate regulation	Sink	Regulating and maintenance	Regulating
Nature-based recreation for the tourism sector	Information	Cultural	Cultural
Nature-based recreation for households	Information	Cultural	Cultural
Mimicking nature	Information	Cultural	Cultural

Source: Commission Services

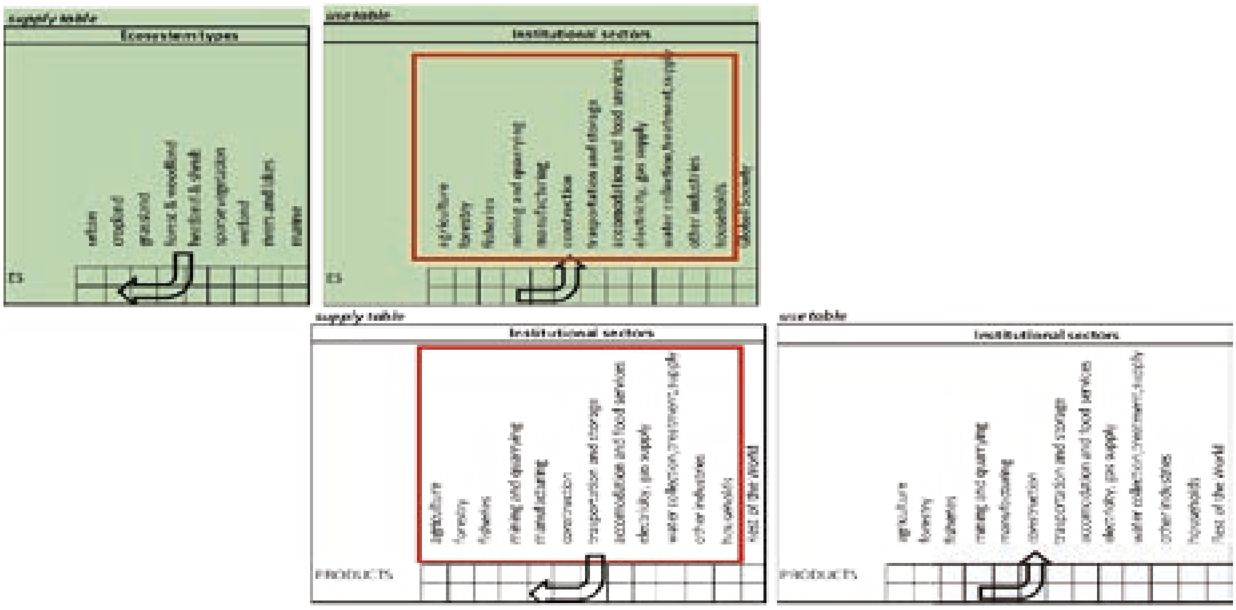
[155] European Commission & European Environment Agency. 2016. "Report on phase 1 of the knowledge innovation project on an integrated system of natural capital and ecosystem services accounting in the EU". KIP-INCA Phase 1 Report. 106pp.
[156] Further information in https://biodiversity.europa.eu/maes.
[157] La Notte, A. et al. 2017. "Implementing an EU system of accounting for ecosystems and their services. Initial proposals for the implementation of ecosystem services accounts". Publications Office of the European Union, European Union, Luxembourg. 124pp. ISBN:9789279705175 DOI: 10.2760/214137.

Figure 4.4 Relationship between ecosystem services and ecosystem assets



Source: Commission Services

Figure 4.5 Ecosystem Services satellite accounts as entry point into the System of National Accounts



Source: Commission Services

There are a considerable number of ecosystem services that can be provided by the marine ecosystem[158] and it is relevant to group ecosystem services according to the way they are delivered to the economy and the society[159], example reported in Table 4.2, where a first set of ecosystem services to be assessed is proposed.

The estimation of the economic value of ecosystem services flows results from the interaction between:

- Ecosystem service potential: the service that can be provided by different ecosystem types, depending on their properties and condition (providers of the supply table).

158 Mongruel R.et al. 2019. Milieux marins et littoraux: évaluation des écosystèmes et des services rendus. Rapport de l'étude réalisée pour le compte du programme EFESE, IFREMER – UBO – AFB, 354 pages + Annexes (in French).

159 La Notte, A.et al. 2019. Beyond the economic boundaries to account for ecosystem services. Ecosystem Services, 35, 116-129.

- Ecosystem service demand: the need for a specific ecosystem service by economic sectors and household to generate a benefit (users of the use table).

Under the MAES Initiative[160] ecosystem services have been mainly assessed in relation to their ecosystem potential, which is necessary but not sufficient to determine the actual flow. A step forward to assess the flow is to identify the demand, its location and its spatial relationship with areas providing the targeted ecosystem service. Ecosystem assets are often identified with Ecosystem Types (Figure 4.4)[161].

As satellite accounts, ecosystem service accounts provide an entry point to the economic system (Figure 4.6). In many cases, economic sectors directly depend on the ecosystem service flows, which constitute the raw input that the economic sector transforms and sells (as intermediate consumption, other industries, or as final consumption to households). The transformation and selling is already part of the SNA. Without the ecosystem service flow, none of those activities could be possible.

In other cases, marine ecosystem is a mean to provide abiotic services such as transport and energy, on which the economy and human welfare depend (Table 4.2).

BOX 4.1: ECOSYSTEM SERVICES VALUATION — CHALLENGES AND OUTLOOK

It has increasingly been recognised that the sustainable management of natural capital calls for a comprehensive and quantitative method to measure and monitor the health of marine natural capital and its ecosystems services supporting the Blue Economy activities.

The purpose of ecosystem valuation is not to put a price-tag on nature, but to help answer clearly defined policy questions, as it can help visualise and quantify (in monetary or non-monetary terms) the diverse direct and indirect contributions of ecosystems to human well-being. The ecosystem valuation studies need to take the specific context, knowledge and spatio-temporal scale into account with the appropriate level of complexity. This requires a transdisciplinary approach and the inclusion of socio-economic drivers[162], as well as a serious of key recommendations:

- include ecosystem valuation in marine management decision models and conservation policies to provide an integrative policy approach;
- promote the harmonisation of ecosystem service frameworks and classification system to improve the usage and comparability at global level;
- improve understanding of the role of marine biodiversity and ecosystems processes in providing ecosystem services and benefits to develop a set of indicators for ecosystems services that can be included under existing monitoring programme;
- create an open database that contains the data, metadata, applied methodology and results of marine ecosystem valuation studies to improve the quality and availability of monetary and non-monetary value;
- set the right scale and boundaries of valuation studies to make a robust assessment in trade-off analysis;
- enhance transdisciplinary connections by incorporating fundamental marine science, social science, economic and public health approaches to develop concrete policy questions and answers;
- enhance and standardise existing marine asset and valuation data sets, assessment methods and reporting of results to develop the Natural capital Approach and Natural Capital Accounting;

In this context, the European Commission's MAES initiative coordinates and oversees the knowledge base in ecosystems including aspects of ecosystem condition, the capacity of ecosystems to provide services, biodiversity and the pressures they are exposed to[163]. Meanwhile, the European Commission KIP-INCA joint project establishes a sound method for natural capital accounting with a strong focus on ecosystems and the services they deliver[164].

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160 Maes, J. et al. 2013. "Mapping and Assessment of Ecosystems and their Services. An analytical framework for ecosystem assessments under action 5 of the EU biodiversity strategy to 2020". Publications office of the European Union, European Union, Luxembourg. 57pp. ISBN:9789279293696.

161 Based on La Notte, et al. 2019. Capacity as "virtual stock" in ecosystem services accounting. Ecological Indicators, 98, 158-163.

162 Austen, M.C. et al. 2019."Valuing Marine Ecosystems — Taking into account the value of ecosystem benefits in the Blue Economy". Coopman, J., Heymans, J.J., Kellett, P., Muñiz Piniella, A., French, V., Alexander, B. [Eds.] Future Science Brief 5 of the European Marine Board. Ostend, Belgium. 32pp. ISBN: 9789492043696 ISSN: 4920-43696 DOI: 10.5281/zenodo.2602732.

163 Maes, J. et al. 2018. "Mapping and Assessment of Ecosystems and their Services: An analytical framework for ecosystem condition". Publications office of the European Union, Luxembourg. 75pp. ISBN:97892797974288.

164 Further information in https://ec.europa.eu/environment/nature/capital_accounting/index_en.htm.and https://ec.europa.eu/eurostat/web/environment/methodology under "Ecosystem Accounts".

4.6. ECONOMIC VALUATION OF MARINE ECOSYSTEM SERVICES: BENEFITS AND MONETARY VALUE

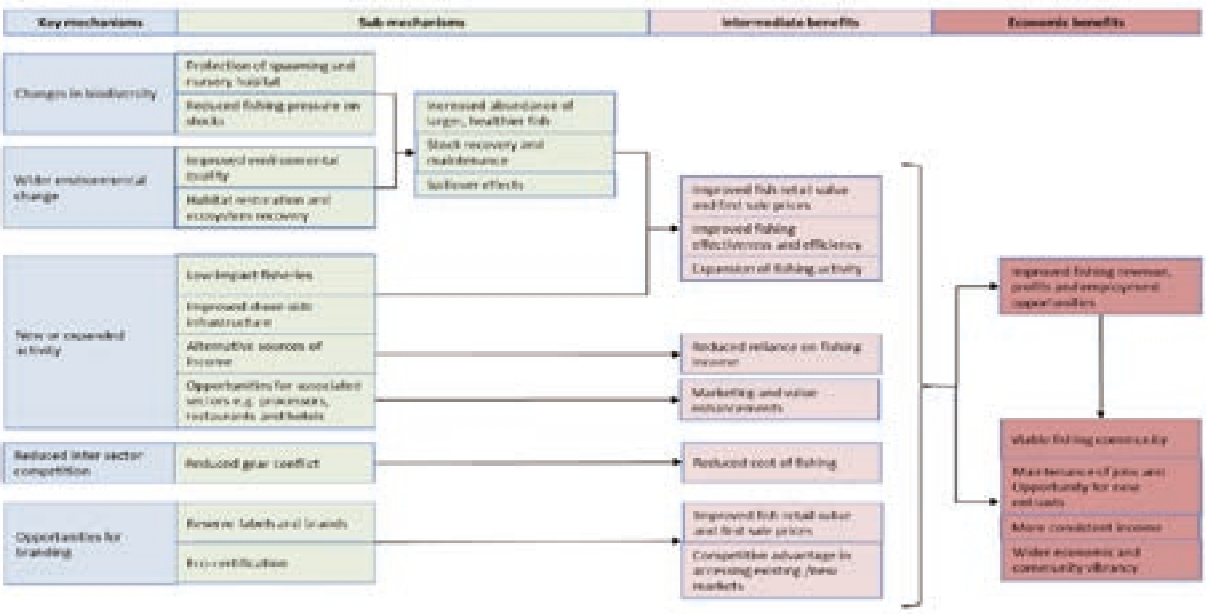
There are trade-offs and synergies as regards the use of natural capital and the ecosystem services they provide. A further step is the natural capital accounting and the valuation of ecosystem services. However, while the quantification is important to support policy decisions, the economic value of ecosystem services is very difficult to quantify.

The valuation of provisioning services, where the connection between ecosystems and humans is direct through the generation of tangible goods, most often relies on the economic and monetary values of goods for which markets usually (already) exist, using currency as metrics. Regulating and maintenance services, as well as cultural services, i.e., benefits that humans obtain and/or consume indirectly from nature, are usually assessed using monetary and non-monetary values and using different metrics, such as their effect on human lifespan, revealed preferences, willingness to pay, avoided costs, costs of protection, etc.

As mentioned above, understanding the link between biodiversity, conservation and services as well as the functioning of the ecosystem and how the functions provide benefits is needed in order to determine the change in services flow that might occur following a disturbance to the ecosystem. A clear example is the existing evidence of economic benefits generated from the Marine Protected Areas (MPAs) and other Spatial Protection Measures (SPMs)[165], where several mechanisms and pathways contribute to the total economic benefits for commercial fishing, tourism and other Blue Economy sectors (Figure 4.6), even if their regulating or cultural benefits are less tangible and more difficult to quantify in economic terms.

Several economic valuation studies of natural capital and ecosystem services, with different methodological approaches, have been performed at country and sea basin level (e.g. Ireland[166] and Baltic Sea[167]), assigning estimated monetary values to marine ecosystem services. Providing monetary values comprehensively for marine ecosystem services in European Union waters is confronted with a lack of data as well as a lack of standardised and harmonised methodologies. Moreover, there are difficulties in providing consistent values for some categories of services. Finally, some estimates may be subject to high levels of uncertainty. With these caveats in mind, Table 4.4 provides a number of examples of estimated economic values for the Blue Economy activities documented in this report, which can be linked to a marine ecosystem service (although not necessarily reflecting its complete value) or linked to the marine environment as abiotic elements of natural capital. Subsequent editions of the EU Blue Economy Report will endeavour to improve the accuracy and comprehensiveness of such valuation.

Figure 4.6 Economic benefit pathways to the fisheries sector resulting from MPAs and SPMs



Source: Haines et al., 2018.

[165] Haines, R. et al. 2018. "Study on the Benefits of MPAs". Publications office of the European Union, Luxembourg. 93pp. ISBN:9789290023782.

[166] Hynes., S. et al. (2019) Ireland's Ocean Economy. The Socio-Economic Marine Research Unit (SEMRU), National University of Ireland, Galway. https://www.nuigalway.ie/media/researchsites/semru/files/Online_Irelands-Ocean-Economy-Report_for-web_final.pdf

[167] Sagebiel, J.et al. 2016 Economic valuation of Baltic marine ecosystem services: blind spots and limited consistency. ICES Journal of Marine Science, 73: 991–1003.

Table 4.4 Examples of how ecosystem services underpin economic value for the EU Blue Economy

Ecosystem service category	Blue Economy: Sector (subsector and activity)		Annual production: Value € billion	Annual production: Quantity	Section in this Report
Ecosystem Service: Provisioning services					
Food provision	**Living resources** (Primary production) [i]				
		Capture fisheries	6.5	t million: 4.6	Section 5.1
		Aquaculture: Marine finfish	2.5	t million: 0.4	Section 5.1
		Aquaculture: Shellfish	1.1	t million: 0.7	
	Living resources (Blue bioeconomy)				
		Aquatic plants (algae and seaweed) [ii]	0.3	t million: 0.2	Section 6.2
		Microalgae and bioactive compounds	0.4		Section 6.2
Water storage and provisioning	**Desalination**		2.7	m^3: 340	Section 6.3
Biotic materials and biofuels	**Blue bioeconomy**		1.5		BER 2019
		Biofuels			
		Medicines			
		Cosmetics			
Ecosystem Service: Regulating and maintenance services					
Water purification			n.a.		
Air quality regulation			n.a.		
Coastal protection [iii]			n.a.		Section 3.4
Climate regulation		*CO_2 sequestration* [iv]	17.4 – 58.1	CO_2 t million: 616	Section 3.2
Weather regulation			n.a.		
Ocean nourishment			n.a.		
Lifecycle maintenance			n.a.		
Biological regulation			n.a.		
Ecosystem service: Cultural services					
Symbolic and aesthetic values; recreation and tourism	**Coastal tourism**		249.6		Section 5.7
	Accommodation		84.0		Section 5.7
	Other expenditure		94.4		Section 5.7
	Transport		71.2		Section 5.7
Cognitive effects	**Research and education** [v]				
		EU funding provided	> 0.1		
		Patents and IPR	n.a.		
Abiotic outputs from natural systems					
Nutritional abiotic substances	**Solar salt** [vi]		> 0.1	t million: 4.0	Section 5.2
Abiotic materials	**Marine aggregates**		0.5	t million: 22.0	Section 5.2
Energy	**Extraction of oil and gas**		42.9		Section 5.2
	Blue energy				
	Offshore wind		4.0		Section 5.3
	Ocean energy		n.a.		Section 6.1
Support for other human activities	**Maritime transport**		173.2		Section 5.6

*Notes: **n.a. = not available**: currently there is not enough information or robust methodology to provide an economic value.*

As further delineated in the text, this table provides a number of examples of estimated economic values for blue economy activities documented in this report that can be linked to a marine ecosystem service, there is no 1 to 1 value therefore not reflecting its complete value) or linked to the marine environment as abiotic elements of natural capital.

*i. **Capture fisheries and aquaculture production** can be used as a proxy when assessing the marine ecosystem service underpinning food provisioning. The activity of the distant water fleet (14% landed weight / 15% of value) is excluded, as it takes place outside EU waters. Catches/value by third country fleets in EU waters are not included either. **For aquaculture**, some methodologies include both finfish and shellfish. Others just shellfish, which feed by filtering the sea water, as finfish aquaculture requires a high level of human involvement (including feeding, broadstock, medicines, etc.). Fresh water aquaculture is not included either.*

*ii. The value for **aquatic plants** is based on O'Toole and Hynes (2014): €132.68 / tonne. Taken from: An Economic Analysis of the Seaweed Industry in Ireland. Working Paper Series. Working Paper 14-WP-SEMRU-09. The Socio-Economic Marine Research Unit (SEMRU) National University of Ireland, Galway.*

*iii. Section 3.4 provides an estimate of the damage avoided through the construction **coastal protection** infrastructures such as dykes. Ideally, the ecosystem could provide a similar service.*

*iv. **Oceans sequester CO_2**, which helps to regulate global climate. The ecosystem service is a climate regulation that manifests by sequestering carbon. Even if the sequestered carbon has no formal market, there are multiple market-price estimates for CO_2 emissions, which can be used to impute its value. The values provided in the table are a highly approximate approach to assess the value of carbon sequestration by EU marine waters. The carbon sequestration capacity of marine waters is highly dependent on regional marine parameters and conditions (see also Section 3.2 – Study on the Mediterranean Sea The approximate values in the table is calculated as follows: EU waters cover about 5.81 million km^2. According to the Irish BE report, marine inlets and transitional water carbon sequestration equals 0.4 t per ha and year. NOOA estimates that offshore water carbon sequestration equals 1.06 t CO_2 per ha and year. The value per tonne of CO_2 is estimated to be between €30 (OECD) and €100 (tutelary value), as further delineated in Section 3.2.*

*v. For **R&D**, examples of expenditure at EU level include: EMODNET average cost = €7 million / year. Copernicus marine service: €30million/year (operational oceanography services developed from R&D). Direct management EMFF's calls for proposals for BlueInvest projects in 2019/20 = €20million / year. Blue careers in 2019 = €6 million. Ocean literacy: €1.3 million.*

*vi. The value for **solar salt** is based on an extraction costs of €14/t.*

Source: Commission Services

The seven established sectors

GVA €218 billion in 2018
+15% compared to 2009.

GROSS OPERATING SURPLUS (profit) €95 billion
+18% compared to 2009.

TOTAL TURNOVER €750 billion
+12% compared to 2009.

- 40% Coastal tourism
- 16% Port activities
- 16% Maritime transport

Direct EMPLOYMENT 5 million
+12% since 2017.

- 62% Coastal tourism
- 11% Living resources
- 11% Port activities

HIGHEST GROWTH

compared to 2017

GVA
+16%
+7%

EMPLOYMENT
+20%
+14%

50 persons in 2009 X8 4600 persons in 2018

Offshore wind energy (production and transmission), young sector in expansion

CHAPTER 5

ESTABLISHED SECTORS: STATUS AND RECENT TRENDS

The established sectors continue to be a major pillar and contributor to the EU Blue Economy and it is also in these sectors where more complete, accurate and comparable data are available.

The seven established sectors considered in this report are *Marine living resources*, *Marine non-living resources*, *Marine renewable energy,*[168] *Port activities*, *Shipbuilding and repair*, *Maritime transport* and *Coastal tourism*. Each sector is further divided into subsectors as summarised in Table 5.1. The details of what is included in each sector and subsector are explained in Annex 3.

This chapter provides results on the main socio-economic indicators[169] for each of the established sectors. Data submitted by Member States through the EU **Data Collection Framework** (DCF) are used for the primary sector[170] in the *Marine living resources* sector, while **Eurostat Structural Business Statistics** (SBS) data are used for all the other sectors. In addition, data from Tourism expenditure survey and from the EU Tourism Satellite Account are used to estimate indicators for the *Coastal tourism* sector.[171]

The socio-economic indicators covered in this section include: persons employed, average remuneration per employee, turnover, GVA (value added at factor cost), gross profit (gross operating surplus) and net investments in tangible goods (purchases minus sales). **Turnover** is included as a reference and should be interpreted with caution due to a double counting problem down the value chain, i.e. values of the same commodity are counted more than once (intermediate consumption). The double counting issue is solved by using the **value-added approach**. On the other hand, the activities selected to estimate the Blue Economy sectors may be incomplete owing to the difficulty of identifying all the economic activities throughout the value chain and assessing their maritime shares; for this reason, the turnover, GVA and the other indicators could be underestimated. All values are **nominal**, i.e., they have not been adjusted for inflation. Hence, changes in nominal value reflect at least in part the effect of inflation.

Only the direct contribution of the Blue Economy established sectors is considered. However, all sectors have **indirect** and **induced effects**. This means that, beyond their specific contribution, each sector has important multiplier effects on income and jobs in other sectors of the economy. For example, in *Shipbuilding and repair*, most of the value added is from upstream and downstream activities. This is briefly considered in Section 5.5.

The time series analysed goes from 2009 to 2018. Data for 2018 are provisional (or nowcasts in the case of the capture fisheries) and may be subject to revision in future editions. The **data presented in this report supersede data presented in previous** editions. Differences may stem from updates and revisions in the methodology and/or data (see Methodology section in Annex 3 for more details).

For each sector, a general background is provided, followed by the main socio-economic results for 2018 and recent trends, i.e. an explanation of some of the drivers behind the trends and interactions with other sectors. This basic analysis is complemented by one or more specific topics aimed at providing a more in-depth view on the sector or sub-sectors.

In *Marine living resources,*[172] the **Farm to Fork Strategy**, a key component of the European Green Deal, is touched upon, highlighting its maritime contribution ('Fish to Fork"). The external dimension of the Common Fisheries Policy (CFP) is exemplified through the EU **Sustainable Fisheries Partner Agreements** (SFPAs) with third countries.

Table 5.1 The established Blue Economy sectors and their subsectors

Sector	Sub-sector
Marine living resources	Primary sector Processing of fish products Distribution of fish products
Marine non-living resources	Oil and gas Other minerals
Marine renewable energy	Offshore wind energy
Port activities	Cargo and warehousing Port and water projects
Shipbuilding and repair	Shipbuilding Equipment and machinery
Maritime transport	Passenger transport Freight transport Services for transport
Coastal tourism	Accommodation Transport Other expenditure

Source: Commission Services.

168 Offshore wind energy, production and transmission
169 More results can be found on the Blue indicators online dashboard at https://blueindicators.ec.europa.eu/
170 Capture fisheries and aquaculture.
171 For details on the compilation of data for Coastal tourism see the methodological annex.
172 For Marine living resources, comprehensive socio-economic data and analyses are available in various reports published by the STECF, available at: https://stecf.jrc.ec.europa.eu/reports/economic.

In *Marine non-living resources*, a closer look into marine aggregates and the extraction of **solar salt** is presented, using the Sečovlje Salina Nature Park (Slovenia) as a case example. In *Marine renewable energy*, a detailed account of the growing EU **installed offshore wind energy capacity** and the extent of the **supply chain** is provided. In *Port activities*, a series of initiatives to reduce the footprint of these major infrastructures is addressed in the context **of Green Ports**. In addition, the **Belt and Road Initiative**, a major development at global level with important implications for shipping and the associated infrastructures, is analysed with compiled data on its impact in the EU. In *Shipbuilding and repair* a rough estimate of the indirect and induced effects of shipbuilding on the economy is provided, as well as how the sector integrates and is affected by developments in the **global shipbuilding market**. In *Maritime transport* the sector's contribution to the **decarbonisation of the economy** with the changeover to less pollutant fuels is addressed. And finally, in *Coastal tourism* the **cruise industry** as a specific niche within the sector is examined.

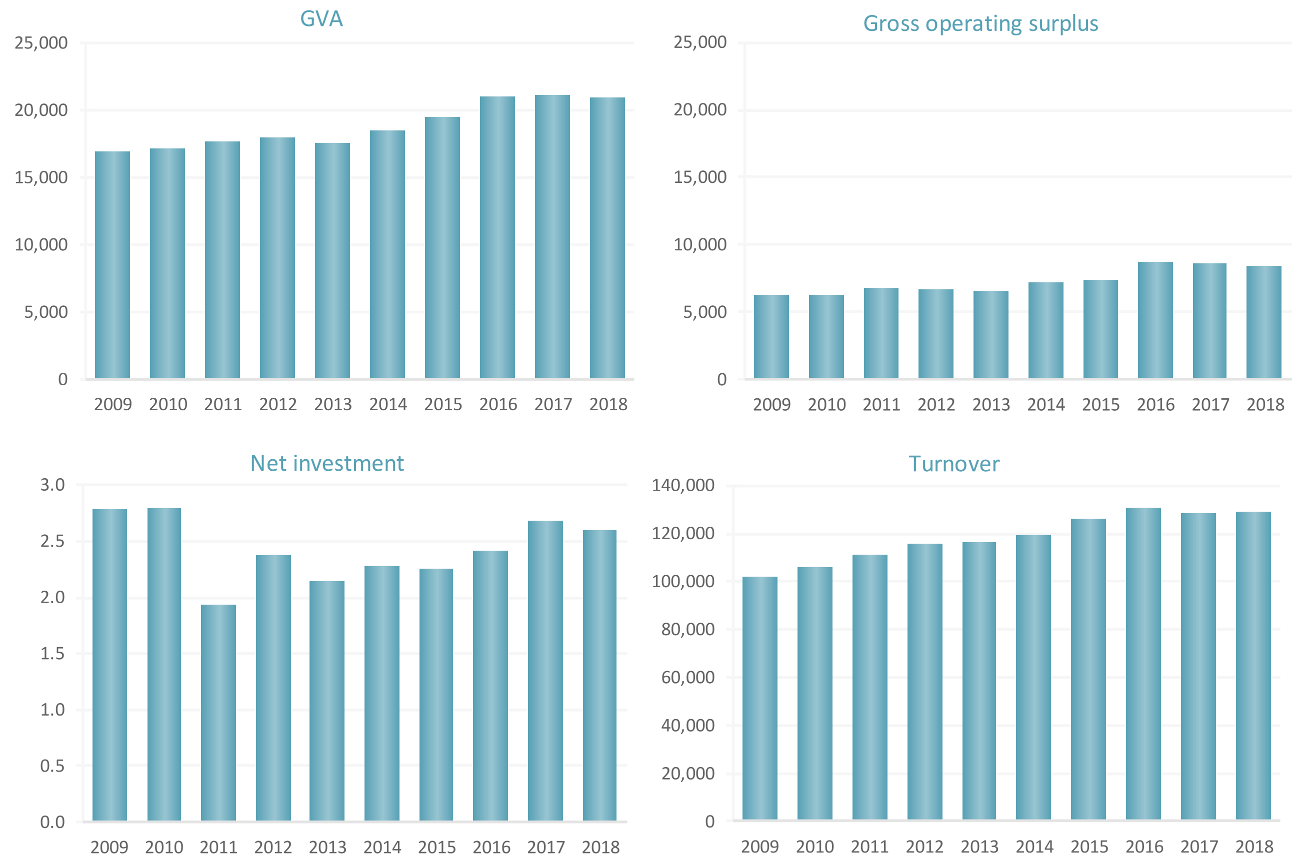
5.1. MARINE LIVING RESOURCES

5.1.1. BACKGROUND

The *Marine living resources* sector encompasses the harvesting of renewable biological resources (**primary sector**), their conversion into food, feed, bio-based products and bioenergy (**processing**) and their **distribution** along the supply chain.

The EU is the fifth largest producer of fishery and aquaculture products, covering around 3% of global production. The processing and distribution of fish products is heavily dependent on the supply of raw materials from the primary sector. Increased internal demand for seafood products and stagnation in the primary sector make these activities increasingly dependent on imports from third countries. In fact, the EU is the largest importer of seafood in the world. Its self-sufficiency in meeting a growing demand for fish and aquaculture products from its own waters is around 45%,[173] i.e. EU citizens consumed more than twice as much as they produced. EU citizens on average consume

Table 5.1 The established Blue Economy sectors and their subsectors



Source: Commission Services.

[173] European Commission (2018). A sustainable Bioeconomy for Europe: strengthening the connection between economy, society and the environment. Updated Bio economy Strategy. Luxembourg: Publications Office of the European Union. KI-04-18-806-EN-C ISBN 978-92-79-94145-0; doi: 10.2777/47838.

around 24 kg of seafood and spend around €100 on seafood a year. The main products consumed are tuna (mostly canned), cod, salmon, Alaska pollock, shrimps, mussel and herring.

For the purpose of this report, *Marine living resources* comprises three subsectors that are further broken-down into the following activities:

- **Primary sector**: Capture fisheries (small-scale coastal, large-scale and industrial fleets) and Aquaculture (marine, freshwater and shellfish);
- **Processing of fish products**: Processing and preservation of fish, crustaceans and molluscs; Prepared meals and dishes, Manufacture of oils and fats and Other food products;
- **Distribution of fish products**: Retail sale of fish, crustaceans and molluscs in specialised stores[174] and Wholesale of other food, including fish, crustaceans and molluscs.

In broader terms, these activities form an integral part of the EU **Blue bioeconomy**, which includes any economic activity associated with the use of renewable aquatic biological biomass, e.g. food additives, animal feeds, pharmaceuticals, cosmetics, energy, etc. Due to limited data availability and its inception nature, the *Biotechnology* and *Bioenergy* industries are discussed in the **Emerging sectors** (Section 6.2).

Overall, the contribution of* Marine living resources *to the EU Blue Economy in 2018 was 11.5% of the jobs, 9.6% of the GVA and 9% of the profits. Overall, the economic performance of the sector has improved and is better off than in 2009.

5.1.2. MAIN RESULTS

Size of the EU Marine living resources in 2018 and recent trends

Overall, the performance of the *Marine living resources* sector has steadily increased over the period analysed in terms of production and profit while stagnating in terms of employment.

Marine living resources generated a gross value added (GVA) of almost €21 billion in 2018, a 24% increase compared to 2009 (Figure 1 Figure 5.1). In 2018, the sector contributed to 9.6% of the EU Blue Economy GVA (established sectors), up from 7.8% in 2009.

Gross profit, valued at €8.4 billion in 2018, saw a 34% rise on 2009 (€6.6 billion). Turnover reached €129 billion, 26% more than in 2009, contributing to 17% of the total turnover produced by the Blue Economy sectors covered. The sector invested (net) €2.6 billion in tangible goods, a figure that has fluctuated between €1.9 billion in 2011 and €2.8 billion in 2009 (Figure 5.1).

The activities included in the sector directly employed over 573 300 persons in 2018, representing 11.5% of the EU blue jobs (established sectors), down from 11.9% in 2009. With the number of jobs decreasing and annual personnel costs increasing, amounting to almost €12.2 billion in 2018, the average annual wage was €21 316; a 20% increase on the 2009 average of €17 772 (Figure 5.2).

Spain leads the Marine living resources sector with 20% of the jobs and 17% of the GVA. Moreover, Spain generates the most jobs in all three sub-sectors apart from processing, where the United Kingdom takes the lead.

Results by subsector and Member State

Employment: The Primary sector contributed to 38% of the jobs, closely followed by Distribution (37%) and then Processing (25%). Employment fell by 3% since 2009: Processing and Distribution saw slight increases of 3% and 1%, respectively, while the Primary sector decreased by 11%. The top employers, in descending order, include Spain, Italy, France, the United Kingdom and Germany.

Gross value added: Distribution contributed with 41% of the sector's GVA of €20.9 billion, followed by the Primary sector (30%) and then Processing (29%). GVA of the sub-sectors increased by 24% compared to 2009: +33% for the Primary sector, +23% for Processing and +18% for Distribution. The top contributors, in descending order, include Spain, the United Kingdom, France, Italy and Germany.

Gross profit: reaching almost €8.4 billion in 2018, gross profit increased by 34% compared to 2009: +149% for the Primary sector, +15% for Processing and +7% for Distribution. Distribution contributed to 42% of the sector's total profit, followed by the Primary sector (32%) and then Processing (26%).

Net investment in tangible goods: Contrary to profit, net investments saw an overall cut of 7% compared to 2009. This decrease is driven by the 22% reduction in the Primary sector. Net investments increased in the Processing and Distribution subsectors by 10% and 5%, respectively.

Turnover: Distribution contributed with 62% of the sector's total turnover of €129 billion, followed by Processing (28%) and then the Primary sector (10%). Turnover of the three sub-sectors increased by 26% compared to 2009: +36% for Processing, +25% for Distribution and +14% for the Primary sector.

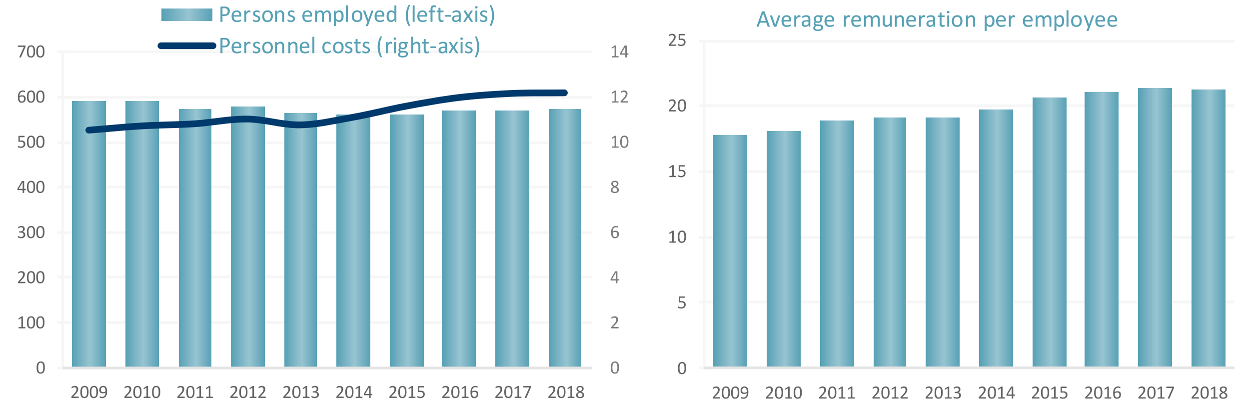
5.1.3. TRENDS AND DRIVERS

Within the primary sector, **capture fisheries**[175] production has increased and may have the capacity to do so further, particularly in the Mediterranean Sea. Profits have risen over the last few years, in part due to better status of fish stocks and increased fishing opportunities, in particular in the North-East Atlantic and nearby waters, together with higher average market prices and reduced operating costs, such as fuel, which is one of the main constraints for the EU fishing fleet. The economic performance

174 The retail sale in non-specialised stores (e.g. supermarkets and hypermarkets) is not included as it is currently not possible to identify the volume of seafood with respect the rest of products sold in those stores. See the methodological annex for additional information.

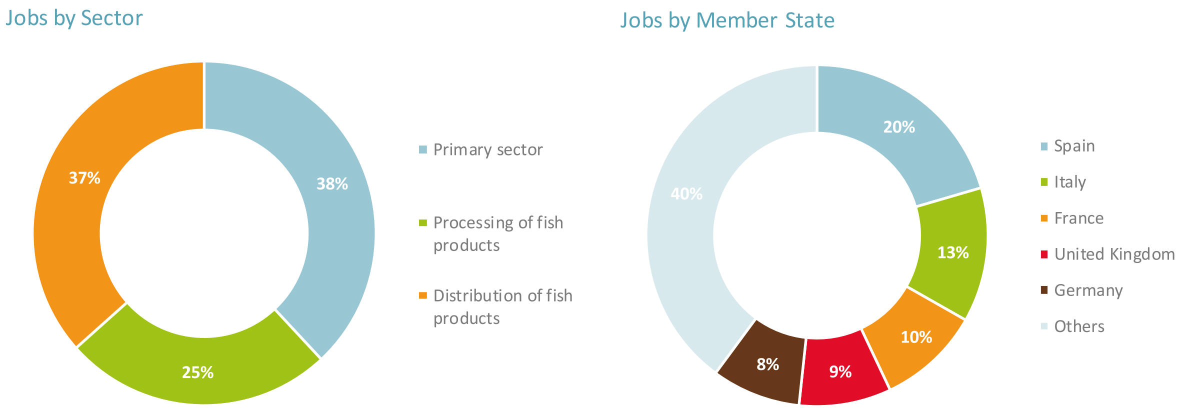
175 A detailed analysis of the economic performance of the EU fishing fleet activity is produced annually by the STECF and can be consulted at https://stecf.jrc.ec.europa.eu/reports/economic.

Figure 5.2 Persons employed (thousand), personnel costs (€ million) and average wage (€ thousand) in the EU *Marine living resource* sector



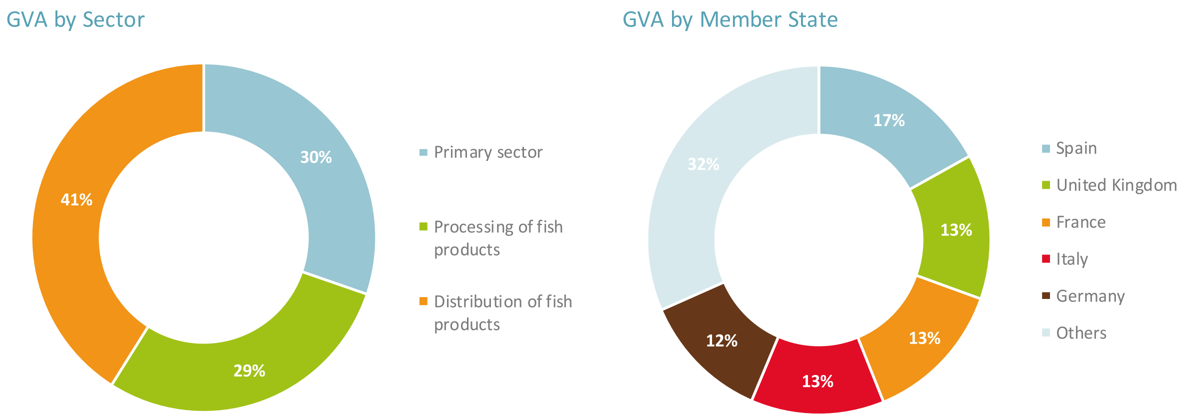
Source: Eurostat (SBS) and Commission Services.

Figure 5.3 Share of employment in the EU *Marine living resources sector*, 2018



Source: Eurostat (SBS) and Commission Services

Figure 5.4 Share of the GVA generated by the EU *Marine living resources sector*, 2018



Source: Eurostat (SBS) and Commission Services

is expected to continue to improve as fish stocks recover and capacity continues to adapt. The landing obligation should lead to more abundant fish stocks with larger fish sizes in the long term, which would be translated into an increase in the revenues and a reduction in the operational costs, leading to further improvements in the economic performance.

On the other hand, EU **aquaculture**[176] production (in volume) has stagnated over the last decades even if its value has increased. In 2013, there was an important effect from diseases and lack of seeds affecting mainly mussels and other shellfish. From 2014 on, the production has recovered. The production of other important species (such as salmon, seabream and seabass), where the producers have a higher degree of control on the production factors, has increased. Considering the increasing demand of seafood products in the EU, it seems realistic to expect a growth of the EU aquaculture products with a high degree of control (e.g. in close systems) as far as the investments and costs involved ensure that these facilities are profitable, while production of shellfish will be more dependent on environmental factors. The economic performance of the EU aquaculture sector is at the same time dependent on international competition. The sector has very high production standards in terms of environmental protection, animal health and welfare, public health and safety, and working conditions.

While production is largely carried out by a big number of operators, distribution is increasingly concentrated in the hands of a few players. Adding value can enable producers to recover part of the value of the product, which is usually generated further down the chain. Under the European Maritime and Fisheries Fund (EMFF), FLAGs have the opportunity to support "adding value, creating jobs, attracting young people and innovation at all stages of the supply chain of fishery and aquaculture products"[177]. Besides, the common organisation of the markets in fishery and aquaculture products (the CMO Regulation) establishes Producer Organisations to allow producers to strengthen their collective bargaining power by enhancing their responsibilities in the management of fisheries and marketing.

The EU is the largest importer of seafood in the world. Imports of fish and seafood products from around the globe help satisfy the needs of the **processing** and **distribution** sectors to have a steady supply of fish products for EU consumers throughout the year. The supply of fisheries and seafood products to the EU market is ensured by the EU's own production and by imports,

BOX 5.1: 'FARM TO FORK' STRATEGY

Ensuring more sustainable food systems

The ***Farm to Fork Strategy*** is a key component of the **European Green Deal**. The goal of the strategy is to change the way the EU produces and consumes, without compromising the safety, quality and affordability of healthy food; while being produced with minimum impact on nature.

The strategy will address each and every step of the food chain, from production and processing, to distribution, marketing, consumption and international trade. It will also contribute to achieving a circular economy and reducing the environmental impact of the food processing and retail sectors by taking action on transport, storage, packaging and food waste. It will establish the EU food system as a global standard of sustainability, contributing to the objective of making Europe the first climate-neutral continent by 2050. Moreover, the strategy will include actions to combat food fraud, including strengthening enforcement and investigative capacity at EU level, and to launch a process to identify new innovative food and feed products, such as seafood based on algae.

European farmers and fishers are key to managing this transition. The "Farm to Fork Strategy" will strengthen their efforts to tackle climate change, protect the environment and preserve biodiversity, in particular during the current health and economic crisis. Sustainable food systems are resilient by nature and, together, the EU will be able to deliver on its commitments while supporting economic recovery and ensuring a fair and just transition to all.

From 'Fish to Fork', the maritime contribution

Our oceans and fisheries are key to food production and consumption in Europe. The EU's Farm to Fork Strategy sets ambitious targets to reduce seafood consumption and to make seafood production ecologically sustainable and a source of low-carbon food. The Common Fisheries Policy (CFP) will remain a key tool to support these efforts while ensuring a decent living for fishers and their families. Around 30% of the overall Maritime Fisheries Fund budget is set to contribute to climate action.

[176] A detailed analysis of the economic performance of the EU aquaculture sector produced by the STECF can be consulted at https://stecf.jrc.ec.europa.eu/reports/economic

[177] Article 63 (1a) of the EMFF (Regulation (EU) No 508/2014).

BOX 5.2: BEYOND THE EU: SUSTAINABLE FISHERIES PARTNERSHIP AGREEMENTS

Sustainable Fisheries Partnership Agreements (SFPAs) provide a framework for EU fleets to fish in third countries' Exclusive Economic Zones (EEZ). In exchange for access rights to surplus stocks, the EU provides financial and technical support to help develop the fishing industry, as well as other marine and maritime sectors in partner countries.

There are currently 13 active SFPAs in the Atlantic, Indian and Pacific oceans, involving the following countries: Cape Verde, Cook Islands, Gambia, Greenland, Guinea Bissau, Ivory Coast, Liberia, Madagascar, Mauritania, Mauritius, Morocco, Sao Tome e Principe, Senegal, and Seychelles.

The Blue economy is anchored within the governance framework provided through the SFPAs. Thus, in many partner countries, sectoral support, which is part of the financial compensation that the EU provides, supports the implementation and development of the Blue Economy. A few examples include:

The **Ivory Coast** and **Guinea Bissau** SFPAs earmark 10 % and 2.3 % of their sectoral support respectively to blue economy and aquaculture projects and a further 7 % and 2.3 % to support blue economy activities in coastal fisheries communities.

The SFPA with **Cape Verde** allocates 14.6 % of its sectoral support to blue economy and aquaculture projects and a further 25.5 % to support young entrepreneurship in blue economy projects, improving fish management conditions and trading facilities in local fish markets.

In **Senegal**, sectoral support from the SFPA targets the amelioration landing facilities for artisanal fisheries and the creation of artificial reefs. Up to 47 % of this budget further supports blue economy activities in coastal fisheries communities.

The SFPA with **Mauritius** foresees an amount of €135 000 per year to support the development of maritime policy and ocean economy. It covers activities in aquaculture, sustainable development of the oceans, maritime spatial planning, marine energy and marine environment.

In the case of the **Seychelles** SFPA, 31 % of their sectoral support budget went to blue economy initiatives developed in the area of aquaculture. One concrete example is the launch of aquaculture as an industry in Seychelles with the opening of the Broodstock Acclimation and Quarantine Facility (BAQF) in October 2019 at the Providence Fishing Port. The BAQF benefitted from almost €900 000 in funding under the sectoral support; and was developed within the framework of the Aquaculture Sector plan and National Aquaculture Policy, defined in Seychelles' Blue Economy Roadmap.

leading to a total of around 15 million tonnes available for human consumption. Apparent consumption (own production + imports – exports) is around 13 million tonnes[178].

EU production (from capture fisheries and aquaculture) covers less than 50 % of the total raw material requirements for the EU fish **processing** sector[179]. The processing sector is therefore very dependent on global fish markets. Whether the dependency on imports will be reduced as more stocks in European waters are fished at MSY level remains to be seen. Raw material prices have not decreased over the last years, despite an increase in the supply, due partly to an increase in demand. The high percentage costs of raw materials is expected to further increase and is not expected to be offset by improvements in efficiency (e.g. via innovations). Thus, the rising costs in raw materials and energy, are one of the main causes of the sector's low, although slightly improved, profit margins. Moreover, several Member States especially around the eastern Baltic Sea, have been and are still negatively affected by the Russian embargo and the subsequent substantial reduction in exports to Russia, which has been extended until December 2020.

Production and consumption of organic fish and seafood still represent a niche and new market in the EU despite growing demand in recent years[180]. From a global perspective, Europe continues to be the largest market for organic seafood and although the consumption of organic seafood products is still relatively small, it is expected to grow strongly in the near future as consumers become more environmentally and socially aware. Several large retailers across Europe have declared their strong commitment for selling more sustainable seafood but this mostly includes ASC[181] and MSC[182] certified products. Seafood labelled as sustainable does not need to be organic.

[178] EUMOFA (2019). The EU Fish Market [https://www.eumofa.eu/documents/20178/157549/EN_The+EU+fish+market_2019.pdf].
[179] A detailed analysis of the economic performance of the EU fish processing sector produced by the STECF can be consulted at https://stecf.jrc.ec.europa.eu/reports/economic
[180] https://www.cbi.eu/market-information/fish-seafood/organic-seafood/
[181] Aquaculture Stewardship Council
[182] Marine Stewardship Council

5.1.4. INTERACTIONS WITH OTHER SECTORS

Commercial fishing competes with other maritime activities in terms of access to resources and space. This is particularly the case with respect to *Maritime transport*, *Marine non-living resources* and *Marine renewable energy*. On the other hand, capture fisheries may benefit from *Port activities* and positive spill over effects generated by the MPAs where fisheries resources are protected effectively. There are also mixed interactions. For instance, *Coastal tourism* activities may compete for space with fishing but tourists are also an important source of demand for fish products, especially from small-scale coastal fleets. Similarly, recreational fishing may target the same resources as commercial fishing but it also provides a potential reconversion opportunity for professional fishers to use their know-how to offer such services to visitors.[183]

Aquaculture may compete for access to space with *Coastal tourism*, *Port activities*, *Maritime transport*, *Non-living resources* (offshore oil and gas, marine mining) and fishing. Synergies may exist with offshore windfarms (e.g. multi-use platforms) and mix interactions with *Coastal tourism*.

5.2. MARINE NON-LIVING RESOURCES

5.2.1. BACKGROUND

The exploitation of Europe's seas and oceans for non-living marine resources has increased over the last decade and is projected to continue growing. However, the mature offshore gas and oil sector has been in decline for some years.

More than 80% of current European oil and gas production takes place offshore, mainly in the North Sea and to a lesser extent in the Mediterranean, and Black seas. Offshore production in the North Sea is carried out by the United Kingdom, Denmark, the Netherlands, Germany and Ireland. Offshore production occurs in the Baltic mainly along the Polish coast and in the Mediterranean, on the Italian continental shelf but also in Greece, Spain and Croatia. Romania and Bulgaria are hydrocarbon (oil and gas) producers in the Black Sea. Increasing exploration plans are foreseen for the Mediterranean region (in the Cypriot, Greek and Maltese continental shelves), the Black Sea (Bulgarian and Romanian continental shelves) as well as for the Atlantic East coast (Portuguese continental shelf).[184]

The offshore gas and oil sector is mostly in decline due to decreasing production and rising production costs, as well as a push towards clean energy in line with the European Green Deal. Low oil prices and the trend towards alternative sources of energy with a lower carbon footprint has also had some influence in making offshore facilities less economically viable.

Conversely, the *Other minerals* sub-sector is expected to be on the rise. The demand for resources such as sand and gravel, used for construction purposes and for producing concrete, is also likely to increase. Increasing demands for drinking and, in general, fresh water mean that desalination is also expected to grow, although trade-offs with energy consumption and environmental protection (release of brine and other by-products) are possible. Likewise, as coastal communities attempt to adapt to new pressures posed by climate change, dredging, beach nourishment and sand reclamation may intensify.

For the purpose of this report, the *Marine non-living resources* sector comprises two main subsectors, further broken-down into activities:

(1) **Oil and gas**: Extraction of crude petroleum, Extraction of natural gas and Support activities for petroleum and natural gas extraction;

(2) **Other minerals**: Operation of gravel and sand pits; mining of clays and kaolin, Extraction of salt and Support activities for other mining and quarrying.

Other activities that are still on an exploratory or emerging phase are discussed in Section 6.4.

[183] Note that various requirements, conditions and licencing may be required for providing such services.
[184] Joint Research Centre (JRC) (2015). EU Offshore Authorities Group – Web Portal: Offshore Oil and Gas Production. https://euoag.jrc.ec.europa.eu/node/63

Overall, the contribution of Marine non-living resources to the EU Blue Economy in 2018 was 1 % to jobs, 9 % to GVA and 16 % to profits. The sector is in a decline driven mainly by the offshore oil sector.

5.2.2. MAIN RESULTS

Size of the EU Marine non-living resources sector in 2018

In 2018, the GVA generated by the sector amounted to almost €19.6 billion, a 28.8 % decrease compared to 2009. Gross profits, at €14.9 billion, shrunk by 30.7 % on 2009 (€21.5 billion). Reported turnover was €43.3 billion, a 59 % decrease on the €105.6 billion turnover in 2009 (Figure 5.5).

Net investments in tangible goods reached almost €8.8 billion in 2018, almost 12 % less than in 2009. The ratio of net investments to GVA was estimated at almost 45 % in 2018, up from 36 % in 2009. New investments are being channelled into innovation, exploration and production units further offshore and in deeper waters.

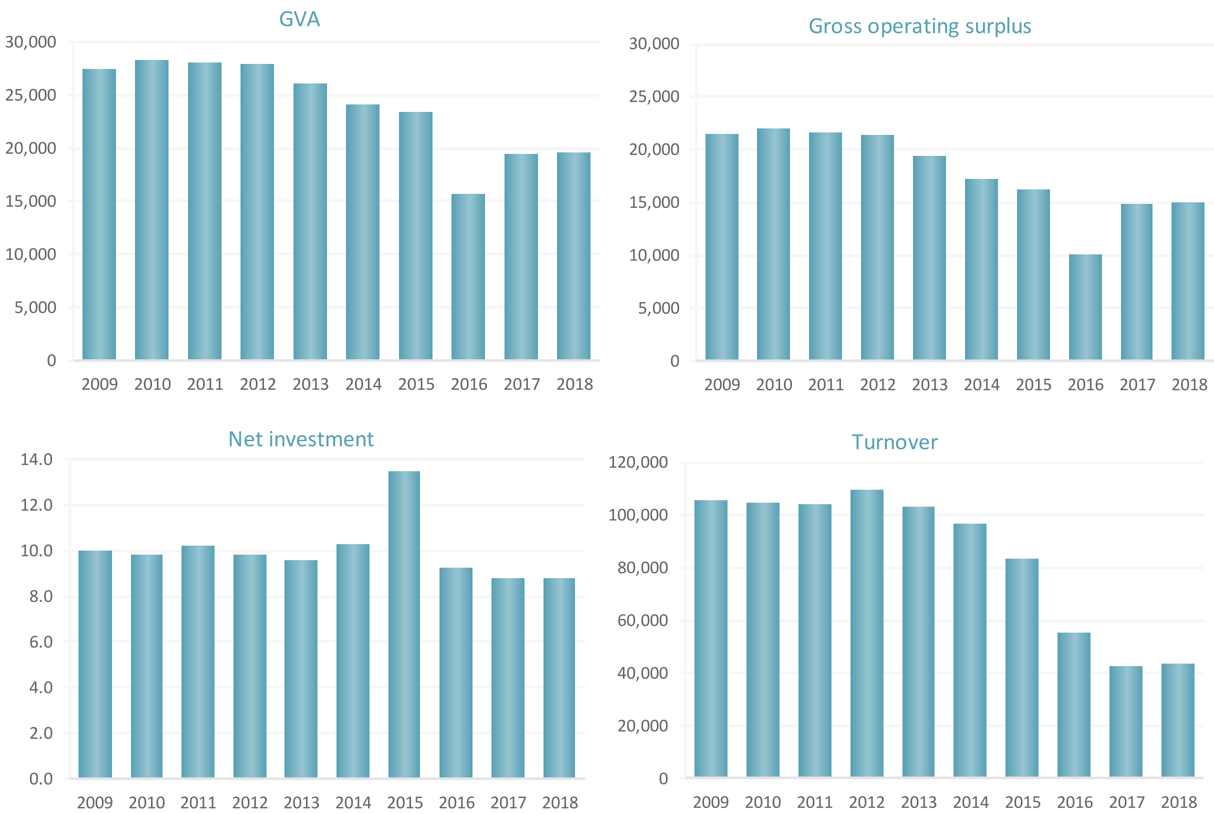
The sector directly employed more than 47 000 persons, 28.4 % less than in 2009. Personnel costs totalled €4.6 billion, 22 % less than in 2009. As personnel costs decreased less than persons employed, annual average wage, estimated at almost €98 700, increased slightly compared to 2009 (€90 870) (Figure 5.6).

The United Kingdom leads in Marine non-living resources with 73 % of the jobs and 79 % of the GVA. The sector is in decline, in most part due to the oil and gas sub-sector.

Results by subsectors and Member States

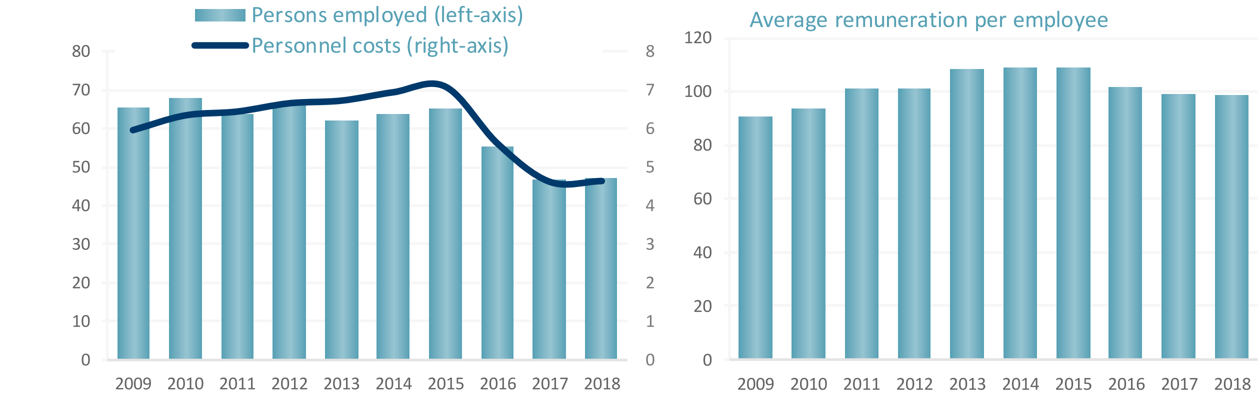
Employment: Oil and gas accounted for more than 45 300 persons employed in 2018, which represents 96 % of *Marine non-living resources*; other minerals employed the remaining 4 %. Overall, employment in the sector decreased by 28 % compared to 2009; a 29 % decrease for oil and gas and a 22 % decrease for other minerals. The top contributors, in descending order, include the United Kingdom (with 73 %), Romania, the Netherlands, Italy and Denmark.

Figure 5.5 Size of the EU *Marine non-living resource* sector, € million



Note: Turnover should be interpreted with caution due to the problem of double counting throughout the value chain.
Source: Eurostat (SBS) and Commission Services.

Figure 5.6 Persons employed (thousand), personnel costs (€ million) and average wage (€ thousand) in the EU *Marine non-living resource* sector



Source: Eurostat (SBS) and Commission Services.

Turnover: Oil and gas accounts for almost €42.9 billion, which represents the 99 % of the whole *Non-living resources* sector turnover; other minerals only produced slightly more that €450 million. Overall turnover in the sector decreased by 59 %, driven by a similar decrease for the oil and gas subsector.

Gross value added: Oil and gas accounts for more than €19.4 billion, which represents the 99 % of the whole sector GVA; other minerals only produced slightly less than €150 million of GVA. Overall turnover in the sector decreased by 29 %, driven by a similar decrease for the oil and gas sub-sector. The top contributors, in descending order, include the United Kingdom (with 79 %), the Netherlands, Denmark, Italy and Croatia.

Gross profit: The bulk of profits are generated by oil and gas (€21.4 billion). Gross profits suffered a significant fall compared to 2009 (31 %); both sub-sectors saw declines, with oil and gas declining by 31 % and other minerals by 26 %.

Net investment in tangible goods: The overall 12 % fall in investments compared to 2009 was driven by the oil and gas sub-sector; while other minerals remained stable (1 % increase).

5.2.3. TRENDS AND DRIVERS

The EU aims to be climate neutral, i.e., no net emissions of greenhouse gases, by 2050. To achieve these reduction targets, significant investments need to be made in new low-carbon technologies, renewable energies, energy efficiency, and grid infrastructure. Natural gas should play a key role in achieving this reduction even with current technologies, in the short and medium term, until supply of renewable energies becomes the main source. As investments are made for a period of 20 to 60 years, policies that promote a stable business framework, which encourages low-carbon investments, need to be in place well beforehand.

None of the EU Member States are self-sufficient in relation to their energy needs (as far as fossil fuels are concerned), with some smaller MSs, such as Malta, Cyprus and Luxembourg, almost completely reliant on external supplies. At the other end of the range, Estonia and Denmark are much less reliant on imports to meet their energy needs.

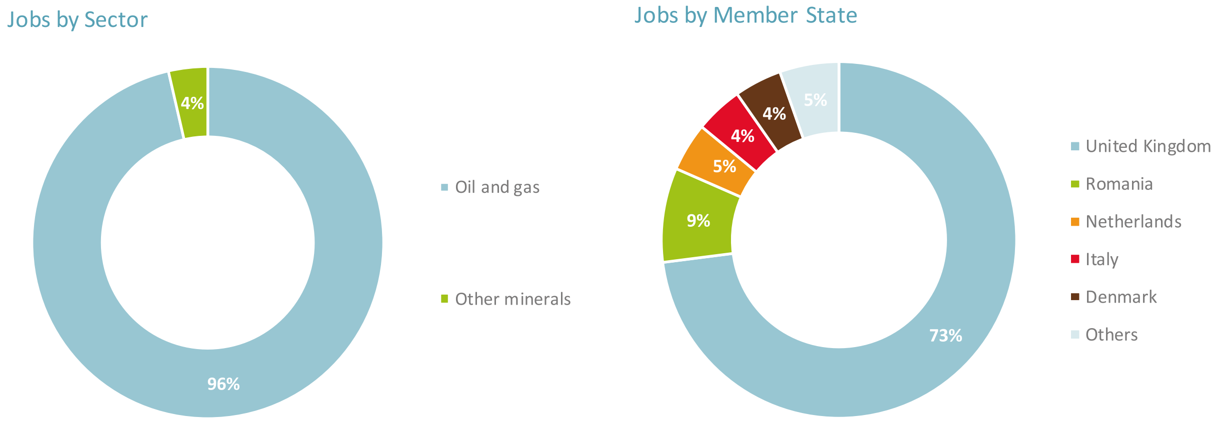
Despite decreasing crude oil production and consumption in the EU in recent years, crude oil and its derived products still remain the largest contributors to energy consumption.[185] The EU imports more than half of the fossil fuel energy it consumes each year, with a particularly high levels of dependency for crude oil and natural gas. The main extra-EU crude oil and natural gas sources for the EU are Russia and Norway.

Crude oil and gas prices have been relatively low in recent years, while recently increasing. Future fossil fuel prices however remain uncertain. The reduction in EU demand for crude oil together with the potential reduction in Chinese demand and increases in world production of crude oil may lead to a decrease in oil prices. On the other hand, demand for gas is expected to continue increasing and, in consequence, so will its price. The limited expected price increases, at least in the short term, together with a decreasing trend in production and increasing costs to exploit more remote reserves point to the continued deterioration of the economic performance of the sector.

More recently and following the measures taken to confront the COVID-19 pandemic in early 2020, oil prices collapsed due to market concerns and the fall in economic activity, as well as the related Saudi Arabia-Russia oil price war that began in March 2020. Therefore, it is expected that offshore exploitation of oil and gas will further continue to decline.

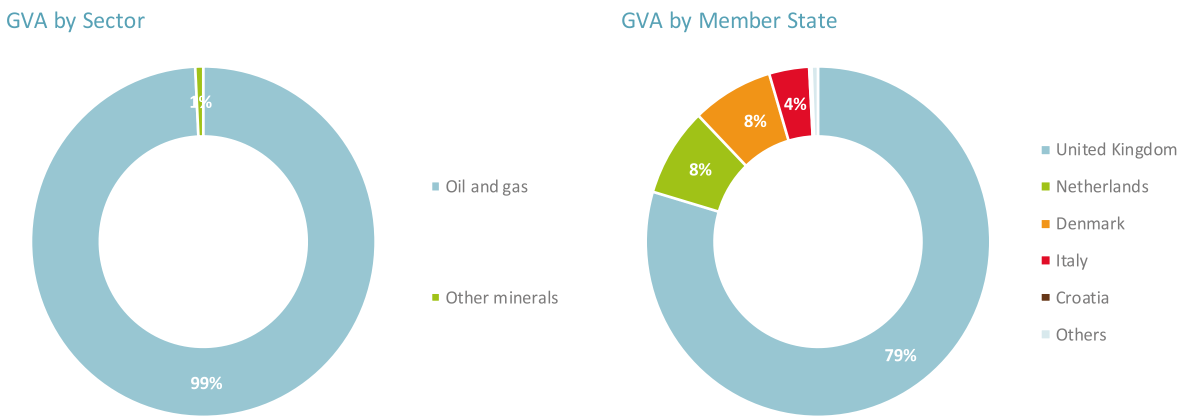
[185] Eurostat. Oil and petroleum products — a statistical overview. Available at: https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Oil_and_petroleum_products_-_a_statistical_overview&oldid=315177#Imports_of_crude_oil

Figure 5.7 Share of employment in the EU *Marine non-living resources* sector, 2018



Source: Eurostat (SBS) and Commission Services

Figure 5.8 Share of the GVA generated by the EU *Marine non-living resources* sector, 2018



Source: Eurostat (SBS) and Commission Services

5.2.4. INTERACTIONS WITH OTHER SECTORS

Activities related to *Marine non-living resources* may compete for access to space with activities in *Coastal tourism*, the *Marine living resources'* primary sector (capture fisheries and aquaculture) and *Maritime transport*. In particular, gravel extraction may conflict with capture fisheries because gravel beds are the principal spawning grounds for several commercially important species. On the other hand, synergies exist with *Port activities* and *Shipbuilding and repair* and mixed interactions with *Marine renewable energy* (wind farms and Multi-use platforms).

The sector has developed technologies, infrastructure and operational skills of significant value to the Blue Economy. With the depletion of many exploited fields and the start of dismantling, these strengths could prove very useful for the development of new offshore activities, such as floating offshore windfarms or geothermal power and structures such as multi-use platforms (see Section 6.1).

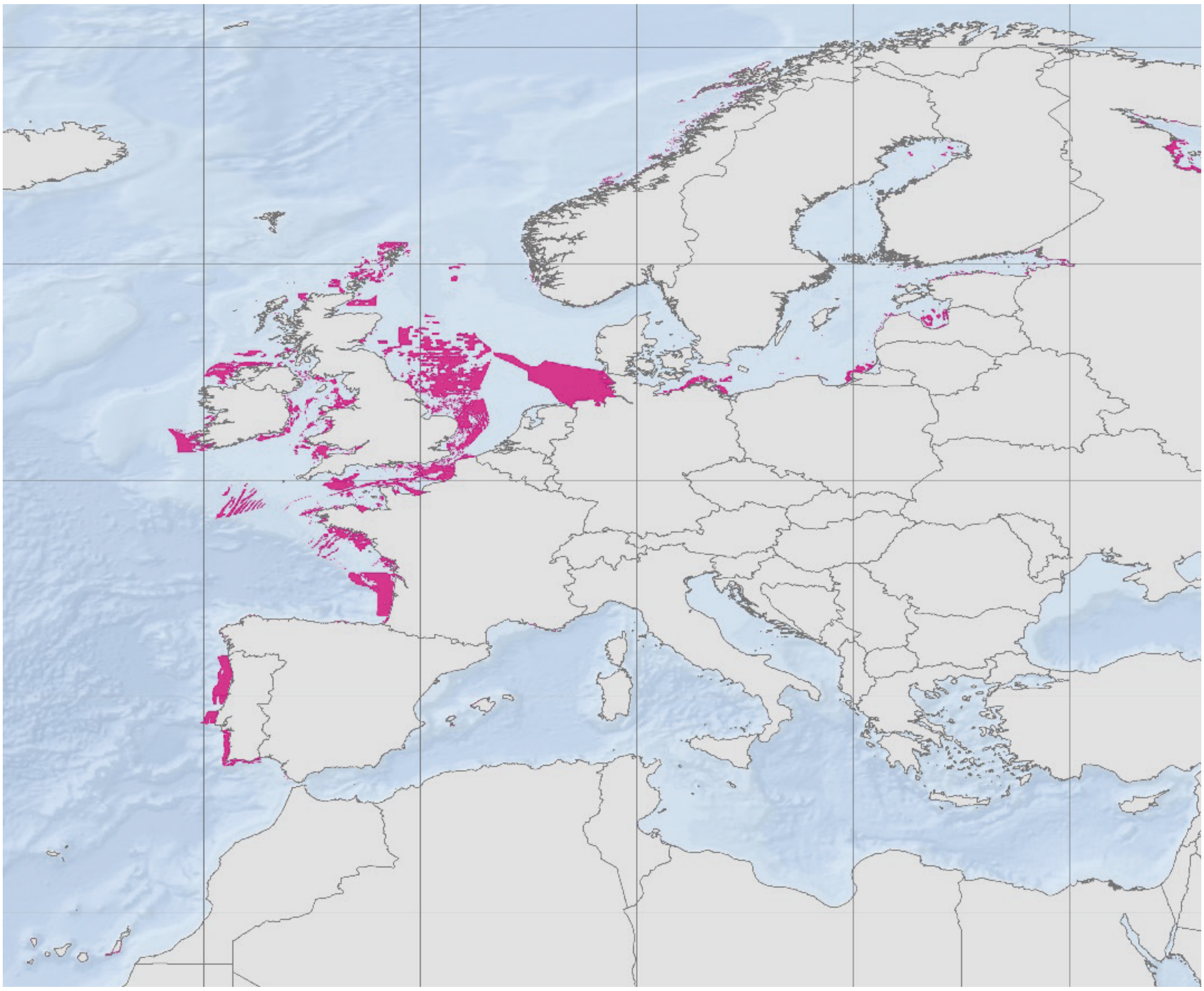
Against a backdrop of increased renewable energy production, offshore oil and, in particular, natural gas projects are expected to continue to be a major source of hydrocarbon resources into the coming decade. These activities will further develop *Port activities*, where a significant share of traffic involves offshore support vessels (OSV), such as, offshore construction vessels (OCV), dive support vessels, stand-by vessels, inspection, maintenance and repair vessels (IMR), ROV support vessels, etc. As well as offering further cargo and EPC (Engineering, Procurement, and Construction) opportunities, offshore oil and gas also enables *Port activities* to be involved in the decommissioning of platforms. This involves moving components that are (nearing) to the end of their working lives away from hydrocarbons fields. For example, the Port of Aberdeen is seen as a market leader in capturing oil and gas cargoes in the fiercely competitive North Sea area, while the Port of Rotterdam is evaluating expansion of its existing facilities to include decommissioning facilities at its Maasvlakte 2 port upgrade project.

Table 5.2 Licences for exploration or extraction of aggregates and known occurrences in a selection of EU MS EEZ, 1970-2018, Number

Type of licence	Extraction			Exploration		Total	Occurrences
Status	Active	Unknown	Not active	Unknown	Not active		
Belgium	10		13			23	1
Denmark	106		96	30	2	234	1,017
France	24	6	43	12		85	153
Germany	27	9				36	367
Italy		3	3			6	
Lithuania		1				1	
Poland	4	15	6			25	18
The Netherlands	105	9	136			250	4
United Kingdom	91		220	16		327	5
Total	**367**	**43**	**517**	**58**	**2**	**987**	**1,565**
Estonia							5
Finland			3			3	7
Ireland							22
Portugal							24
Spain							284
Sweden			1			1	10

Source: EMODnet Human Activities and GeoERA-MINDeSEA.

Figure 5.9 Identified occurrences of marine aggregates



Source: EMODnet

5.2.5. MARINE AGGREGATES (SAND AND GRAVEL)

Marine aggregates are naturally occurring sediment deposits found in coastal areas and in the seabed of the continental shelf. The extraction of aggregates is long established in some EU Member States (e.g. the Netherlands, Belgium and the United Kingdom). The extraction and dredging of sand and gravel from the seabed is mainly used for beach nourishment and construction, but also for reclamation fill, port construction and agronomics (soil enrichment and wastewater treatment). In general, it can be considered a non-renewable resource, as a continuous extraction of marine aggregates will not be sustainable in the long run. Hence, effective policies/regulatory frameworks and suitable maritime spatial planning need to be in place to address future demand and ensure a sustainable development.

The identification of potential deposits is often linked to marine research projects, such as general geological mapping of the seabed and/or habitat mapping. Many EU Member States have produced geological and seabed habitat maps of their coastal areas. EMODnet Geology and EMODnet Seabed Habitats display harmonised broad-scale physical maps for all European sea-basins, including sea-floor geology, seabed habitats and mineral resources (including aggregate deposits).

According to project MINDeSEA, almost 2 000 occurrences of aggregates have been identified in EU waters (Figure 5.9). EMODnet Human Activities estimates that between 2008 and 2018 about 165 million m^3 of marine aggregates plus 220 million tonnes of marine aggregates were extracted from EU waters. For the Member States where data are available, a total of 990 licences for either exploration or extraction of marine aggregates have been identified, of which only 367 are currently active. Most of these licences are found in Denmark (106), the Netherlands (105) and the United Kingdom (91) (Table 5.2).

BOX 5.3: SEČOVLJE SALINA NATURE PARK (SSNP), SLOVENIA

The Slovenian coastline is 46km long, but despite its size, it creates a large concentration of offshore activities. In terms of GVA and employment, maritime transport and tourism are two of the most important sectors in Slovenia's Blue Economy[186]. However, other relevant but more minor sectors include the *Marine living resources* and **salt production**.

The *Sečovlje* Salina is a Marine Protected Area (MPA) used for traditional salt production through seawater evaporation. A number of other products are produced using the natural resources (mud, algae) available in the saltpans and surrounding water. The commercialisation of such products is strengthened due to its MPA origin.

The *Sečovlje* saltpans extend over an area of 6.5km^2, and are a Special Protected Area under the Natura 2000. It is divided into three areas. *Fontanigge*, where no economic activities are allowed, *Lera*, where all salt-making activities take place (other activities allowed but cannot interfere in its conservation), and a third, which permits activities so long as they do not undermine the natural balance of the park.

Economic benefits of salt production

According to 2017 data, yearly salt production in *Lera* was approximately 2 400 tonnes and although salt is not produced at *Fontanigge*, water managed in this area is pumped to *Lera* for that purpose. Traditional salt-making activities have a direct impact on the socio-economic value of the site. Aside of jobs in salt fields, the renovation/maintenance of saltpans provide job opportunities for subcontractors and service. Additionally, salt production is a tourist attraction, hence providing for catering activities.

The latest data shows that Soline (salt production company), employs 206 people. In 2016 it produced 2 411 tonnes of various salts and salt flower compared to 2 201 tonnes in 2015 (Table 5.3). Additionally, the overall value of sales for 2016, (including non-salt products such as the dining programme and merchandise), was around €2.5 million, increasing by 6 % from 2015.

Table 5.3 Salt production in Sečovlje Salina Nature Park by type

Type	Production tonnes	
	2015	**2016**
Piran salt	234.6	0
Traditional salt	1,125.7	1,326
Industrial salt	798.2	1,050
Salt Flower	42.9	35
Total	**2,201.4**	**2,411**

Sources: Study on Economic benefits of MPAs and SPMS.

Table 5.4 Income from sales in Sečovlje Salina Nature Park, € thousand

Category	2015	2016
Own sales/stores	1,243	1,276
Other domestic sales	792	917
Abroad	312	305
Total	**2,347**	**2,499**

Sources: Study on Economic benefits of MPAs and SPMS.

186 ICF, IEEP and PML (2018). Study on the Economic Benefits of MPAs and SPMs. European Commission – Case Studies. P239-255. Available at: https://op.europa.eu/en/publication-detail/-/publication/a41531f1-b0bd-11e8-99ee-01aa75ed71a1/language-en. Note: all data provided in this Box comes from ICF, IEEP and PML (2018) p239-255.

Because of the traditional/manual processes used, the quantity of salt produced by Soline is limited. However, it is precisely this, which has enabled the company to sell its products at a higher value by building an image that reflects the value in the origin of the resources and the traditional processes used in their production.

Benefits from the MPA to other blue economy sectors

The Sečovlje Salina Nature Park (SSNP) is a good example of how the same space can host several (economic) activities, which may even generate synergies. For instance, besides the production of salt, the SSNP provides tourism services, is an important research site and source for several products linked to the bio-economy.

Coastal tourism: Tourism activities include: sightseeing, birdwatching, salt-related activities and outdoor sports; however, no over-night stay is possible at the park. In 2016 the park received almost 40 000 visitors, an increase of 25 % compared to the previous year, generating a revenue of €232 840. The park also hosts a Spa, *Lepa Vida Thalasso*, which is a popular tourist attraction and which had roughly 4 500 customers in 2016, up 24 % from 2015.

Research/ Science: Due to its unique specificities much research and monitoring is undertaken at SSNP and a number of projects have been supported by regional and international funding programs such as MANSALT (2010-15). Soline was also the lead partner in a €7 million LIFE+ project.

Blue Bio-economy: Apart from salt, Soline uses its natural resources to produce other products such as brine and mud, which together generated a revenue €29 640 in 2016. They are mostly used in health centres, spas and to produce cosmetics, an activity, which has significant potential for expansion. The Slovenian Ministry of Health issued a certificate stating that the brine and mud from the saltpans are beneficial for human health.

Funding and costs

The sources of funding for Soline are a combination of public and private, in addition to the income derived from the sales of goods and services. Their overall budget for 2018 was around €0.5 million and almost 50 % came from revenues generated by the park, approximately 45 % from the Slovenian government and the rest from private companies such as Telekoms (Table 5.5).

Table 5.5 Funding sources of Sečovlje Salina Nature Park, plans for 2018, € thousand

Funding Source	Amount
Government budget	230
SSNP own revenue (sale of goods/services)	240
Revenue from SKZGS	30
Total	**500**

Sources: Study on Economic benefits of MPAs and SPMS.

Aggregate extraction and dredging are activities thought to potentially cause significant environmental impact. Both the operation of removing material from the bottom, as well as its relocation to another place can affect the marine ecosystems and other services for humans, such as fishing resources, beaches, etc. In Europe, dredging activities and the disposal of these materials are well established and regulated by national authorities, which in turn are normally based on international guidelines (e.g. OSPAR guidelines[187]). To guarantee that these activities are environmentally sustainable, projects are normally subject to environmental impact assessments, consent and control procedures, often integrated in the maritime spatial plans. Good maritime spatial planning could help mitigate competition for access and space by the different economic activities.

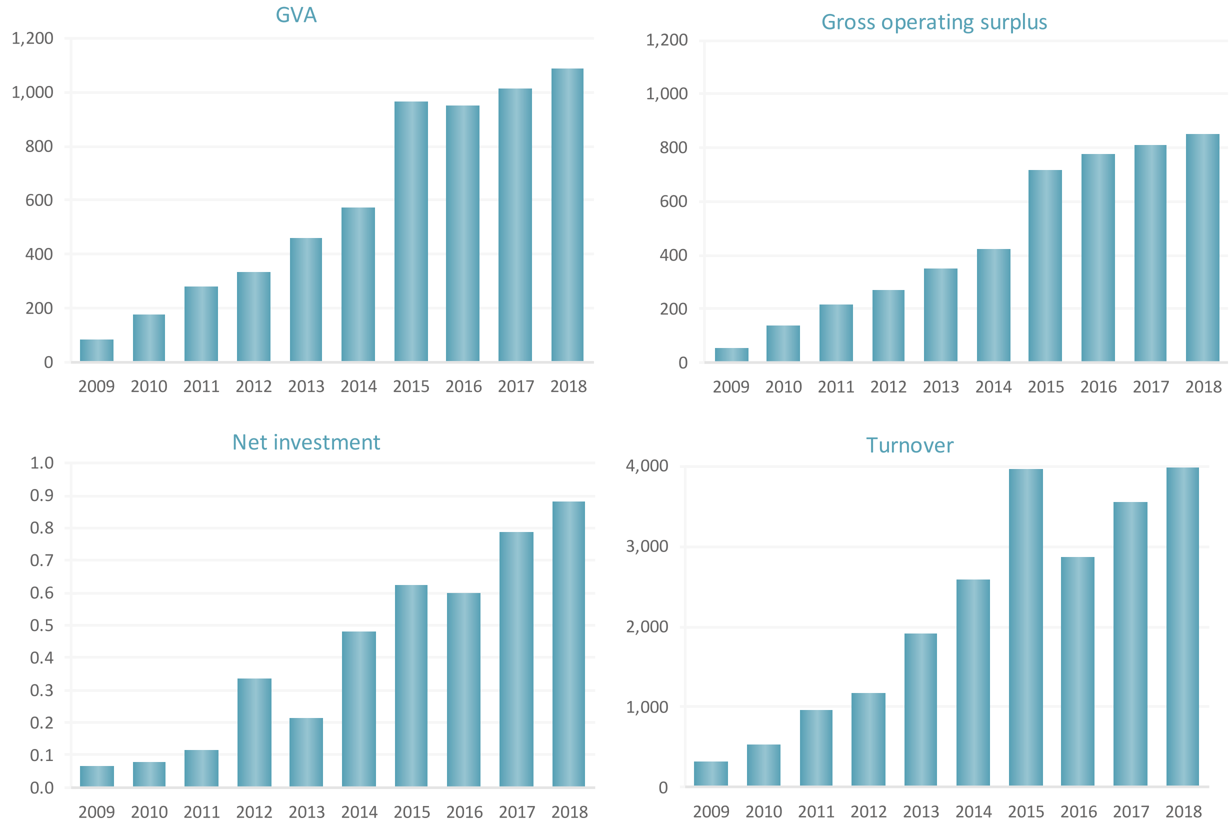
5.2.6. SOLAR SALT

While salt is used in a variety of applications (food, feed, de-icing, pharmaceutical, water-treatment, chloralkali, etc.), salt extracted from the sea (and salty lakes) by evaporation is mainly used for human food and food processing, which require about 2 million tonnes of salt per year.

In Europe, salt is mainly produced through solution mined salt (salt-in-brine) and rock salt for industrial applications and de-icing. Production from solar salt represents less than 10 % of total EU salt production, which is about 4 million tonnes of a total of 48 million tonnes produced in the EU 28 in 2016.[188] Solar salt is mostly produced along the coasts of France, Greece, Italy, Portugal and Spain. Solar evaporation is the cheapest method available for the production of salt, at a cost of about €14 per tonne compared to more than €20 per tonne for other methods such as rock and brine salt.

[187] OSPAR Guidelines for the Management of Dredged Material at Sea, Agreement 2014-06. Available at: www.ospar.org/documents?d=34060.
[188] This is a bit unusual, as worldwide solar salt represents about 40 % of the production.

Figure 5.10 Size of the EU *Offshore wind energy* (production and transmission), € million



Note: Turnover should be interpreted with caution due to the problem of double counting throughout the value chain.
Source: Eurostat (SBS) and Commission Services.

5.3. MARINE RENEWABLE ENERGY

5.3.1. BACKGROUND

Marine Renewable Energy (MRE) includes all renewable energy sources that can be generated at sea such as ***offshore wind energy*** and ***ocean energy,*** as well as ***floating solar PV***. MRE represent an important source of green energy and can make a significant contribution to the EU's 2050 energy strategy. Moreover, the MRE sector presents a great potential to generate economic growth and jobs, enhance the security of its energy supply and boost competitiveness through technological innovation.

Offshore wind energy is currently the only commercial deployment of a marine renewable energy with wide-scale adoption. **Ocean energy technologies** are currently being developed and tested to exploit the vast source of clean, renewable energy that our seas and oceans have to offer. Although still at the research and development stage and not yet commercially available, promising ocean technologies include: wave energy, tidal energy, salinity gradient energy and ocean thermal energy conversion (OTEC). Wave and tidal energy are currently the more mature of these technologies.

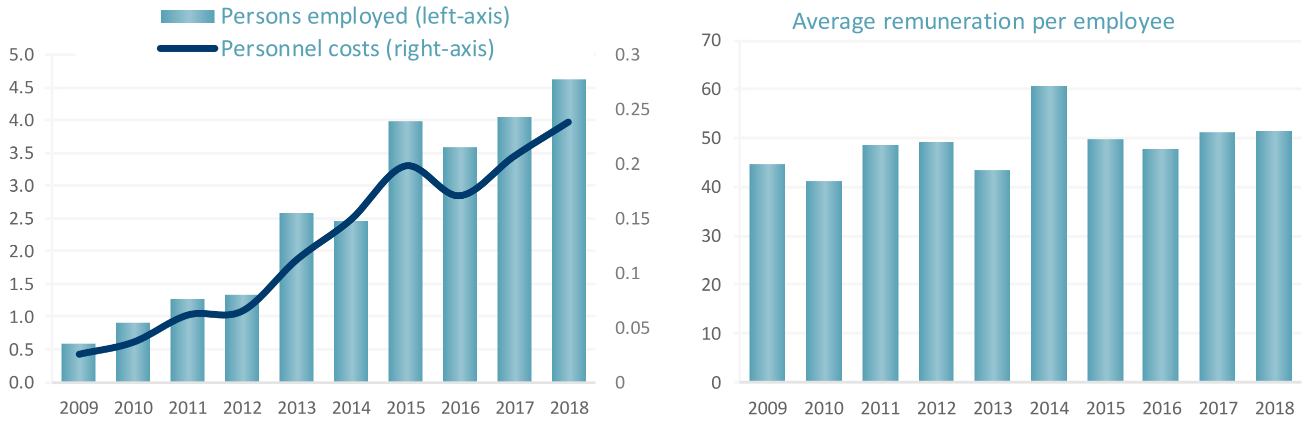
Europe is by far the world leader in offshore wind energy, with over 90% of the world's total installed capacity. Starting with only a small number of demonstration plants[189] in the early 2000s, the EU now has a total installed offshore wind capacity of 22.1 GW from 5047 grid-connected wind turbines across 12 countries.[190] In 2019, 502 new offshore wind turbines were connected to the grid across 10 projects. This brought 3.6 GW of new (gross) additional capacity. The main EU producers of offshore wind energy are: the United Kingdom, Germany, Denmark, the Netherlands and Belgium.

Given the development in the construction of plants but also in being operational, this edition of the EU Blue Economy Report includes the **production** and **transmission** of electricity generated by offshore wind farms as an additional established sector.

For the purpose of this report, and due to data availability, the **Marine renewable energy** sector currently only comprises **Fixed offshore wind**. Results are complemented by analyses of the sector in terms of capacity and construction of new plants (Section 5.3.5) while other ocean energy technologies (i.e. floating wind energy, wave and tidal energy, etc.) are presented under **Emerging Sectors** (Section 6.1).

[189] The first offshore wind farm (Vindeby) was installed in Denmark in 1991 and decommissioned in 2017, after 25 years of useful life.
[190] Wind Europe (2019): Offshore Wind in Europe. Key trends and statistics 2018.

Figure 5.11 Persons employed (thousand), personnel costs (€ million) and average wage (€ thousand) in EU *Offshore wind energy* (production and transmission)



Source: Eurostat (SBS) and Commission Services.

Overall, Offshore wind energy (production and transmission) contributed 0.1 % of the jobs, 0.5 % of the GVA and 0.9 % of the profits to the total EU Blue Economy in 2018. The sector is still relatively small but is in expansion.

5.3.2. MAIN RESULTS

Size of the EU Offshore wind energy (production and transmission) in 2018

In 2018, the GVA generated by the production and transmission of *Offshore wind* energy[191] was almost €1.1 billion, a 1 276 % increase compared to 2009 (€79 million). Gross profits, at €850 million, increased by 1 460 % on 2009 (€55 million) (Figure 5.10). Reported turnover was just under €4 billion, 1 185 % higher than the €310 million in 2009.

Net investments in tangible goods reached €884 million in 2018, about 1 268 % more than in 2009. The ratio of net investments to GVA was estimated at 81 %, similar to the 82 % in 2009. New investments are being channelled into innovation, development, exploration and production units further offshore and in deeper waters.

The sector directly employed 4 624 persons, up from 582 persons in 2009. Personnel costs totalled €238 million, 820 % more than in 2009. The annual average wage, estimated at €51 570, increased compared to 2009 (€44 519) (Figure 5.11).

The United Kingdom currently leads in Offshore wind energy with 60 % of the jobs and 48 % of the GVA, closely followed by Denmark with 42 % of the GVA, however, data for Germany, also a leading contributor, are not available. The sector is in large expansion.

Results by Member States

Employment[192]: The top contributors, in descending order, include the United Kingdom with 60 % (2 758 persons), followed by Denmark (767 persons), the Netherlands (743 persons) and Belgium (356 persons).

Gross value added: The top contributors, in descending order, include the United Kingdom with 48 % (€521 million), Denmark (€463 million) and Belgium (€105 million).

Gross profit: Demark produced 48 % of the profits (€410 million), followed by the United Kingdom with 44 % (€374 million), and then Belgium with the remaining 8 % (€66 million).

Net investment in tangible goods: The United Kingdom invested 59 % (€522 million) of the total reported, followed by Demark with 25 % (€220 million), the Netherlands with 9 % (€83 million) and then Belgium with the remaining 7 % (€59 million).

Turnover: The United Kingdom accounted for 51 % (€2 billion) of the turnover produced, followed by Demark with 29 % (€1.1 billion) and then Belgium with the remaining 20 % (€798 million).

5.3.3. TRENDS AND DRIVERS

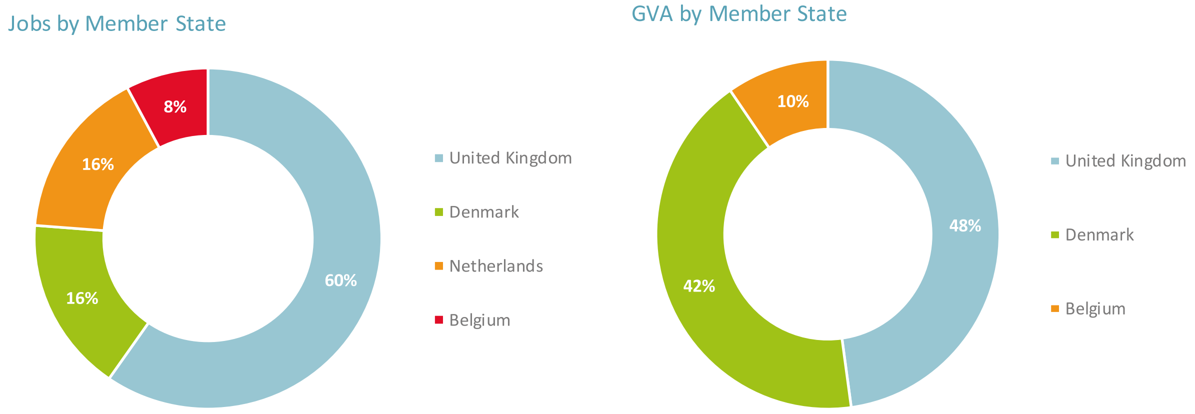
Europe has more than 90 % of the world's total installed offshore wind capacity, and will continue to dominate the offshore wind market for years to come. Offshore wind in Europe is focused mainly on the North Sea which has relatively shallow waters. The United Kingdom, Denmark and Germany are the clear leaders in offshore wind energy development in Europe.

Over the past 10 years, the European Commission has invested over €300 million in ocean energy research, development and innovation (RD&I), through a multitude of funding programmes. EU research and innovation support is mainly directed at reducing the costs and increasing the performance and reliability

[191] Information on this still emerging sector is limited and the results presented are undervalued. Data are available for Belgium, Denmark and the United Kingdom. Data on employment and investments only are available for the Netherlands. Eurostat data currently unavailable for Germany, one of the leaders in EU offshore wind energy.

[192] Due to data availability, all results exclude Germany. For the Netherlands, only employment and net investment data available.

Figure 5.12 Share of employment and GVA generated by the EU *Offshore wind energy* (production and transmission), 2018



Source: Eurostat (SBS) and Commission Services.

of offshore wind. The Commission is also supporting the development of floating substructures or integrated floating wind energy systems for deeper waters and use in other climate conditions. This will increase deployment possibilities and improve the European position in the global market.

Europe added 3.6 GW of new (gross) capacity in 2019, supplied to the grid by: the United Kingdom (1 764 MW), Germany (1 111 MW), Denmark (374 MW), Belgium (370 MW) and Portugal (8 MW).

Offshore wind turbines continue to get more powerful. On average, turbine capacity has increased by 16 % every year since 2014. Offshore wind farms continue to get bigger. Size almost doubled over a decade from 313 MW in 2010 to 621 MW in 2019. Wind farms are moving farther offshore and into deeper waters. This is a result of both better stable wind resources and the depletion of near-shore locations.

5.3.4. INTERACTIONS WITH OTHER SECTORS

Marine renewable energy may compete for the access to space with the *Marine living resources* (primary sector), *Coastal tourism* and the *Maritime transport* sectors.

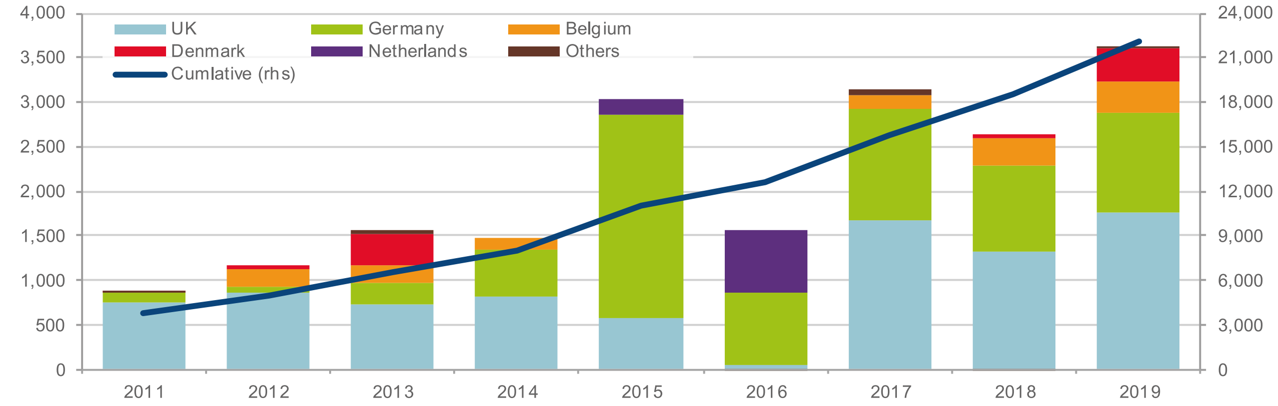
The growth of marine energy, in particular **offshore wind** creates potential synergies with the **offshore oil and gas sector**, with competencies required to construct and maintain offshore projects and to operate in harsh marine environments. Integration could bring benefits in terms of reduced costs, improved environmental performance and utilisation of infrastructure. The possibility to provide electricity to offshore oil and gas operations where there are wind farms nearby, or via floating turbines, reducing the need to run diesel or gas-fired generators on the platform and reducing emissions of carbon dioxide and air pollutants. New uses for existing offshore infrastructure once it reaches the end of its operational life, in ways that might aid energy transitions: for example, platforms could provide offshore bases for the maintenance of wind farms, house facilities to convert power to hydrogen or ammonia, or be used to inject CO_2 into depleted fields. In fact, some crossover between the sectors are already evident, in particular in the North Sea – a mature oil and gas basin with a thriving renewable energy industry — with some large oil and gas companies being also major players in offshore wind. For example, the former oil and gas company, Ørsted in Denmark, has moved entirely to wind and other renewables.

The potential synergies extend well beyond the energy sector to encompass shipping, port infrastructure and other maritime industries. *Port activities* and Ship*building and repair* (shipyards) benefit from the economic potential of offshore wind energy. Ports are home to the manufacturers of offshore wind turbines and their large components, as well as project developers and logistics companies. In particular, ports in the North and Baltic seas are adapting rapidly to offshore wind energy with, for example, expansion areas for plant and component manufacturers and heavy-duty terminals and berths for special ships in the sector. While coastal regions benefit in particular from this development, inland suppliers also benefit, e.g. from the metal and mechanical engineering industries, technical service providers, insurance or financing companies, certifiers and consulting firms.

Thus, the expansion of offshore wind energy offers growth impulses throughout the EU Blue Economy as well as other sectors. A comprehensive value chain (development, construction, operation) creates additional jobs in many businesses. This means that offshore wind power creates value across the economy. For example, according to BWO,[193] the development of offshore wind energy in Germany has so far created about 27 000 jobs. These are not only located near the coast, but also in southern and western Germany, where important components such as bearings, gearboxes and generators are manufactured, due to the industrial value chain. The expansion of offshore wind energy has great economic potential: total sales along the entire value chain amounted to around €9 billion in 2018.

[193] https://www.bwo-offshorewind.de/

Figure 5.13 EU *Offshore wind energy* installed capacity, MW



Note: Other Member States include Sweden, France, Spain, Ireland and Portugal.
Source: JRC, GWEC, WindEurope.

5.3.5. OFFSHORE WIND CAPACITY AND ITS SUPPLY CHAIN

Installed capacity in the offshore wind sector has witnessed a 10-fold growth between 2010 and 2019, having reached a total capacity of 22 GW in the EU at the end of 2019. Therefore, its production of electricity starts to be material and the previous sections have shown its growing importance in several EU Member States.

According to the European Commission's Long-term Strategic Vision, offshore wind capacity will increase to 240-440 GW capacity by 2050, stimulating economic growth in coastal areas and across Europe. Offshore wind is expected to play a key role in the path towards meeting the 2030 Energy and Climate Targets[194] and in supporting the transition to a climate neutral Europe in the context of the European Green Deal.

Between 2018 and 2019, the capacity of EU offshore wind increased by 3.63 GW, a 20% growth. (Figure 5.13). The United Kingdom is the country with the largest installed capacity of offshore wind energy (45%) followed by Germany (34%), Denmark (8%), Belgium (7%) and the Netherlands (5.5%). A nascent industry is present in Finland, Sweden, France, Spain, Ireland and Portugal. The EU's offshore wind industry keeps on leading the sector driven by a strong home market representing about 79% of the worldwide capacity deployed.[195]

As the sector continues to grow it requires important amounts of investments to keep increasing its capacity. The cumulative capital investment needed to deploy the 22 GW of capacity is estimated to have amounted to €80 billion, about €3.6 million per MW.

In 2019, 1.4 GW of new offshore wind capacity was financed, reaching final investment decision (FID) of €6 billion, with an average capital expenditure of €4.29 million per MW. These numbers represent the lowest commitment in terms of new capacity and investment in the past four years (Figure 5.14). While offshore wind has been concentrated in a few Member States, additional Member States are installing offshore wind farms. For instance, the 480 MW Saint-Nazaire wind farm has reached final investment decision, for a total cost of €2.4 billion and will become the first commercial offshore wind farm in France.

Offshore wind energy is gaining importance in relation to onshore wind energy: new offshore wind capacity increased from representing 11.5% of the new wind capacity installed in 2016 to 27% in 2019. In accumulated terms, offshore wind represents about 11% of the total installed wind energy capacity in the EU, growing from 8% in 2016. It represents over 42% of the wind energy capacity installed in the United Kingdom and 30% in Belgium (Figure 5.15).

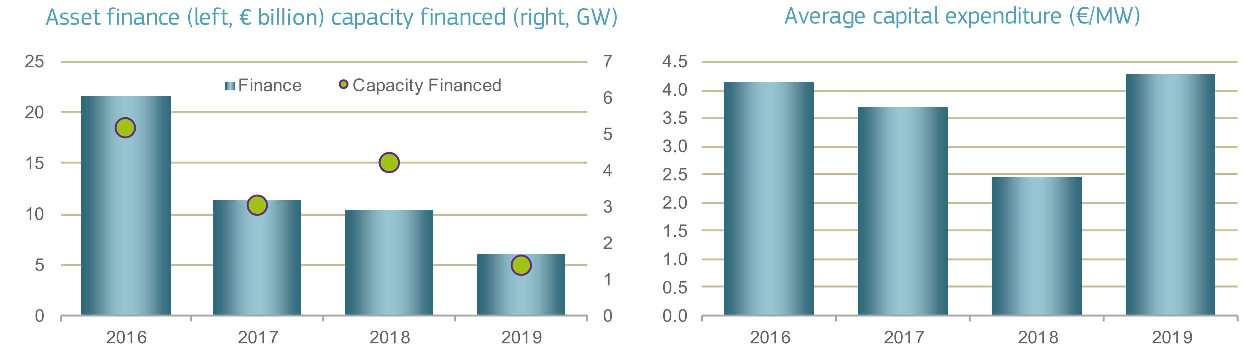
The installation of wind farms depends generally on the existence of some planning (see Section 2.2.3 on MSP) and on a process of public tendering of specific concessions. The shift from feed-in–tariffs (FiT)[196] to tender-based support schemes promoted by the State Aid Guidelines for Environmental protection and Energy (EEAG) has resulted in highly competitive price bidding in offshore tenders from mid-2016 onwards. So far, more than 3.1 GW of offshore capacities have been allocated under zero-subsidy bids[197] in Germany and the Netherlands, and bid prices have decreased in tenders held in Denmark and in the United Kingdom. Across the EU, a cumulative offshore wind capacity of about 13 GW has been allocated through competitive tendering procedures, which are expected to be commissioned by 2025.

Even though zero-subsidy bids are only possible under specific conditions in a few markets and to certain players, offshore bid prices are generally decreasing as a consequence of the advancements in technology (e.g. move towards bigger turbines), reduced financing costs, scalability towards larger wind farms, industrialisation and standardisation.

Looking ahead, some European countries have announced upcoming offshore tenders. In the Netherlands ongoing and upcoming

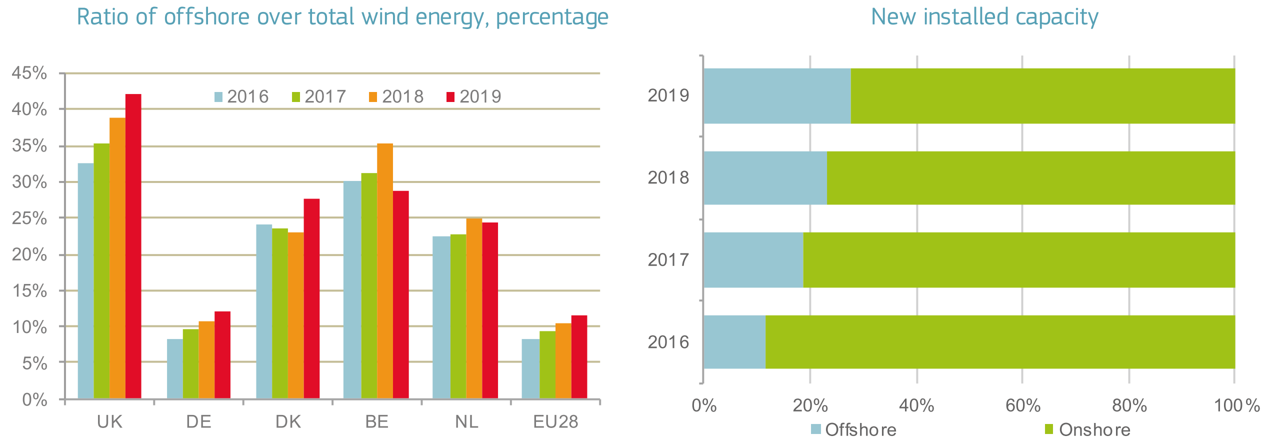
194 https://ec.europa.eu/energy/topics/energy-strategy/national-energy-climate-plans_en?redir=1
195 JRC (2020). Technology Development Report LCEO: Wind Energy. Forthcoming.
196 FiT is defined as a policy mechanism designed to accelerate investment in RET, by offering long-term contracts to RE producers, typically based on the cost of generation of each technology.
197 Zero-subsidy bid, i.e., without government support. The projects will rely solely on the wholesale electricity price when commissioned.

Figure 5.14 Announced financing and capacity to be installed, EU *Offshore wind energy*



Notes: Data based on the finance deals closed each year. Capacity might be added in the respective year or in the following years.
Source: WindEurope (2019, 2020), EurObserver'ER (2019, 2020).

Figure 5.15 Onshore vs. offshore wind energy in the EU



Source: EurObserver'ER (2020) WindEurope (2020), JRC.

tenders include offshore wind in five development zones amounting to an additional 6700 MW. Germany will hold a tender of 700 to 900 MW of offshore wind per year starting from 2021. After announcing the first commercial wind farm in Saint-Nazaire, France is planning to increase its offshore wind tendering target to 1GW per year until 2028. Moreover, the government plans to tender 250 MW each of floating offshore wind capacity off the coast of Brittany and in the Mediterranean in 2020 and 2021.

The continuous growth of the offshore wind energy sector is having a significant impact across Europe, with the sector linked to 110000 jobs[198]. The growing offshore wind market offers the opportunity for European manufacturers to expand their market and production capabilities and allows to lift synergies from the onshore wind market.

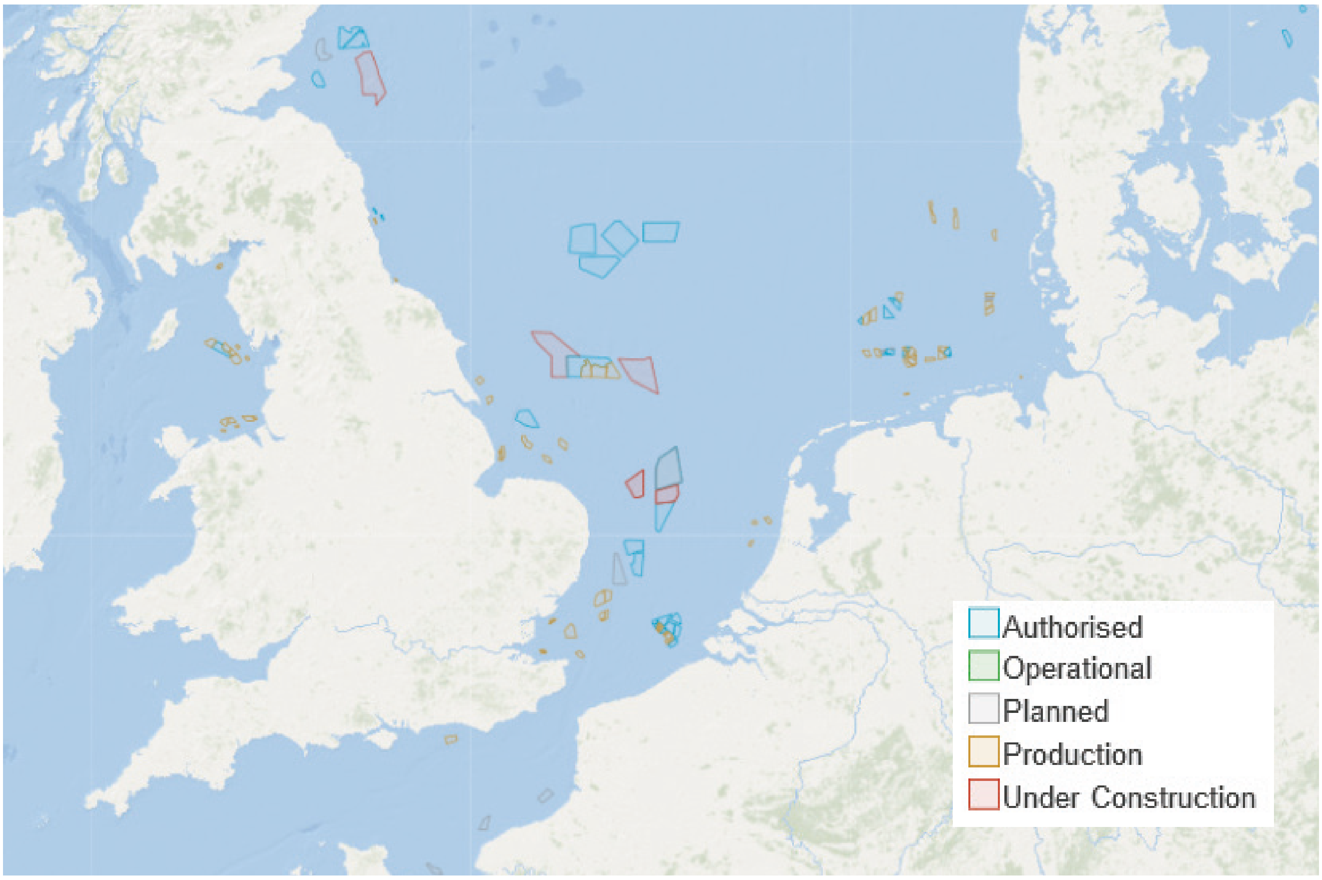
In the offshore wind market, Siemens Gamesa Renewable Energy (DE-ES) maintained their market leadership in 2019, with around 44% of new global capacity installed. MHI Vestas ranked the second largest offshore wind turbine supplier with around 14% of new installations. The Chinese market continues to grow and so does the market share of Chinese offshore manufacturers (between 7 and 10%) overtaking GE Renewable Energy (US) after commissioning only one European wind farm in 2019. Notably, an even stronger market concentration among European manufacturers can be witnessed following the insolvency of Senvion and the closure of its Bremerhaven turbine manufacturing plant at the end of 2019.

Offshore wind: a supply chain beyond coastal regions

European manufacturers capture around 35% of the global wind turbine value chain (onshore and offshore), only superseded by Chinese players who dominate the global manufacturing of components with almost 50%. The European wind industry has high manufacturing capabilities in components with a high value in wind turbine cost (towers, gearboxes and blades), as well as, in components with synergies to other industrial sectors (generators, power converters and control systems) and in the shipping industry for the production of vessels to support wind energy installation and maintenance. Additionally, European manufacturers show overcapacity in all key wind turbine components, when compared to the present and future European demand, at deployment rates between 12.1 and 22.7 GW/year. Expected deployment rates at global level also suggest an additional market potential for European manufacturers outside the EU.

[198] WindEurope 2019, Personal communication.

Figure 5.16 Location of EU offshore wind farms (polygons)



Source: European Commission (European Atlas of the Seas).

The construction of wind farms may have an effect well beyond the coastal areas, as the production and supply of wind turbine components and services can be located in other areas within the EEA internal market. For instance, the German and Danish Original Equipment Manufacturer (OEMs) have expanded to other European markets. Nordex SE, Enercon GmbH and Siemens Gamesa RE have spread their manufacturing facilities to big markets such as Spain, the United Kingdom and France, among others, but also to smaller markets such as Portugal, Sweden, Belgium, and Romania. The Danish wind turbine manufacturer Vestas Wind Systems and blade supplier LM Wind Power A/S have also installed facilities not only in Denmark, but also in Spain, Germany, and the United Kingdom. Some of the leading non-EU OEMs have located part of their manufacturing facilities close to their supply areas in Europe (Goldwind (located in Germany), GE Wind Energy (the United Kingdom, France) and Suzlon (Spain)) (see Figure 5.17 and Figure 5.18).

Services for offshore wind farms

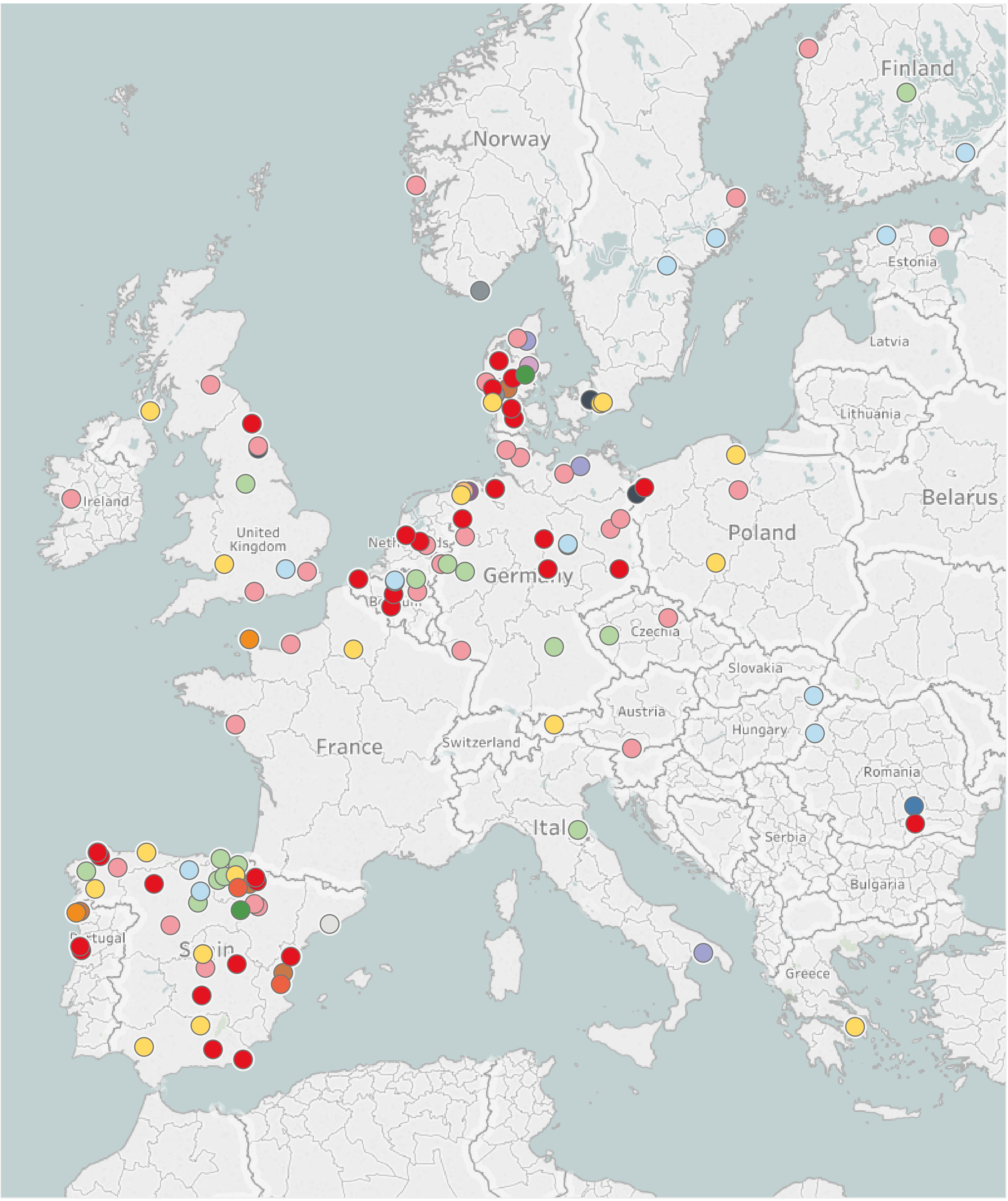
Besides the production of components, the installation and functioning of offshore wind farms generate additional economic activity in other sectors, particularly in shipbuilding. There are two types of vessels: on the one hand installation vessels, which are highly specialised; and on the other, service vessels, for the day to day functioning, inspection and maintenance of the farm once it is in operation.

In terms of installation vessels, the market is dominated by European companies, being home to more than 80 vessels, with the broadest crane capacity range. The offshore wind industry uses jack-up vessels and heavy-lift vessels to install wind turbines, foundations, transition pieces and substations. This includes the heavy-lift vessels with the highest crane capacity Saipem 7 000(14 000 t) and Heerema's Thialf (15 652 t).

The move towards wind turbines with higher capacity, longer blades, higher towers, and XL foundations capable to operate at deeper waters, resulted in a significant increase of the vessels' weight and size, a trend that is expected to continue in the mid-term. In Europe, but also globally, increased crane capabilities will especially be needed in the area of foundations, where current monopoles (ranging at about 1 200 t) are already reaching the limits of most vessels. Future XL monopoles weighing 2 000 t are already in the pipeline. Similarly, the installation of heavy offshore substations (foundations and topsides) requires heavy-lift vessels with significant crane capacity.

In this context, the transition to floating offshore wind technology (see section 6.1) will not only open new markets for offshore wind energy, but also for the constructions of vessels to support its installation and operation.

Figure 5.17 Location of wind manufacturing facilities by the wind turbine component produced

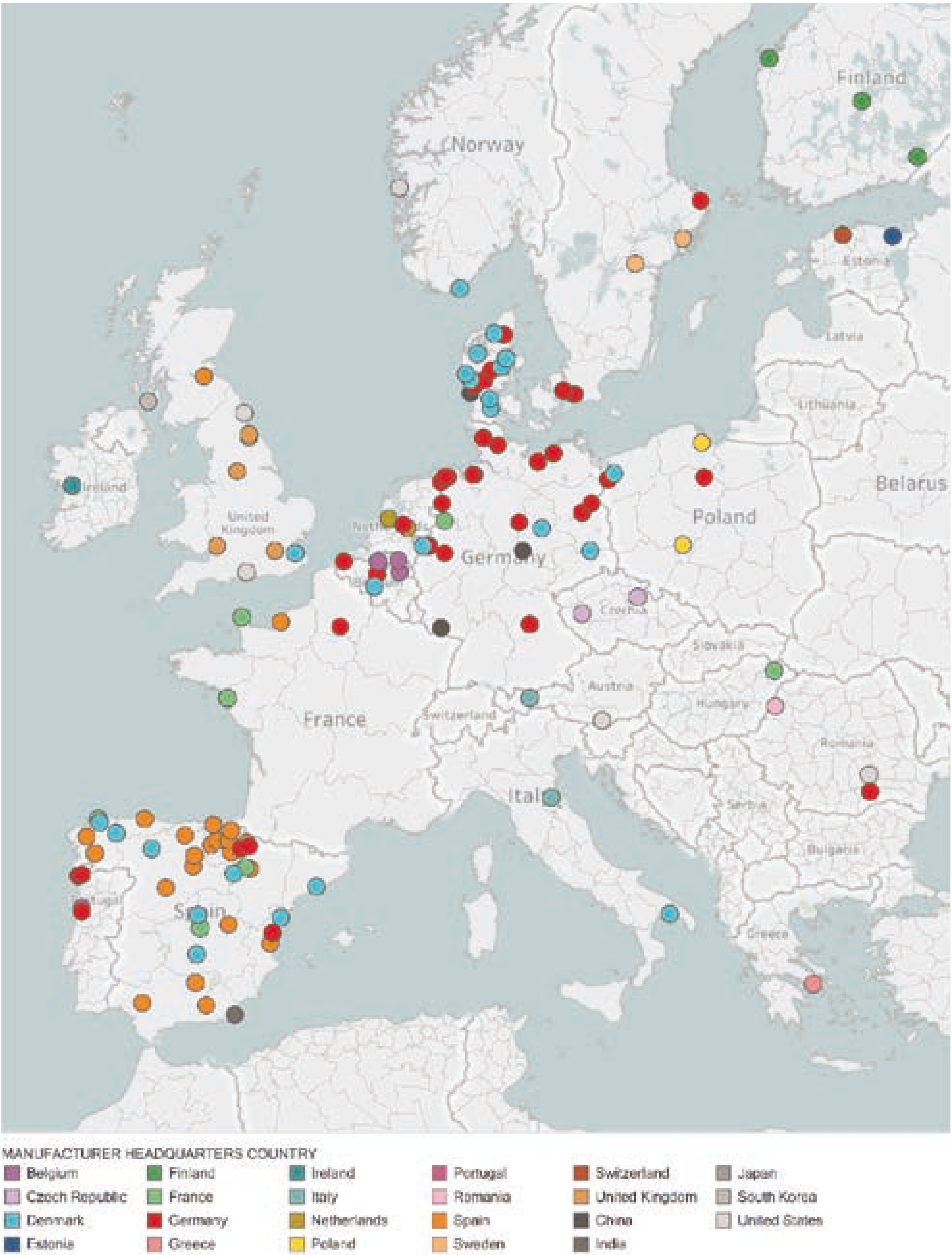


WIND TURBINE COMPONENTS

Generators	Nacelle Assembly	Blades & Towers
Power converters	Hubs & Shafts	Blades & Nacelle Assembly
Control systems	Bearings	Generators & Nacelle Assembly
Towers	Foundations	Hubs & Shafts & Nacelle Assembly
Gearboxes	Foundry	Spare Parts & Repair
Blades	Blades & Generators	Spare Parts & Repair & Nacelle Assembly

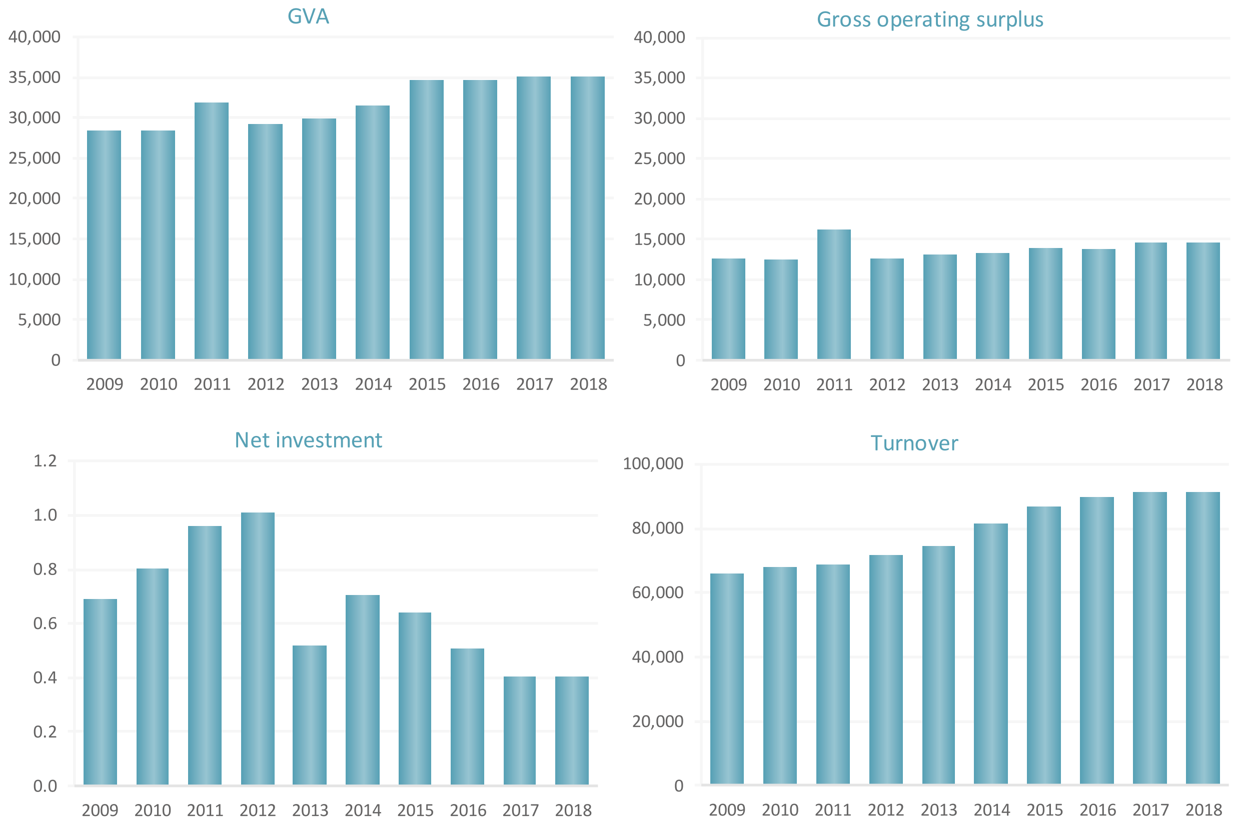
Source: JRC (2019) LCEO Wind Energy Technology Market Report, JRC118314. Luxemburg.

Figure 5.18 Location of wind manufacturing facilities by country of origin



Notes: Manufacturers refer to subsidiary level, and not the parent company in case of conglomerates. Non-EU facilities are marked with flags.
Source: JRC (2019) LCEO Wind Energy Technology Market Report, JRC118314.

Figure 5.19 Size of the EU *Port activities* sector, € million



Note: Turnover should be interpreted with caution due to the problem of double counting throughout the value chain.
Source: Eurostat (SBS) and Commission Services.

5.4. PORT ACTIVITIES

5.4.1. BACKGROUND

Port activities continue to play a key role in trade, economic development and job creation. According to the European Sea Ports Organisation (ESPO), 90 % of Europe's cargo trade in goods passes through the more than 1 200 seaports in the 23 coastal EU Member States. Many of these ports also receive hundreds of millions of passengers aboard cruises liners and ferries. Ports, as multi-activity transport and logistic nodes, also play a crucial role in the development of maritime sectors.

The number of containers heading into European ports has risen by more than four times over the past 20 years.[199] Europe's busiest container ports include Rotterdam (the Netherlands), Antwerp (Belgium); Hamburg (Germany); Amsterdam (the Netherlands) and Algeciras (Spain).

Many ports across the EU, known as **Green Ports**[200] are reducing their environmental and climate impact while also enabling green shipping fleets. These activities will have an important role in reaching the objectives of the European Green Deal (EGD).

For the purpose of this report, the *Port activities* sector comprises two main subsectors, further broken-down into the following activities:

(1) **Cargo and warehousing**: Cargo handling and Warehousing and storage;

(2) **Port and water projects**: Construction of water projects and Service activities incidental to water transportation.

Port activities accounted for 11 % of the jobs, 16 % of the GVA and 15 % of the profits in the EU Blue Economy in 2018. The sector has grown since 2009 in terms of jobs and GVA.

5.4.2. MAIN RESULTS

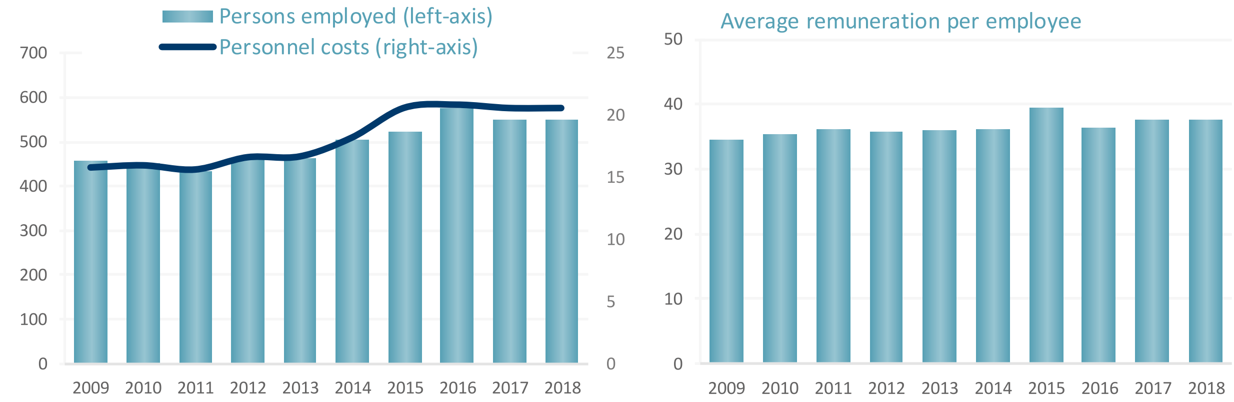
Size of the Port activities sector in 2018

The value added generated by *Port activities* grew by 24 % from 2009 to 2018, reaching €35.2 billion. Gross profit, at €14.6 billion, was 16 % higher than in 2009. Turnover amounted to €91.4 billion, a 39 % rise on 2009 (Figure 5.19).

The sector directly employed 549 340 persons in 2018, 20 % more than in 2009. Personnel costs increased by 31 %, from

199 World Shipping Council
200 ?????????????????

Figure 5.20 Persons employed (thousand), personnel costs (€ million) and average wage (€ thousand) in the EU *Port activities* sector



Source: Eurostat (SBS) and Commission Services.

€15.8 billion in 2009 to €20.6 billion in 2018. This led to an 8.5 % increase in average wages compared to 2009. The average annual wage was estimated at €37 560 (Figure 5.20).

The United Kingdom leads Port activities by contributing 22 % of the GVA and generating 25 % of the jobs. Germany closely follows in terms of jobs and GVA (20% and 23 %, respectively).

Results by subsectors and Member States

Employment: The majority of the employment (66 %) is located in Cargo and warehousing, with 362 353 direct jobs; while Ports and water projects employed 186 987 persons (34 %). Compared to 2009, the number of jobs in Cargo and warehousing increased by 46 % while decreasing 10 % in Ports and water projects, from 208 464 persons employed in 2009. The top contributors, in descending order, include: the United Kingdom (25 %), followed closely by Germany (23 %) and then France (8 %), Spain (7 %) and Italy (6 %).

Gross value added: The value added generated is almost evenly distributed between Cargo and warehousing (51 %) and Ports and water projects (49 %). The top contributors, in descending order, include the United Kingdom (22 %), followed by Germany (19 %), the Netherlands (12 %), Spain (9 %) and France (9 %).

Gross profit: Total gross profit amounted to €14.6 billion in 2018: €6.4 billion (44 % of the sector total) in Cargo and warehousing, and €8.2 billion (56 %) in Ports and water projects. Cargo and warehousing increased by 43 % compared to 2009, while Ports and water projects remained relatively stable, with a 1 % increase.

Gross investments in tangible goods:[201] Most of the investments went to Ports and water projects (62 %), which saw a 9 % drop on 2009 figures. Overall, the sector saw only a slight decrease (-1 %) in investments, being compensated by a 15 % increase in Cargo and warehousing.

Turnover: Total turnover amounted to €91.4 billion: €53.2 billion (58 % of the sector total) in Cargo and warehousing and €38.2 billion (42 %) in Ports and water projects. Cargo and warehousing increased 65 % compared to 2009, while Ports and water projects increased by 14 %; with an overall increase of 39 % for the sector.

5.4.3. TRENDS AND DRIVERS

Seaports are economically very important in the EU, as they are key nodes in the global trade network, handling a large share of all the EU's cargo. However, EU ports are very heterogeneous, with significant differences in their size, type, organisation and in how they are connected to their hinterlands. Efficiency and productivity vary greatly between ports, and these differences have increased further in recent years.[202]

Ship sizes for all segments (e.g. tankers, container carriers) have increased in recent years in order to lower costs, increase operational efficiencies and improve the carbon footprint of *Maritime transport*. Larger ships lead to lower average transport costs, and thus have replaced smaller ones. However, larger ships require new ports infrastructure and have an impact on competition between port authorities and port operators.

Most ports in the EU are publicly owned. The port authority owns the basic infrastructure and leases it out to port operators, usually by means of a concession, while retaining all regulatory functions. Hence, port operations are run by private companies, which provide and maintain their own superstructure, including buildings and cargo-handling equipment at the terminals. Port authorities have often limited autonomy in setting port charges, because governments often delineate them and because they compete with other ports.

However, ports need to invest in infrastructure, in particular for additional capacity and new port infrastructure and superstructures due to the increase in the ship sizes. Given the size of these new ships and the cargo they carry, investments need to go beyond the ports to ensure adequate connections through inland waterways, road and rail to major production and consumption markets. This represents an important multiplicative factor of *Port activities*.

[201] Net investments in tangible good are unavailable for most of the activities.
[202] SWD(2013) 181 final of 23 May 2013 'Impact assessment accompanying the document Proposal for a Regulation of the European Parliament and the Council establishing a framework on market access to port services and financial transparency of ports'.

Investments in port infrastructures are eligible for EU co-financing through the European Regional Developments Fund (ERDF) and the Cohesion Fund (CF) under shared management, but also through the Trans-European Transport Networks (TEN-T) and the Connecting Europe Facility (CEF) under the direct management of the European Commission. Overall, between 2000 and 2013, around €6.8 billion of funding were provided from the EU budget for investments in ports. In addition to funding from the EU budget, the European Investment Bank (EIB) financed port investments in the form of loans amounting to around €10.1 billion.

5.4.4. INTERACTIONS WITH OTHER SECTORS

Port activities provide the basic infrastructure and services for many other sectors including *Marine living resources*, *Maritime transport*, *Marine non-living resources*, *Marine renewable energy*, *Coastal tourism* and *Maritime defence*. Ports are at the heart of the maritime shipping industry, they are the departure, entry and transfer points for all goods, services, and persons transported by ship. Beyond making use of these key services, ships also dock, refuel, and offload their waste at ports.

In this context, ports may act as facilitators of economic and trade development for their hinterland. On the other hand, ports may compete for space, for instance, with respect to aquaculture and *Coastal tourism*.

Many European ports are important clusters of energy and industry. The greening of the shipping sector is a priority for European ports and Europe's ports are committed to playing their part in helping the shipping sector make this transition. Close cooperation between ports and shipping lines is required. This cooperation is also largely dependent on decisions by energy producers, energy providers and cargo owners.[203]

5.4.5. GREEN PORTS

According to the International Maritime Organisation (IMO), maritime transport emitted 960 million tonnes of CO_2e in 2010, 2.5% of the world's greenhouse gas emissions.[204] Data on emissions and fuel consumption illustrates that the large vessels (i.e. weighing more than 5 000 GT) using EU ports were responsible for 137 million tonnes of CO_2 emissions in 2018.[205]

The term **green port** describes the actions that ports undertake to transform their processes, structures or policies to lessen their environmental and climate impact. The main green port activities concern:[206]

- Energy and fuels.
- Climate mitigation and adaptation.
- Environmental pollution reduction.
- Waste and noise management.
- Maritime and hinterland transport connections.
- Linkages to circular economy models.
- Management, policy and finance.

Fuel and energy are one of the most prominent focal points of green port development because they can contribute to significant greenhouse gas emission reductions. Green port development in the sphere of energy and fuels involves the energy use of the port, the availability of alternative fuel-bunkering infrastructure, and onshore power supply for ships.

Some notable sources of energy that are in the pipeline at green ports are liquefied natural gas (LNG), hydrogen fuel, biofuel, batteries, onshore power supply, and wind and solar energy installations. LNG is cheaper than conventional marine gas oil or heavy fuel oil, it emits less air pollutants (such as sulphur oxides, nitrogen oxides, and particulate matter), and it has a lower CO_2 emission footprint.[207] The current global LNG shipping fleet is estimated at fewer than 100 vessels.[208]

In order to solve the chicken-and-egg problem, the Directive 2014/94 on the deployment of alternative fuels infrastructure requires that "an appropriate number of refuelling points for LNG are put in place at maritime ports, to enable LNG inland waterway vessels or seagoing ships to circulate throughout the TEN-T Core Network by 31 December 2025".[209]

Similarly, ***shore-side electricity***, a source of onshore power supply for docked ships, is essential to reduce onsite port emissions. Shore-side electricity "shall be installed as a priority in ports of the TEN-T Core Network, and in other ports, by 31 December 2025, unless there is no demand and the costs are disproportionate to the benefits, including environmental benefits".[210] According to ESPO, there were 32 ports that provided onshore power supply in 2018, and 50 ports in 2019.[211]

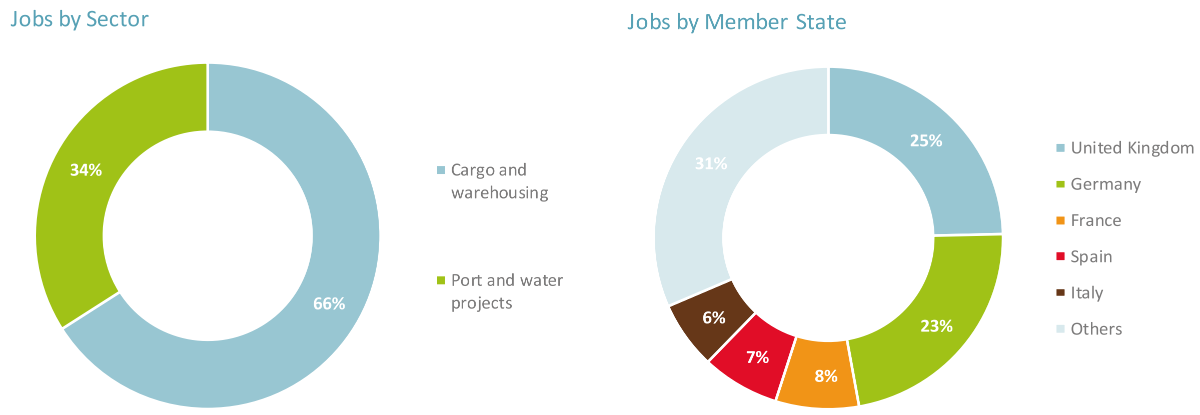
Funding resources for Green ports

Investments are needed for ports to keep up with new environmental and climate requirements, this also goes for the port logistics sector and port related industries. Investments needed for EU seaports are estimated at approximately €48 billion between 2018 and 2027 (€5 billion per year).[212] Several funding opportunities for green ports at the EU level are presented below.

Through **Horizon 2020**, the EU's Research and Innovation programme, a budget of €6.34 billion has been allocated to 'smart, green, and integrated transport' projects for the period

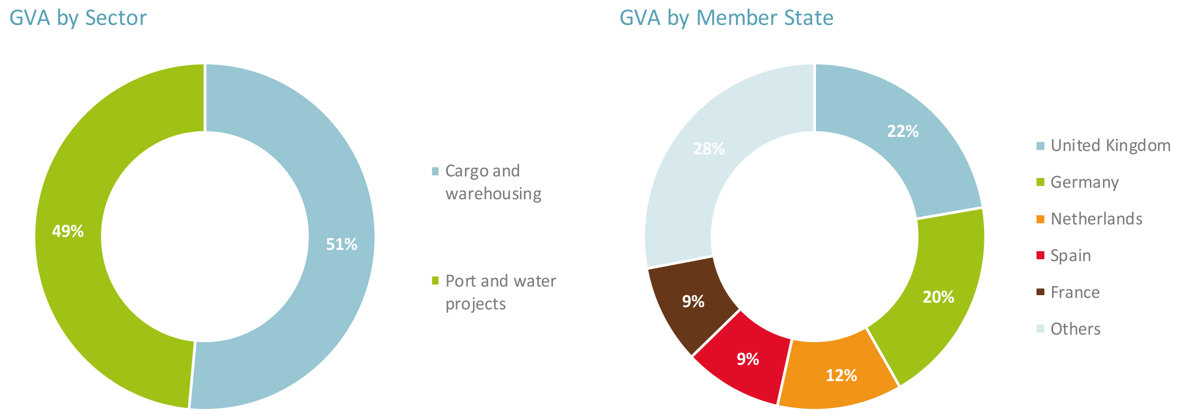
[203] https://www.espo.be
[204] International Maritime Organisation. (2015). Third IMO GHG Study 2014.
[205] THETIS-MRV automated reporting and notification system on ships' CO_2 emissions managed by EMSA (https://mrv.emsa.europa.eu).
[206] Bergqvist, R. and J. Monios. (2019). Green Ports: Inland and Seaside Sustainable Transportation Strategies. Elsevier. https://doi.org/10.1016/C2017-0-00965-5.
[207] Bergqvist, R. and J. Monios. (2019).
[208] Ibid.
[209] Art 6(1).
[210] Art 4(5).
[211] ESPO (2019). Environmental Report 2019. Pp. 13-14. https://www.espo.be/media/Environmental%20Report-2019%20FINAL.pdf
[212] De Langen, P., M. Turró, M. Fontanet and J. Caballé. (2018). The infrastructure investment needs and financing challenge of European ports. European Seaports Organisation (ESPO). https://www.espo.be/publications/the-infrastructure-investment-needs-and-financing-

Figure 5.21 Share of employment in the EU *Port activities* sector, 2018



Source: Eurostat (SBS) and Commission Services

Figure 5.22 Share of the GVA generated the EU *Port activities* sector, 2018



Source: Eurostat (SBS) and Commission Services

2014-2020. Horizon 2020 has set out several calls for projects that play a role in green port development, such as SYNCHRONET, AEOLIX & SELIS, Ports of the Future, RCMS, and Portis. For example, the call (MG-7-3-2017) for **Ports of the Future** projects addressed the following dimensions:[213]

- Multi-model optimised cost-effective and flexible operations.
- Sustainable maintenance, repair and reconfiguration.
- Better capacity management with reduced costs and land use.
- Low environmental impact, climate change adaptation and mitigation, and moves towards the circular economy.
- Links and integration with the industrial and urban environment.
- Efficient hinterland connections, including those that facilitate increased use of energy-efficient transport modes.

Under Ports of the Future, four projects were selected: (1) **COREALIS** which focuses on Internet of things (IoT), data analytics, and 5G to enhance cargo port operations; (2) **PortForward** which works with IoT, Cloud, and network tech to create a smart, green and interconnected ecosystem for ports; (3) **Pixel** uses information sharing and IoT tech to target the below objectives of Ports the Future and (4) **Docks the Future**, a research-based project that works, among others, on Port of the Future concepts, key performance indicators, transferability of port solutions, and training packages.[214]

The **European Institute of Innovation and Technology** (EIT) supports a number of projects that contribute to green port developments under **Climate-KIC** (climate knowledge and innovation community). One project is to set up eight **Deep Demonstrations** as test environments for the '1.5-consistent systems transitions'. Three maritime hubs participate in the project: the Port of Valencia, the Port of Piraeus and Cyprus. In each Deep Demonstration, the project aims to find solutions that will reduce emissions of shipping activities in the area. Another Climate KIC example is the **LOOP-Ports project**. The project aims to contribute to the transition to a circular economy model in the port sector. It will create a network of ports to establish an innovation ecosystem and to stimulate circular economy activities.[215]

213 For a few overview of the call, see ec.europa.eu/research/participants/data/ref/h2020/wp/2016_2017/main/h2020-wp1617-transport_en.pdf, pp. 59-60
214 For more information, see: www.corealis.eu; https://twitter.com/portforward_eu; www.pixel-ports.eu; www.docksthefuture.eu.
215 For more information, see: https://www.climate-kic.org/who-we-are/what-is-climate-kic/; https://www.loop-ports.eu/about/overview/; https://eit.europa.eu/news-events/news/climate-transport.

The Connecting Europe Facility (CEF) focuses on the development of trans-European networks that are high-performing, sustainable, and efficient. With a total of €1.22 billion committed, the CEF provides funding opportunities for green port projects via three streams: (1) Motorways of the Sea (MoS) which supports 50 projects with over €435 million in three directions: i) environment, ii) integration and logistics, and iii) safety, traffic management, and human capital;[216] (2) Maritime ports which supports 57 projects with over €980 million in five directions: i) hinterland connections, ii) port access, iii) basic infrastructure, iv) reception facilities, and v) implementation of new facilities and technologies and (3) Innovation and new technologies which supports 15 projects with over €86 million focusing on decarbonising transport through the deployment of alternative fuel distribution infrastructure such as electricity, hydrogen, compressed or liquefied natural gas (L/CNG), and bio-methane.

Green C-Ports is a CEF funded project (€3.58 million) that is running from 2019 to 2023. The project will test pilot solutions at the ports of Bremerhaven, Wilhemshaven, Piraeus, Venice and Valencia. The project aims are: i) reducing the impact of port operations on cities; ii) port and vessels emissions monitoring; (iii) increasing port operations and cargo handling efficiency; and iv) facilitating access and egress of cargo in and out of ports. Another CEF funded project (€1.64 million) is the Masterplan for Onshore Power Supply in Spanish ports. The project, which ran from 2016 to 2019, focused on spreading the use of onshore power supply at Spanish ports that are part of the Core Network Corridors and beyond. To gather this know-how, the project carried out a pilot study in Santa Cruz de Tenerife, Las Palmas de Gran Canaria, and Palma de Majorca.[217]

Between 2009 and 2018, the European Investment Bank provided approximately €6 billion to finance over 65 port infrastructure projects and approximately €2 billion to finance 15 shipping projects. EIB funding focal points are maritime projects that contribute to: i) growth and employment, ii) protection of the environment, iii) safety, iv) energy efficiency, and v) research and development. The EIB is a key source of funding for the development of the Trans-European Network, MoS projects, and for sustainable transport solutions in the EU. For example, the EIB foresees to provide DEPA, a public gas corporation in Greece, with funding of €20 million for the development of an LNG bunkering vessel. The aim is that the vessel, which will be based in the Port of Piraeus, can provide ship-to-ship LNG bunkering services to LNG fuelled vessels. Another example is the development of a new terminal in the Port of Brest. The project, which the EIB supports with €90 million, will facilitate the construction and upkeep of new offshore renewable energy infrastructure, and improve nautical access for existing traffic.[218]

Interreg V programmes have been key in supporting new regional green port initiatives, such as Dual Ports, Atlantic Blue Ports and Smooth Ports.

DUAL Ports aims to decarbonise Regional Entrepreneurial Ports (REPs) in the North Sea Region.[219] The programmes main approach is to reduce the environmental footprint of ports through resource efficiency and the use of new products, services and processes. With a budget of €8.6 million, from December 2015 to 2021, the project funds operational pilots in a number of areas, such as optimising renewable energy, combining wind and hydrogen, absorbing and reducing greenhouse gases, creating a wind cargo platform, etc., that have a potential to be transferred into other REPs.

Atlantic Blue Ports seeks to improve port services that discharge and treat the effluents of ships in the Atlantic.[220] Running from 2017 to 2020, the programme involves 11 major ports in Ireland, the United Kingdom, France, Spain and Portugal with a budget of €2.96 million.[221] Through the programme, stakeholders, port waste reception facilities (PRFs) operators, universities, and the public and private sector, come together to design attractive port services that encourage maritime communities to improve port discharge and treatment services, particularly for oiled effluents and ballast water. The programme will contribute to comply with the requirements on PRFs enshrined in the Directive 2000/59/EC and in the IMO Convention MARPOL 73/79.[222]

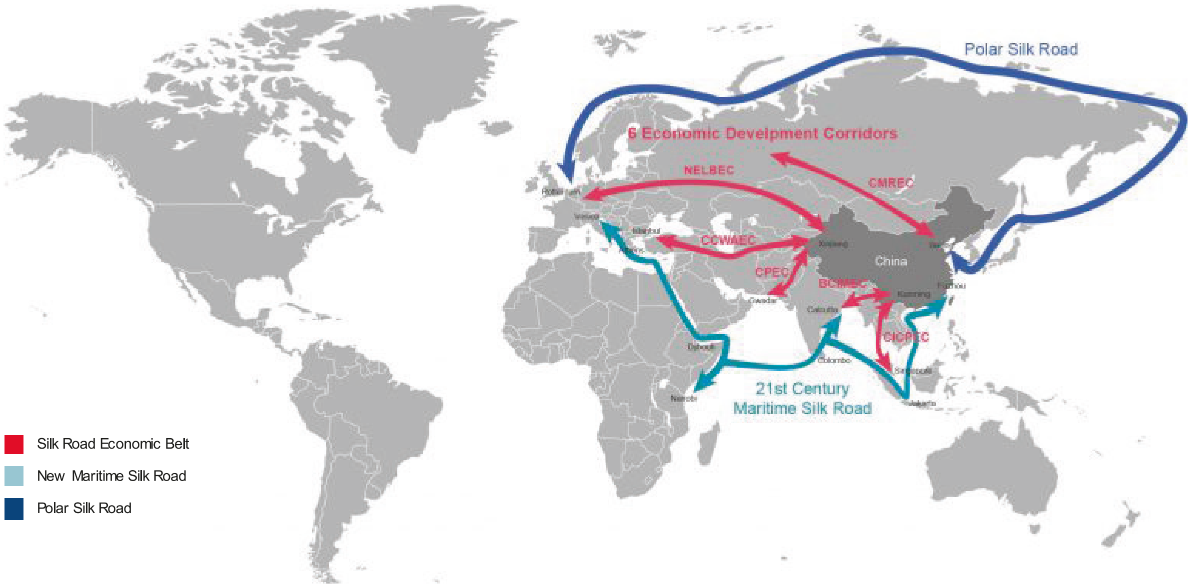
The Smooth Ports project aims at reducing greenhouse gas emissions from port-related road traffic by enhancing regional policy instruments.[223] The programme has a budget of €1.14 million and runs from 2019 to 2023. The programme offers an exchange on tools and best practices to participating ports on: i) optimising procedures for clearing goods; ii) information and communications technology solutions; and iii) powering port activities with alternative fuels. Based on the exchanges, identified strengths and weaknesses can be used by the authorities, public institutions, and ports to enhance local policy instruments. The programme includes partners in Germany, France, Italy and Bulgaria.

5.4.6. THE BELT AND ROAD INITIATIVE

The Belt and Road Initiative (BRI), which started as an investment project in China's wider neighbourhood has since developed into an overall foreign policy vision of China that aims to connect China to the rest of the world (including Asia, Africa, the Americas and Europe), by reinforcing infrastructure and trade along land and sea routes. The initiative encompasses two pillars that involve connections to Europe: the *Silk Road Economic Belt*, an overland connection that stretches from China to Europe (through Asia) that also involves shipping in the Black Sea; and the *New Maritime Silk Road*, i.e. maritime routes that connect South and East China

216 For further details, see Simpson, B. (2018). Motorways of the Sea. Detailed Implementation Plan of the European Coordinator. European Commission.
217 For more information, see: https://ec.europa.eu/inea/en/connecting-europe-facility/cef-transport/2018-eu-tm-0117-s and https://ec.europa.eu/inea/sites/inea/files/fiche_2015-eu-tm-0417-s_final.pdf
218 For more information, see: www.eib.org/en/projects/pipelines/all/20190313 and www.eib.org/en/projects/pipelines/all/20140207
219 www.dualports.eu/about
220 https://atlantic-blue-ports.webnode.fr/
221 www.atlanticarea.eu/project/53
222 For further information, see: www.emsa.europa.eu/implementation-tasks/environment/port-waste-reception-facilities.html
223 www.interregeurope.eu/smoothports.

Figure 5.23: Routes of the Belt and Road Initiative connected to Europe



Notes: Other routes not connecting Europe are not represented.
Source: The Belt and Road Initiative (www.beltroad-initiative.com).

with Southeast Asia, South Asia, Africa, and Europe.[224] In January 2018, China announced a third pillar: the *Polar Silk Road*, that is shipping routes in the Arctic Ocean (Figure 5.23).[225]

Economies and organisations involved in the BRI

Ever since the BRI was launched in 2013, it has grown into a project that involves the cooperation of more than 72 economies in Asia, Africa and Europe. In Europe, 15 EU Member States, and 6 candidate (or potential candidates) countries are cooperating with the BRI by virtue of having signed a MoU (Table 5.6). Reportedly, beyond nations, some International Organisations (e.g. the International Labour Organisation (ILO), the United Nations Development Programme (UNDP), and the International Development Law Organisation (IDLO)) and Multilateral Investment Banks (e.g. the Asian Development Bank (ADB), the European Bank for Reconstruction and Development, the International Monetary Fund (IMF), the World Bank) are also signing cooperation agreements with China.[226]

Chinese investments in EU ports

Chinese investors and state-owned enterprises (SOE) have invested in more than 32 major and medium-sized ports in 14 EU Member States, sometimes with controlling stakes (Table 5.7). The acquisitions of stakes in facilities in EU container ports is usually channelled through Chinese SOE. These include COSCO Shipping, China Merchants Ports Holdings (CMP), and COFCO International. In some cases private parties, such as the Hong Kong based Hutchinson Port Holdings, also play a role. They usually target specific terminals within larger ports.[227]

Table 5.6 European countries that cooperate with the Belt and Road Initiative

Type	Country
EU Member States	Bulgaria, Croatia, Czechia, Estonia, Greece, Hungary, Italy, Latvia, Lithuania, Poland, Portugal, Romania, Slovak Republic, Slovenia
Candidate and potential candidate countries	Albania, Montenegro, North Macedonia, Serbia, Turkey, Bosnia and Herzegovina
Other neighbouring countries	Armenia, Azerbaijan, Belarus, Georgia, Moldova, North, Russian Federation, Ukraine

Sources: SRM (2018).

[224] World Bank (2019). Belt and Road Economics: Opportunities and Risks of Transport Corridors. https://openknowledge.worldbank.org/bitstream/handle/10986/31878/9781464813924.pdf.
[225] Ibold, S. (2018). China's Polar Silk Road. https://www.beltroad-initiative.com/arctic-policy/#more-1.
[226] For more information, see Deandreis, M. (Dir.) and Panaro, A. (Dir.) 2018. Italian Maritime Economy 2018. SRM. Giannini Editore; Musolino, P. 2019. Italian Maritime Economy 2019. SRM. Giannini Editore. Chapter VI; United Nations Environment Programme. UN Agencies Belt and Road Initiative Involvement. [https://www.unenvironment.org/pt-br/node/23697]. Accessed on 13-05-2020.
[227] For further information, see: van der Putten, F. 2019. Clingendael. European Seaports and Chinese Strategic Influence. [https://www.clingendael.org/publication/european-seaports-and-chinese-strategic-influence-0].

- The main Chinese SOE active in the EU is COSCO Shipping, the world's third largest container shipping company and fifth largest operator of port terminals. COSCO is now a majority stakeholder of Piraeus Port Authority (Greece), of Noatum Terminals in Valencia, Las Palmas and Bilbao (Spain), and of the APM Terminal in Zeebrugge (Belgium). In Addition, they are a minority stakeholder in the ECT Euromaxx Terminal in Rotterdam (Netherlands), in the APM Terminal of Vado Ligure (Italy), and the Gateway Terminal in Antwerp (Belgium).
- Secondly, China Merchants Port Holdings (CMP) from China Merchants Group regards the BRI as its core strategy for international activities. As part of its 49% stake in Terminal Link, CMP is a minority stakeholder in eight EU container terminals in Belgium (Antwerp), France (Dunkirk, Fos, Le Havre, Marseille and Montoir), Greece (Thessaloniki) and Malta (Marsaxlokk).
- Thirdly, Hutchinson Port Holdings (HPH), the ports subsidiary of CK Hutchison Holdings, is a private conglomerate that has its headquarters in Hong Kong. HPH is a majority stakeholder of European Container Terminals (ECT), which operates four container terminals in the Netherlands (Amsterdam, Moerdijk, Rotterdam Euromaxx and Delta), and three inland terminals in Belgium (Willebroek), Germany (Duisberg), and Venlo (Netherlands). HPH is also a majority stakeholder of TMA Logistics, which operates container terminals in the Netherlands (Amsterdam, Beverwijk, Harlingen, and Velsen Noord), and Belgium (Antwerp). Moreover, HPH has full ownership of the Barcelona Europe South Terminal in Spain, of container terminals in Gdyna (Poland) and Stockholm (Sweden); and of three ports in the UK (Felixstowe, Harwich, and London Thames).

Table 5.7 European ports with Chinese port operators in some of their terminals. 2019

MS	Port features					Chinese operations in the port			
	Location	Containers volume		Goods volume		Port operator	Facility concerned	Shares or stake	
		TEU's handled	EU rank	Gross weight (mill t)	EU rank			Amount € million	Percentage
BE	Antwerp					COSCO	Container Terminal (Gateway)	134	20%
BE	Antwerp	10,830	2	212.0	2	CMP	Container Terminal (Terminal Link)	50	49%
BE	Antwerp					HPH	Container Terminal (TMA)		50%
BE	Zeebrugge	378	24			COSCO	Container Terminal (APM)	35	100%
BE	Willebroek					HPH	Inland Terminal (ECT)		98%
DE	Duisberg					HPH	Inland Terminal (ECT)		98%
EL	Piraeus	4,886	6	50.9	15	COSCO	Port Authority	269	67%
EL	Thessaloniki					CMP	Container Terminal (Terminal Link)	50	49%
ES	Barcelona	3,422	10	54.6	11	HPH	Container Terminal (BEST)	500	100%
ES	Bilbao	638	23			COSCO	Container Terminal (Noatum Ports)	68	51%
ES	Las Palmas	1,142	19			COSCO	Container Terminal (Noatum Ports)	68	51%
ES	Valencia	5,169	5	62.0	8	COSCO	Container Terminal (Noatum Ports)	68	51%
FR	Dunkirk			41.1	17	CMP	Container Terminal (Terminal Link)	50	49%
FR	Fos					CMP	Container Terminal (Terminal Link)	50	49%
FR	Le Havre	2,866	11	64.9	7	CMP	Container Terminal (Terminal Link)	50	49%
FR	Marseille	1,398	18	75.7	6	CMP	Container Terminal (Terminal Link)	50	49%
FR	Montoir					CMP	Container Terminal (Terminal Link)	50	49%
HR	Zadar					Luxury Real Estate	Overall Port	6	75%
IT	Vado Ligure					COSCO, Qingdao	Container Terminal (APM)	9	49%
MT	Marsaxlokk					CMP	Container Terminal (Terminal Link)	50	49%
NL	Amsterdam			99.5	4	HPH	Container Terminal (ECT)		98%
NL	Amsterdam					HPH	Container Terminal (TMA)		50%
NL	Beverwijk					HPH	Container Terminal (TMA)		50%
NL	Harlingen					HPH	Container Terminal (TMA)		50%
NL	Moerdijk					HPH	Container Terminal (ECT)		98%
NL	Rotterdam					COSCO	Container Terminal (ECT Euromaxx)	126	35%
NL	Rotterdam	13,598	1	441.5	1	HPH	Container Terminal (ECT Euromaxx)		63%
NL	Rotterdam					HPH	Container Terminal (ECT Delta)		98%
NL	Velsen Noord					HPH	Container Terminal (TMA)		50%
NL	Venlo					HPH	Inland Terminal (ECT)		98%
PL	Gdynia					HPH	Container Terminal		100%
RO	Constanta	668	22	39.5	19	COFCO Int.	Grain Terminal	100	100%
SE	Stockholm					HPH	Container Terminal		100%
UK	Felixstowe	3,781	9			HPH	Overall Port		100%
UK	Harwich					HPH	Overall Port		100%
UK	London (Thames)					HPH	Overall Port		100%
p.m. Other Chinese interest in EU ports									
IT	Trieste			57.4	9	Five Ports Initiative			
IT	Genova					Five Ports Initiative			
IT	Venice					Five Ports Initiative			
SI	Capodistria					Five Ports Initiative			
HR	Fiume					Five Ports Initiative			

Notes: CMP: China Merchants Port Holdings; HPH: Hutchinson Port Holdings. CMP obtained 49% shares of "Terminal Link" for €400 million; which has been evenly split over the eight terminals where the company operates. COSCO Shipping obtained 51% shares of "Noatum Ports" for €203 million; which has been evenly split over the three terminals where the company operates. The stakes refer to the specific facility concerned where the Chinese companies operate, which, in most cases, is not the port as a whole.
Source: Clingendael Institute, CMACGM-Group, COSCO Shipping, East West, ECT, EUROSTAT [mar_mg_aa_pwhd and mar_mg_am_pvh], Hutchison Ports, Institute Delors, TMA Logistics, Noatum Ports, news sources, and Commission Services. For a full list of links to the sources, please see the Annex below.

- And finally, in 2014 COFCO International (a Chinese SOE) undertook a full acquisition of a grain terminal in Constanta in Romania.[228] In 2018, Luxury Real Estate obtained a 75 % majority stake in the Port of Zadar (Croatia).

Beyond acquisitions and purchasing stakes, the BRI is also active in other routes to extend its influence on EU container ports. One of the flagship projects of the BRI is the "five ports initiative", which through the North Adriatic Ports Association, aims to streamline operations for container ports in Venice, Trieste and Ravenna (Italy), Capodistria (Slovenia), and Fiume (Croatia), to improve their trade operations with China.[229]

Besides the acquisition of port operating facilities, the BRI also channels investments for the construction and improvement of port infrastructures in the form of loans and other type of funding. These however, have not been analysed here.

The BRI covers one third of world GDP and 60 % of world trade.[230] According to estimations, China invested $60 billion between 2013 and 2016, a figure that some estimate will have grown to $800 billion by 2023 and to a further $1 800 billion by 2028.[231] Since the onset of the BRI in 2013, there have been noteworthy amounts of Chinese investments in the EU's coastal MSs (e.g. ports and other infrastructures and activities) (Table 5.8).

Table 5.8 Chinese investments in EU coastal Member States, 2013-2019, € billion

EU MS	Investment	% GDP	EU MS	Investment	% GDP
Belgium	1.2	0.3%	Italy	20.7	1.2%
Bulgaria	0.1	0.2%	Latvia	0.1	0.3%
Croatia	0.6	1.1%	Lithuania	0.0	0.0%
Cyprus	0.0	0.0%	Netherlands	12.1	1.5%
Denmark	1.3	0.4%	Poland	1.8	0.3%
Estonia	0.00	0.0%	Portugal	4.0	1.9%
Finland	14.6	6.1%	Romania	0.7	0.3%
France	14.6	0.6%	Slovenia	1.9	4.0%
Germany	37.8	1.1%	Spain	5.0	0.4%
Greece	4.0	2.1%	Sweden	9.3	2.0%
Ireland	6.8	1.9%	United Kingdom	63.0	2.5%
Total				**199.7**	

Notes: includes BRI and non-BRI investments in EU coastal MS. Converted using the average 2019 EUR/USD exchange rate.
Source: American Enterprise Institute. China Global Investment Tracker. [https://www.aei.org/china-global-investment-tracker/]; ECB (GDP data for 2019).

Annex: List of sources for Table 7

- http://en.coscoshipping.com/art/2017/6/13/art_6923_59856.html
- http://www.cseba.eu/news/port-of-zadar-capital-increase-completed/174/
- http://www.harwich.co.uk/
- http://www.londonthamesport.co.uk/
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- https://hutchisonports.com/en/ports/world/barcelona-europe-south-terminal-best/
- https://hutchisonports.com/en/ports/world/container-terminal-frihamnen-ctf/
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- https://hutchisonports.com/en/ports/world/port-of-felixstowe-pfl/
- https://hutchisonportsstockholm.se/en/#!/Home
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- https://www.tmalogistics.nl/en/contact
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229 For more information, see: North Adriatic Ports Association. n.d. About NAPA. [http://www.portsofnapa.com/about-napa]; EastWest. 2019. Italy Signs on to Belt and Road Initiative. [https://www.eastwest.ngo/idea/italy-signs-belt-and-road-initiative-eu-china-relations-crossroads]. Accessed on 24-03-2020.
230 World Bank (2018). Belt and Road Initiative. Brief. 29 March. https://www.worldbank.org/en/topic/regional-integration/brief/belt-and-road-initiative.
231 Deandreis, M. (Dir.) and Panaro, A. (Dir.) (2018): Italian Maritime Economy 2018. SRM. Giannini Editore.

5.5. SHIPBUILDING AND REPAIR

5.5.1. BACKGROUND

The EU shipbuilding industry is an innovative, dynamic and competitive sector. With a market share of around 15 % of the global order book in terms of compensated gross tonnage and 34 % in terms of value[232]; for maritime equipment, the EU share rises to 50 %[233], the EU is a major player in the global shipbuilding industry.

The European Shipbuilding industry is currently composed of approximately 300 shipyards specialised in building and repairing the most complex and technologically advanced civilian and naval ships and platforms and other hardware for maritime applications. European shipyards generate a production value of approximately €42 billion yearly and employ more than 300 000 direct jobs in Europe[234].

The EU specialises in segments of shipbuilding with high level of technology and added value, such as cruise ships, offshore support vessels, fishing, ferries, research vessels, dredgers, mega-yachts, etc. The EU is also a global leader in the production of high-tech, advanced maritime equipment and systems. This specialisation and leadership position is a direct result of the sector's continuous investments in research and innovation as well as in a highly skilled workforce.

The economic and financial crisis had a profound impact on the industry for several years, after which the business model changed and part of the workforce shifted to external subcontractors and suppliers. EU shipbuilders are reducing costs and restructuring capacity by adjusting their production programmes and optimising the supply chain. Figures show a significant drop in shipbuilding employment since 2009, yet, recent figures suggest that the sector is recovering.

For the purpose of this report, the *Shipbuilding and repair* sector includes the following sub-sectors and activities:

(1) **Shipbuilding**: building of ships and floating structures, building of pleasure and sporting boats, repair and maintenance of ships and boats

(2) **Equipment and machinery**: manufacture of cordage, rope, twine and netting, manufacture of textiles other than apparel, manufacture of sport goods, manufacture of engines and turbines, except aircraft and manufacture of instruments for measuring, testing and navigation.

Shipyards are clearly identified as working 100 % in the domain of the Blue Economy. However, the equipment and machinery that is incorporated in the vessels is produced by companies working for both maritime and non-maritime industries (see methodology for more details). The "equipment and machinery" categories taken into account in this study represent a small fraction of the wide range of components equipment, systems and technologies from the supply chain involved in shipbuilding projects, which on average account for 70-80 % of the contractual value of complex, high-tech ships produced in Europe. Hence, the values for "equipment and machinery" categories in the report may underestimate the size of the sector as illustrated in Box.4. In addition, shipbuilding is an industry with multiple indirect and induced effects (see Section 6.1 in last year's Report for an illustration).

Overall, Shipbuilding and repair accounted for 6 % of the jobs, 8 % of the GVA and 5 % of the profits in the total EU Blue Economy in 2018. The sector has expanded from recent low in 2013.

5.5.2. MAIN RESULTS

Size of the EU Shipbuilding and repair sector in 2018

The GVA in the sector was valued at almost €17.3 billion, up 32 % compared to 2009. Gross profit, at €4.7 billion, was 126 % higher than the 2009 figure (€2.1 billion) (Figure 5.24). Reported turnover was €59.2 billion, a 13 % rise on 2009.

Around 318 315 persons were directly employed in the sector (down 10 % since 2009). On the other hand, personnel costs increased 15 % compared to 2009 (Figure 5.25). With a total of €12.6 billion in personnel costs, the average wage was €39 500, up from €31 100 in 2009.

The United Kingdom leads Shipbuilding and repair with 14 % of the jobs and 21 % of the GVA, followed closely by Germany with 12 % of the jobs and 18 % of the GVA.

Results by subsectors and Member states

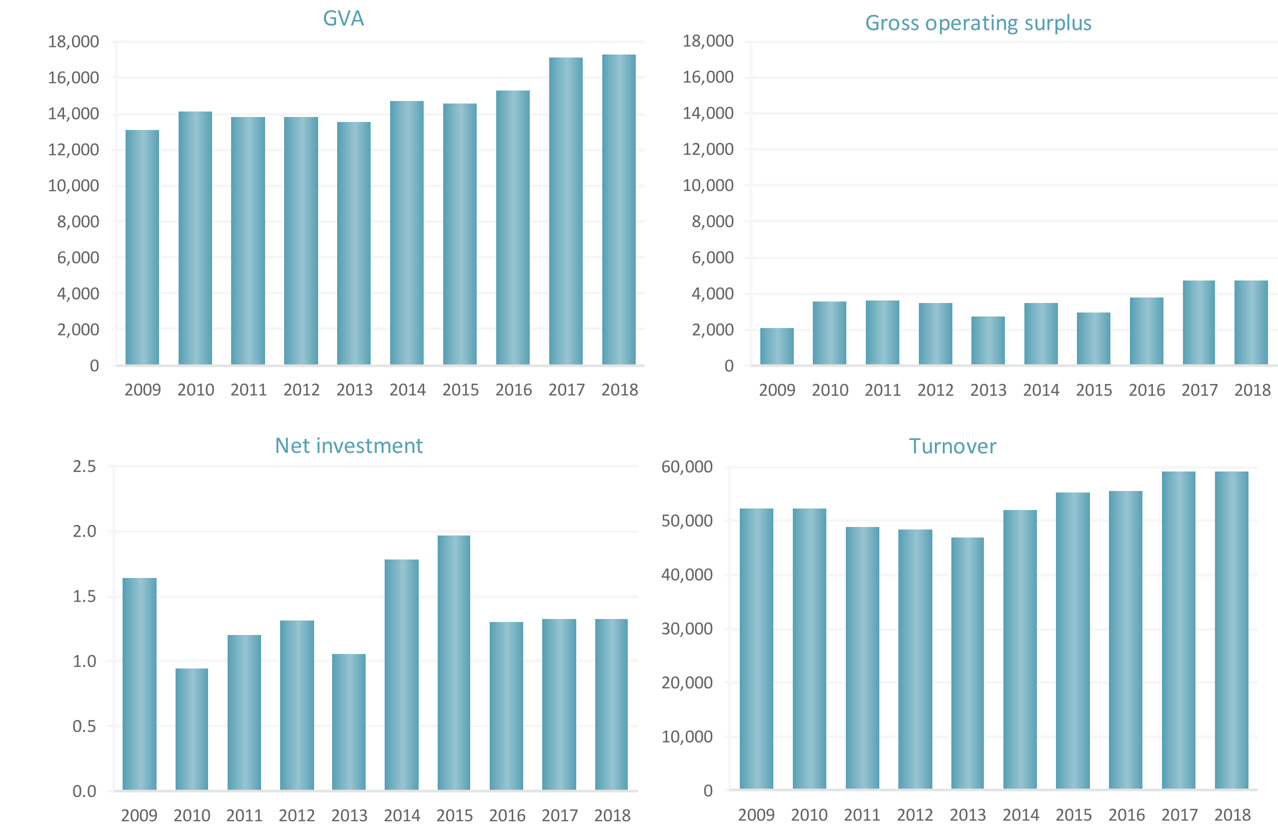
Employment: Of the 318 315 persons directly employed in the sector, more than 269 530 persons (about 85 %) work in Shipbuilding and more than 48 780 persons (15 %) work in the Equipment and machinery sub-sector identified for the purpose of this study (see below Box 5.4). The 10 % fall in employment over the period was due to the 13 % decrease in Shipbuilding, while employment increased 12 % in the Equipment and machinery. The top MS employers are the United Kingdom (14 %), followed closely by Germany, Italy and France (all with 12 %).

Gross value added: Most of the value added is generated in Shipbuilding (82 %). GVA in both sub-sectors increased compared to 2009; Shipbuilding by 33 % and Equipment and machinery by 30 %. The top MS producers are the United Kingdom (21 %), followed by Germany (18 %), France (17 %) and Italy (15 %).

Gross profit: The bulk (82 %) of profits are generated by Shipbuilding (€3.9 billion), while Equipment and machinery generated the remaining 18 % (€0.8 billion). Profits rose by 126 %

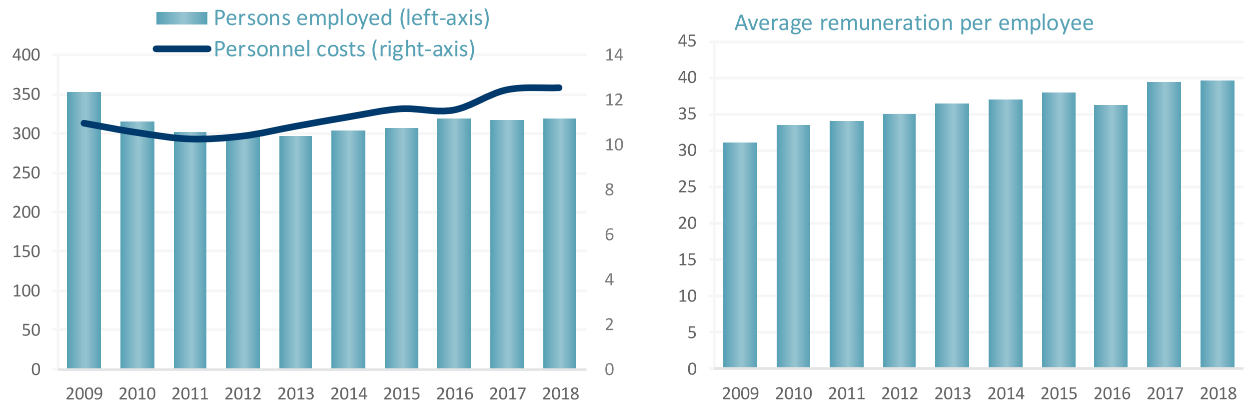
[232] Source: Sea Europe (2020). SEA MM Report No 48.
[233] BALance (2017). Study on new trends in globalisation in shipbuilding and marine supplies.
[234] Source: Sea Europe (2020).

Figure 5.24 Size of the EU *Shipbuilding and repair* sector, € million



Note: Turnover should be interpreted with caution due to the problem of double counting throughout the value chain.
Source: Eurostat (SBS) and Commission Services.

Figure 5.25 Persons employed (thousand), personnel costs (€ million) and average wage (€ thousand) in the EU *Shipbuilding and repair* sector



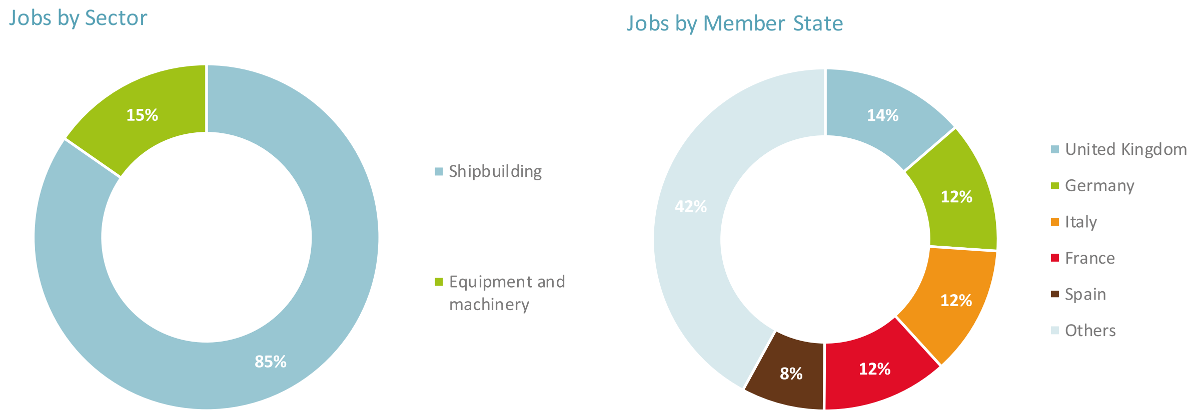
Source: Eurostat (SBS) and Commission Services.

compared to 2009, due to increases in both sub-sectors, in particular in Shipbuilding (+151 %) and Equipment and machinery (+55 %).

Net investment in tangible goods: Net investment reached more than €1.3 billion in 2018. Overall, investments decreased by 20 % compared to 2009 figures. This decrease is due to investments in Shipbuilding falling by 27 %, while investments in Equipment and machinery increased by 32 %

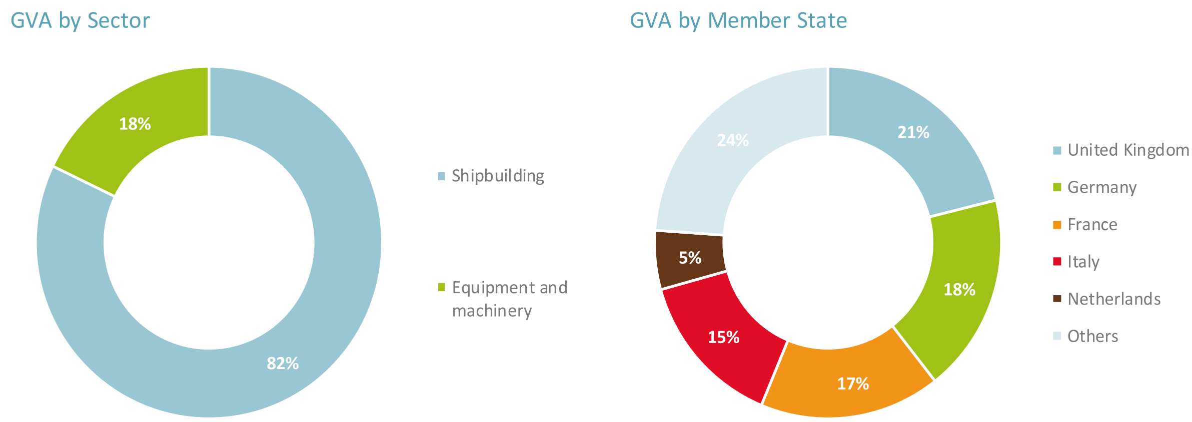
Turnover: Turnover amounted to €49.1 billion for Shipbuilding and €10.1 billion for Equipment and machinery. Turnover from Shipbuilding and from Equipment and machinery increased 13 % and 15 % respectively compared to 2009.

Figure 5.26 Share of employment in the EU *Shipbuilding and repair* sector, 2018



Source: Eurostat (SBS) and Commission Services

Figure 5.27 Share of the GVA generated in the EU *Shipbuilding and repair* sector, 2018



Source: Eurostat (SBS) and Commission Services

BOX 5.4: THE SHIPBUILDING SUPPLY CHAIN

While the report identifies specific equipment for ships (e.g. production of ship propellers or sails), there are many other elements produced for both maritime and non-maritime applications (such as turbines, air conditioning systems, pipes, all type of metal components etc.), which are also vital for shipbuilding projects Hence, the values for equipment and machinery likely underestimate the size of the sector. Analyses from specific studies and the industry indicate that, while the global market share of EU shipyards is not substantial (except in high-tech, complex segments like passenger ships), the EU is still leading the industry of maritime equipment and technologies.

In order to provide a more accurate indication of the size of the sector, a rough estimate has been calculated for shipbuilding supply chain in the EU-28 and the economic footprint of EU ***Maritime technology***[235], i.e., aggregated figures for ***Shipbuilding and repair***, 1st and 2nd tier suppliers (Table 5.9). Evaluating the supplier side is done by considering effects through import of supplies by shipyards and export of suppliers into international markets as well as additional sales to customers other than the national shipbuilding industry.

Beyond the direct contribution of *Shipbuilding and repair* (production value of €49.2 billion), the supply chain creates an additional production value of €81.9 billion and 306 200 additional jobs.

The induced economic impact of the industry is estimated by multiplying the average annual net earnings of €36 384 to the 576 000 employees in the industry supply chain. The maritime technology industry creates an additional value of €21 billion net income, available for consumption and daily expenses.

[235] Maritime technology industries may need to incorporate additional providers, for example, traffic control, offshore wind industry, navy supplies and other offshore orientated or specialised markets. Thus, figures may be underestimated and the industry's economic footprint may be bigger.

Table 5.9 Value of and employment in the shipbuilding supply chain in the EU 28

EU 28	Production value		Employment	
	€ billion	Percentage (on top)	Thousand	Percentage (on top)
Shipbuilding	49.2		269.5	
Supply chain (1st tier)	51.0	103.7%	205.1	76.1%
Supply chain (1st tier) [exports]	28.5	58.0%		
Supply chain (2nd tier)	31.1	63.2%	101.1	37.5%
Total supply chain	131.3	266.90%	576.0	213.7%
Average annual net earnings			€36,384	
Induced economic impact	21.0			
Total economic impact	152.3	309.50%		

Notes: The first row "shipbuilding"excludes equipment and machinery, which form part of the supply chain.
Source: Commission Services based on Sea Europe and Balance: European Shipbuilding Supply Chain Statistics. 2019.

5.5.3. TRENDS AND DRIVERS

Although shipping is already the most environmentally friendly mode of transport, further reductions to emissions are needed. The implementation of the forthcoming global and European regulation on ballast water, and sulphur and nitrogen oxide emissions, as well as action on climate change, offer market opportunities for European maritime equipment suppliers and shipyards.

The global shipbuilding market is expected to grow in the future due to increasing seaborne trade and economic growth, rising energy consumption, demand of eco-friendly ships, LNG fuelled engines and shipping services.

Nonetheless, EU shipbuilding continues to face fierce international competition from countries like China and South Korea, who are trying to enter the European niche markets of specialised high-tech ships given the crisis and the oversupply in the cargo markets. The industry has also suffered from the economic and financial crisis, the absence of effective global trade rules and state supported overinvestment in third countries. The latter is because shipyards are considered strategic in all competing countries outside of Europe, as they offer a wide range of technologies, employ a significant number of workers, and generate foreign currency income (as it is dollar-based).

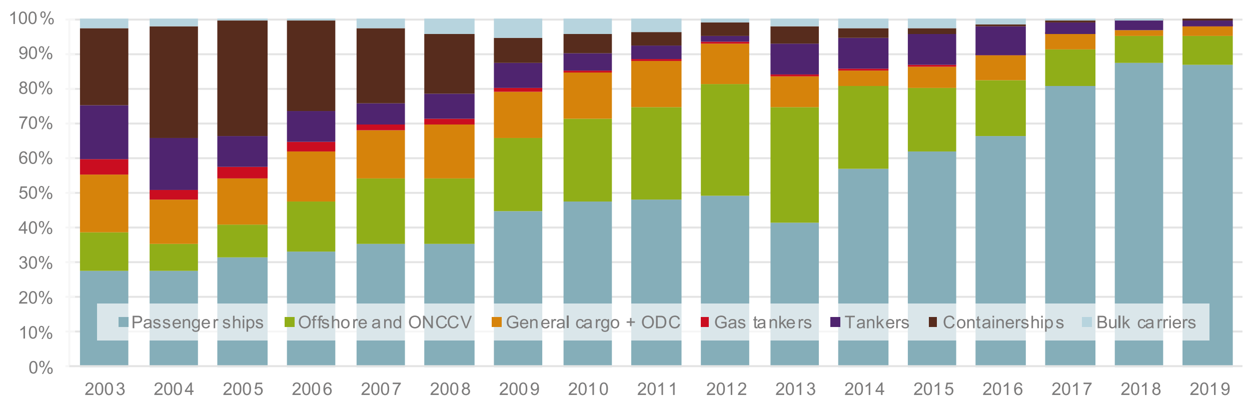
5.5.4. INTERACTIONS WITH OTHER SECTORS

Shipbuilding provides the assets, capabilities, technologies and know-how for several Blue Economy activities such as the Primary sector (capture fisheries and offshore aquaculture), *Maritime transport*, *Non-living resources*, *Marine renewable energy*, *Coastal tourism* (transport) and *Maritime defence*. Shipbuilding and repair is also highly linked to *Port activities*. The EU Shipbuilding and equipment sectors offer new opportunities, especially working alongside growing and emerging sectors, such as support vessels and structures for offshore wind farms, as well as other ocean technologies.

5.5.5. SHIPBUILDING IN THE GLOBAL CONTEXT

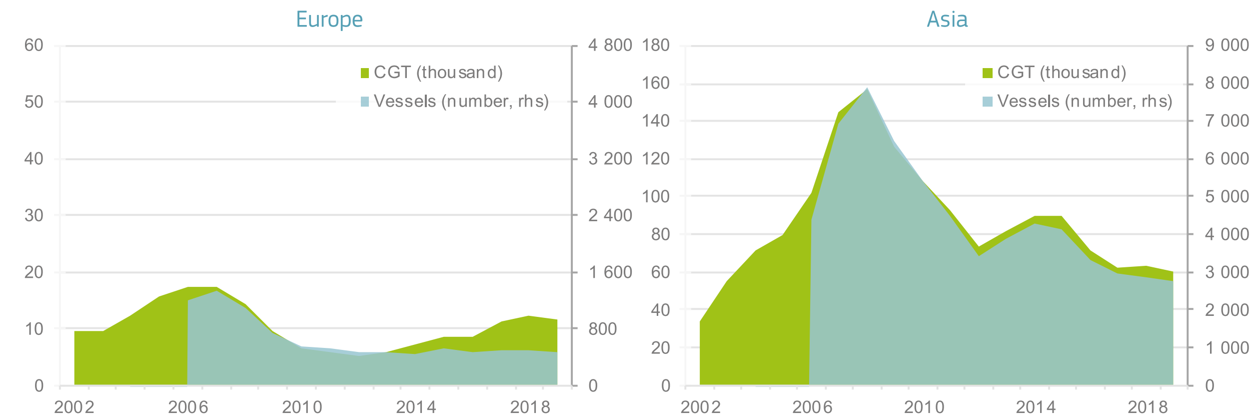
While in the early 2000s, European shipyards produced a variety of ship types, in the latest decade, they have specialised in high-technology segments, i.e. passenger ships (mainly ferries and cruise vessels), offshore structures and other non-cargo carrying vessels (ONCCV), with the combination of these two types of vessels now representing more than 95% of the order book (Figure 5.28). This trend has been pushed by Asian shipyards, aided by strong state support and lower prices in the volume markets (e.g. bulk carriers, containerships, tankers and cargos).

Figure 5.28 Order book by ship type, European Shipyards, percentage



Notes: ONCCV: Other non-cargo carrying vessels; ODC: Over dimensional cargo.
Source: Sea Europe based on IHS Fairplay and Commission Services.

Figure 5.29 Order book in shipyards: Europe vs Asia



Notes: European Union refers to EU 28 plus Norway. Asia includes China, South Korea and Japan. CGT: compensated gross tonnage.
Source: Sea Europe based on IHS Fairplay and Commission Services.

The specialisation of European shipyards in high-technology vessels is also reflected in the evolution of the order book, which has remained stable since 2013 in terms of number of vessels, but has more than doubled in terms of gross tonnage compensated by the amount of work necessary to build those ships (Figure 5.29, left-hand panel). On the other hand, the order books in Asian shipyards have deteriorated as a result of the global excess capacity and downturn in global volume markets (Figure 5.29, right-hand panel).

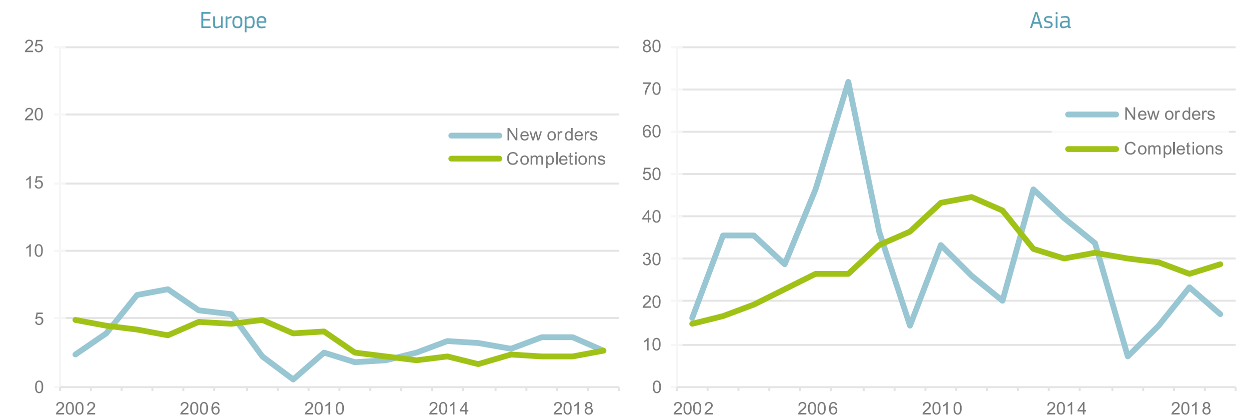
European shipyards have recovered from the dip of 2010-2013, which followed the 2008-2009 financial crisis, with new orders consistently surpassing completions since 2013; while, in Asian shipyards, new orders have remained below completions since 2015 (Figure 5.30).

However, European shipyards saw a decline in their combined order volume in 2019 after several consecutive growth years during which benefits came from their repositioning in healthier high-tech niche markets. However, these high-tech niche market segments i.e. cruise, ferry, and other specialised non cargo carrying vessels, will likely be severely hit by the COVID 19 outbreak.

Besides the direct competition between European and Asian shipyards, the decline in orders observed in Asia indirectly affects the supply chain in Europe, as a significant share of the equipment installed by Asian shipyards is supplied by European companies. Indirect effects come also from the subsequent overcapacity in Asia (and globally), although this may vary from segment to segment.

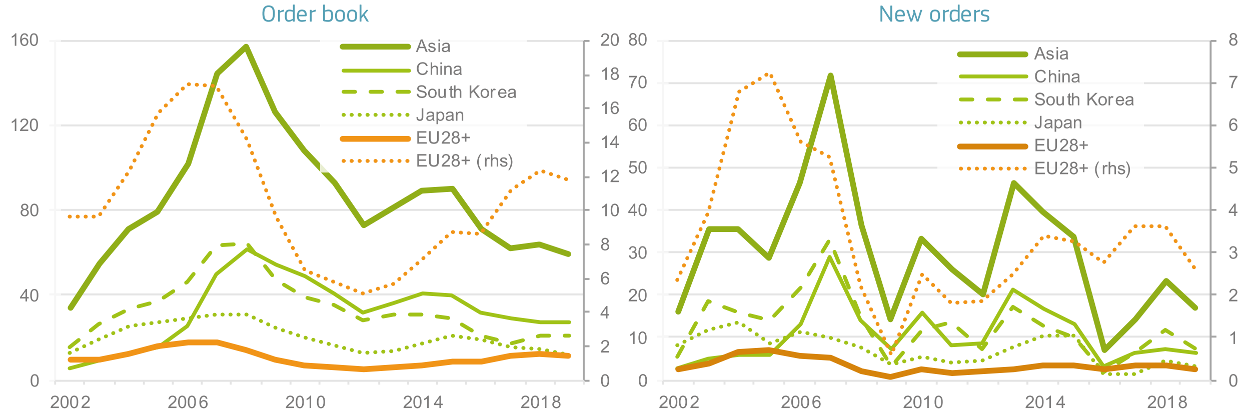
Nevertheless, the Asian shipyards order book remains, in order of magnitude, larger than the European one: 12 000 CGT in Europe vs. 61 000 CGT in Asia (28 000 CGT in China, 20 000 in South Korea and 13 000 in Japan). Similar figures can be observed for new orders (3 200 CGT in Europe and 14 600 CGT in Asia) (Figure 5.31).

Figure 5.30 New orders and completions in shipyards: Europe vs Asia, CGT thousand



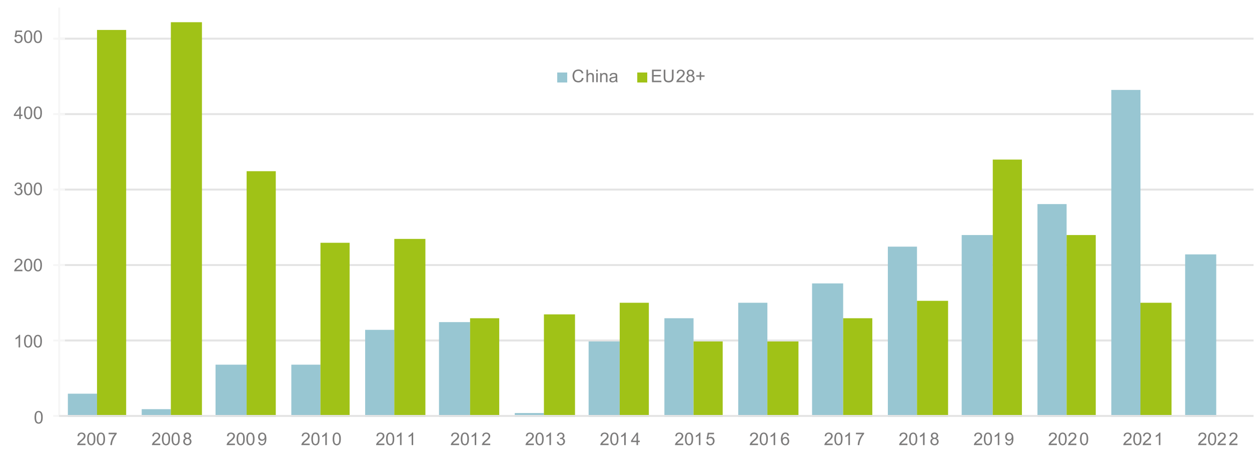
Notes: European Union refers to EU 28 plus Norway. Asia includes China, South Korea and Japan. CGT: compensated gross tonnage.
Source: Sea Europe based on Clarkson and Commission Services.

Figure 5.31 Order book and new orders in shipyards: Europe vs Asia, CGT thousand



Notes: European Union refers to EU 28 plus Norway. Asia includes China, South Korea and Japan. CGT: compensated gross tonnage.
Source: Sea Europe based on IHS Fairplay and Commission Services.

Figure 5.32 Deliveries, passenger ships except cruise vessels, thousand CGT



Notes: EU28+ includes the European Union 28 and Norway. Asia includes China, South Korea and Japan. CGT: compensated gross tonnage.
Data for 2019-2022 according to order book as of June 2019.
Source: Sea Europe based on IHS Fairplay and Commission Services.

In order to address the negative evolution in their shipbuilding industry, the Chinese authorities have embarked in a strong policy of support for shipyards, which is leading (amongst others) the ferry segment to favour Chinese shipyards above EU ones. This is demonstrated by the increase in new orders and deliveries to Chinese shipyards as opposed to EU ones since 2015 (Figure 5.32). This is the case even if the end market for such ferry ships, is mainly Europe (e.g. ferry lines in the Baltic and Mediterranean). EU shipyards are unable to compete with inferior Chinese prices, seemly below (sometimes significantly below) production costs.

EU shipyards are being limited to a few segments such as the cruise vessels. However, it is uncertain these holds will last. In this context, the European Green Deal may provide some opportunities for EU shipyards, albeit challenging too. The EU is still a leader in high-technological issues; therefore, continuous investment in RD&I in aspects such as alternative propulsion systems and auxiliary energy could help maintain the sector's competitiveness.

5.6. MARITIME TRANSPORT

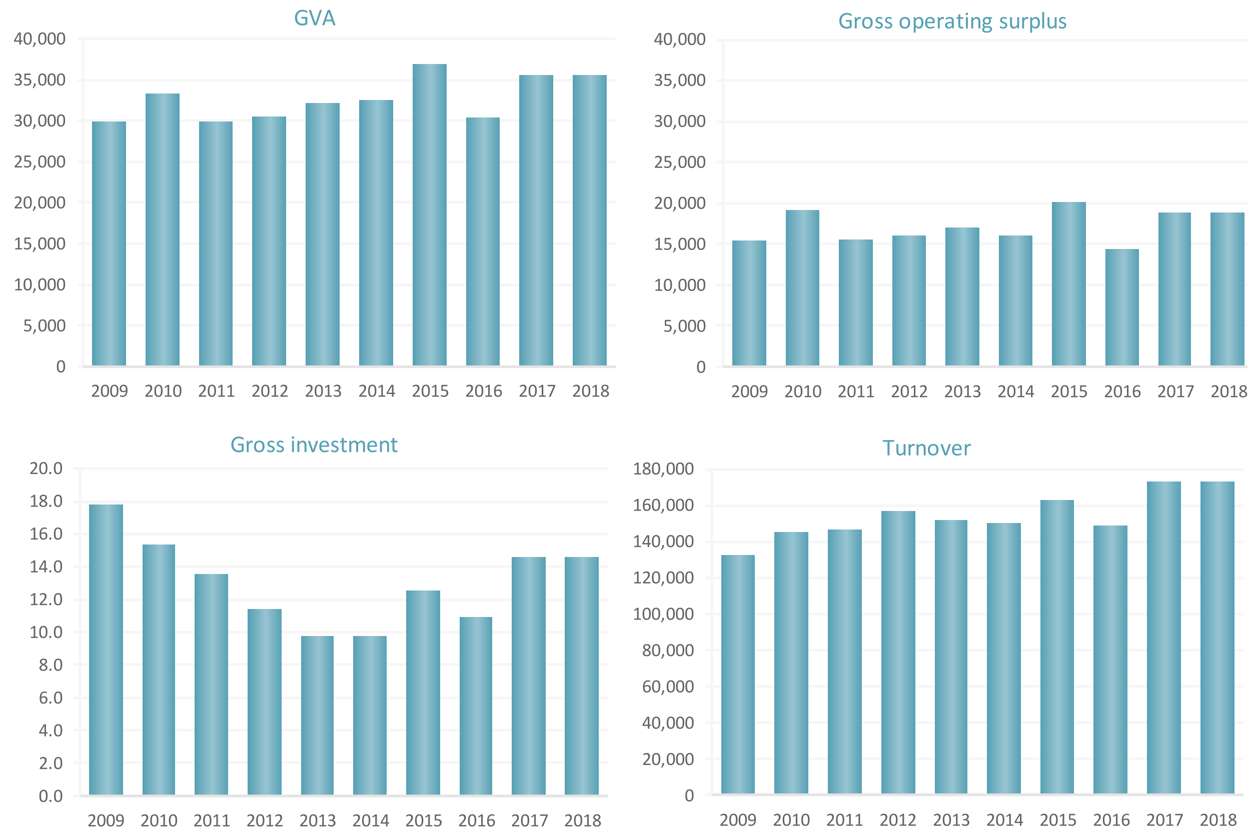
5.6.1. BACKGROUND

Maritime transport is essential to the global economy. Moreover, there is little if any dispute over the fact that shipping is the most carbon-efficient mode of transportation. International maritime shipping accounts for about 3-4% of annual global greenhouse gas emissions[236] and produces less exhaust gas emissions — including nitrogen oxides, hydrocarbons, carbon monoxide and sulphur dioxide — for each tonne transported per one kilometre than air, rail or road transport.[237] The size and global nature of maritime shipping make it critical for the industry to continue to reduce its environmental impact, and significant progress in fuel efficiency has been made.

Due to the expected growth of the world economy and associated transport demand from world trade, greenhouse gas emissions

[236] International Maritime Organisation (2014). Third IMO Greenhouse Gas Study.
[237] Swedish Network for Transport and the Environment.

Figure 5.33 Size of the EU *Maritime transport* sector, € million



Note: Turnover should be interpreted with caution due to the problem of double counting throughout the value chain.
Source: Eurostat (SBS) and Commission Services.

from shipping could grow from 50% to 250% by 2050 if measures are not taken,[238] making it paramount for the industry to continue to improve energy efficiency of ships and to shift to alternative fuels.

Maritime transport plays a key role in the EU economy and trade, estimated to represent between 75% and 90% (depending on the sources) of the EU's external trade and one third of the intra-EU trade. Moreover, more than 410 million passengers aboard cruises and ferries embark and disembark at EU ports in 2018, a rise of 5.6% from the previous year.

In 2018, the total weight of goods transported to/from main ports in the EU by short sea shipping (excludes the movement of cargo across oceans, deep sea shipping) was 1.8 billion tonnes.

For the purpose of this report, Maritime transport includes:

(1) **Passenger transport**: sea and coastal passenger water transport and inland[239] passenger water transport;

(2) **Freight transport**: sea and coastal freight water transport and inland freight water transport;

(3) **Services for transport**: renting and leasing of water transport equipment.

Overall, Maritime transport accounted for 8% of the jobs, 16% of the GVA and 20% of the profits in the EU Blue Economy in 2018. The sector seems to have fully recovered from the drop in 2016.

5.6.2. MAIN RESULTS

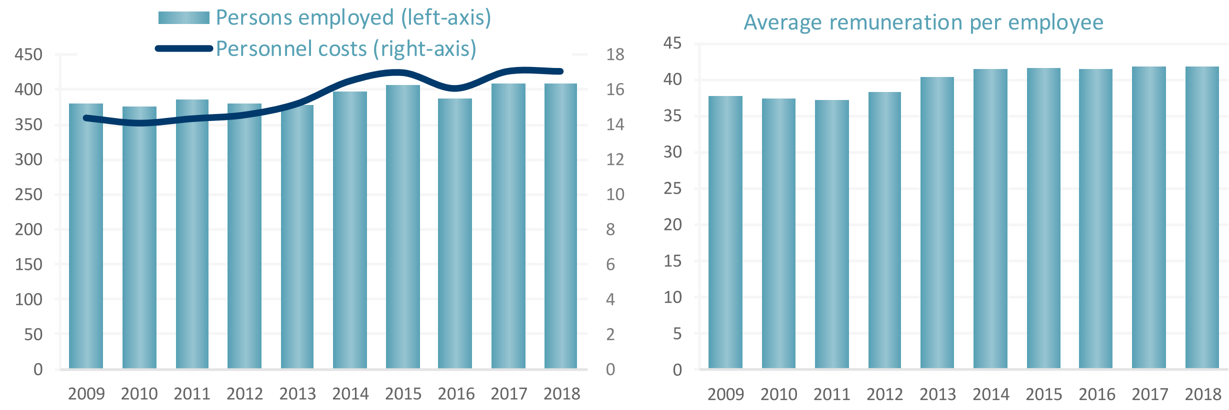
Size of the EU Maritime transport sector in 2018

The sector generated a GVA of €35.6 billion, which is 19% higher compared to 2009. Gross profit, at €18.8 billion, increased by 22% on 2009 (€15.5 billion). The profit margin was estimated at 11%, slightly below the 12% in 2009. The investment ratio (gross investment in tangible goods / GVA) was estimated at 41%, still well below the figure for 2009 (60%). The turnover reported was €173.2 billion, a 31% increase on 2009.

Around 407 825 persons were directly employed in the sector (7% more than in 2009). Total wages and salaries amounted to €17 billion and the annual average wage was estimated at almost €41 800, up 11% compared to 2009.

[238] http://www.imo.org/en/OurWork/Environment/PollutionPrevention/AirPollution/Pages/Greenhouse-Gas-Studies-2014.aspx
[239] Inland transport is considered part of the Blue Economy because it includes transport of passengers and freight via rivers, canals, lakes and other inland waterways, including within harbours and ports.

Figure 5.34 Persons employed (thousand), personnel costs (€ million) and average wage (€ thousand) in the EU *Maritime transport* sector



Source: Eurostat (SBS) and Commission Services. Dotted line shows the two-year moving average

Germany leads Maritime transport, contributing with 32 % of the jobs and 33 % of the GVA, followed by Italy with 17 % of the jobs and 13 % of the GVA.

Results by subsectors and Member states

Employment: Services for transport account for 46 % of the jobs (189 154 persons), while Passenger transport covered 29 % (116 430 persons) and Freight transport the remaining 25 % (102 241 persons). Overall employment increased 7 % compared to 2009; the 19 % decrease in Freight transport was compensated by the +21 % increase in Services and +19 % in Passenger transport. The top MS contributors are Germany (32 %), followed by Italy (17 %), France (8 %), Netherlands and Denmark (7 % each).

Gross value added: Freight transport covered 41 % of the sector's GVA, amounting to €14.4 billion followed by Services with 32 % (€11.5 billion) and then Passenger transport with 27 % (€9.7 billion). Overall GVA increased 19 % compared to 2009: +57 % in Passenger transport, +25 % in Services while Freight transport remained stable. Top MS contributors are Germany at €11.8 billion (33 %), followed by Italy (€4.7 billion), Denmark (€4.6 billion), the United Kingdom (€4.5 billion) and the Netherlands (€2.1 billion).

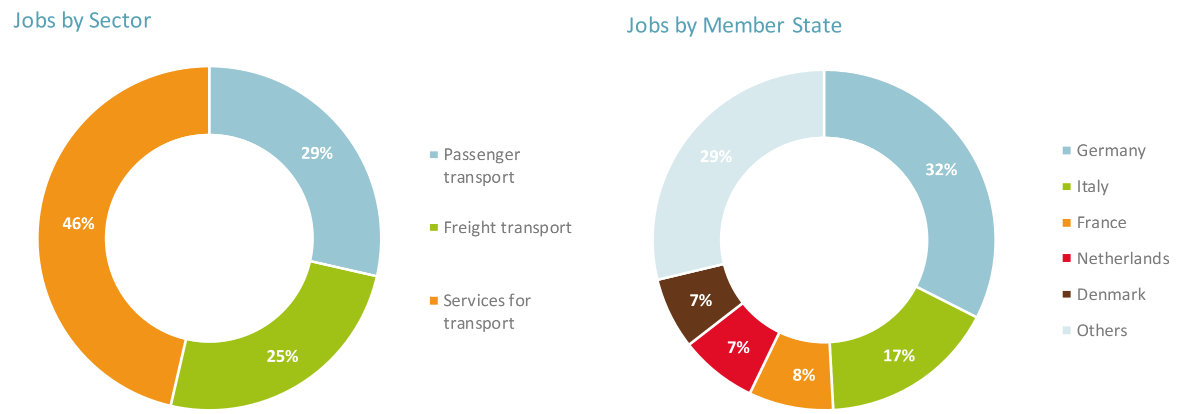
Gross profit: Profit is mainly generated in Freight transport, €8.5 billion (46 %), followed by Passenger transport with €5.8 billion (31 %) and then Services €4.4 billion (23 %). Overall profit increased 22 % compared to 2009, with Services for transport increasing 7 %, Passenger transport increasing 118 % and Freight transport decreasing by 2 %.

Gross investment in tangible goods:[240] Gross investment amounted to €14.6 billion, an 18 % plunge compared to 2009. Services received 23 % of the sector investment, Passenger transport received 17 % and Freight transport received 74 %. Apart from Freight transport (+1 %), all sub-sectors saw investments fall substantially compared to 2009: -60 % in Services and -37 % in Passenger transport.

Turnover: Again, turnover is mainly generated in Freight transport, accounting for 57 % of the total sector turnover (€98.4 billion), followed by Services at 27 % (€47.4 billion) and then Passenger transport with 16 % (€27.4 billion). Overall sector's turnover increased 31 % compared to 2009: +43 % in Passenger transport, +35 % in Services and +26 % in Freight transport.

Germany leads the sector with 32 % of the Maritime transport jobs and 33 % of the GVA, Italy follows with 17 % and 13 %, respectively.

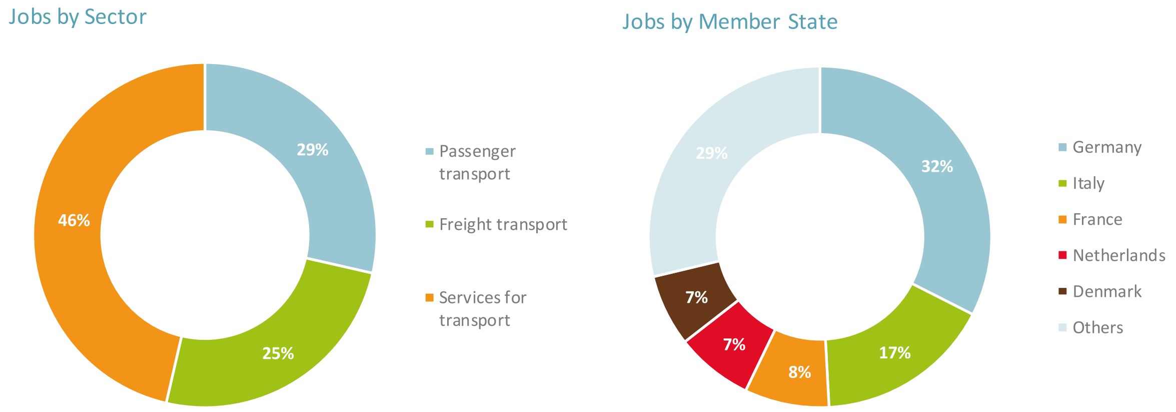
Figure 5.35 Share of employment in the EU *Maritime transport* sector, 2018



Source: Eurostat (SBS) and Commission Services

240 Net investment in tangible goods unavailable for the sector.

Figure 5.36 Share of the GVA generated in the EU *Maritime transport* sector, 2018



Source: Eurostat (SBS) and Commission Services

5.6.3. TRENDS AND DRIVERS

The main developments in *Maritime transport* in recent years are related to the continuous increase in ship sizes for all segments (e.g. tankers and container carriers, but also cruises). This increase in the ship sizes, which aims to lower costs by reaping economies of scale, has been possible thanks to technological improvements. These new forms of maritime transport have significantly affected the *Shipbuilding* and *Ports* sectors, as well as their surrounding infrastructures (e.g. road and rail connections). A possible opening of an Arctic route may have an impact in the medium term for international shipping from and to the EU.

In December 2019, European Commission published the European Green Deal, an ambitious growth strategy, which sets out a plan for an economy-wide transition, which will enable Europe to achieve climate neutrality by the year 2050. Among other measures, the Green Deal strives to increase the EU's greenhouse gas emission reductions target for the year 2030 and to introduce more stringent air quality standards. The Transportation sector, which accounts for a quarter of the EU's total greenhouse gas emissions, is expected to achieve a 90% reduction in transport emissions by the year 2050.

5.6.4. INTERACTIONS WITH OTHER SECTORS

Maritime transport requires Ports and their infrastructure to operate. Transport companies have an interest in optimising their routes, which may compete in space with other activities such the *Marine Living resources* and *Marine Renewable Energy* as well as marine protected areas.

5.6.5. NEW FUELS FOR SHIPPING

The maritime transport sector is an essential vector for European trade and a key driver of economic growth, since 75-90% of the EU's external trade and 36% of intra-EU trade is seaborne. Currently, shipping is also and by far, the most carbon-efficient form of commercial transport.

Yet, international shipping consumes as much fuel as the entire energy needs of Germany, Europe's largest economy, and accounts for 2-3% of worldwide CO_2 emissions. Maritime shipping is also responsible for 13% of the world's sulphur emissions and 15% of the world nitrogen oxides emissions, and is associated with marine biodiversity losses and degradation of the ocean's ecosystem (EPSC, 2019).[241]

Maritime shipping, as an international transport sector in particular, has a significant potential to support reaching climate neutrality as outlined by the European Green Deal. In 2018, the International Maritime Organisation (IMO) reached a first global agreement to cut total GHG emissions from shipping by at least 50% by 2050 (compared to 2008).

To reach this target, the sector has to considerably increase its R&D spending, and technologies need to be deployable by 2030. Achieving decarbonisation will require a combination of technological and operational innovations and the large-scale use of alternative fuels. Low-carbon fuels will progressively integrate the energy mix (Figure 5.37). The work at the IMO to reduce the sector's emissions is ongoing.

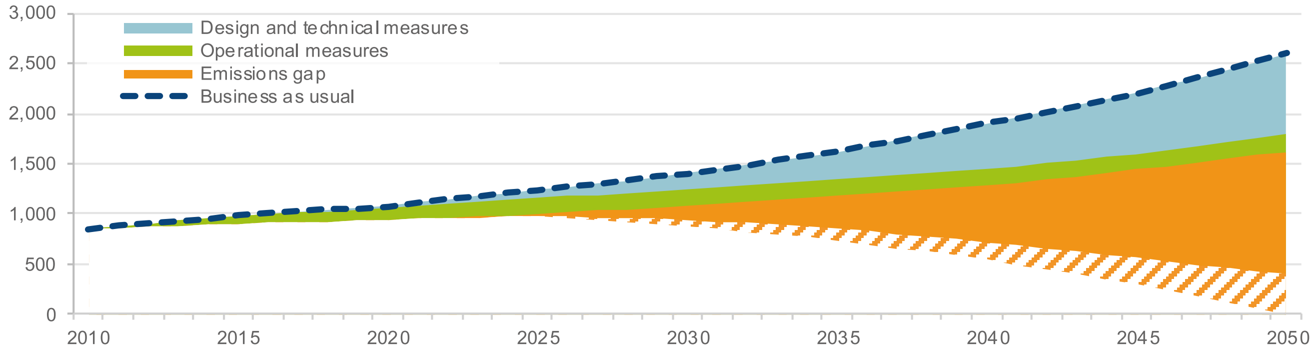
Finding sustainable technological and viable solutions for reducing shipping emissions is a key challenge and no one-solution will fit all vessel types, trades and geographies. The choice of a new technology will vary across vessel segments and will be strongly influenced by the investment horizon, coherent long-term policy framework and optimal solutions for specific vessel types.

Deep-sea vessels have fewer options compared to short-sea segments and will likely rely on different solutions. Short-sea shipping vessels typically operate in limited geographical areas, on relatively short routes and with frequent port calls. On the other hand, deep-sea vessels require fuel that is globally available, and with high fuel energy density to maximise the available space for cargo transport.

While Liquid Natural Gas (LNG) has been considered as a solution to the 2020 global sulphur cap and as a potential transition fuel, its GHG abatement potential is limited and its use would require complex engine and vessel transformations together with global investments in ports and bunkering infrastructures.

[241] EPSC (2019), Clean Transport at Sea https://ec.europa.eu/epsc/sites/epsc/files/epsc_clean-transport-at-sea.pdf

Figure 5.37 A pathway towards IMO 2050 targets: baseline and potential emission reduction scenarios, CO_2 million t per year



Source: IMO, 2018 — IMO action to reduce GHG emissions from international shipping.

A range of alternative fuels and technologies could provide a low to zero-carbon solutions for shipping[242][243]. **Biofuels**, while not an emission free alternative, can provide significant reduction on a lifecycle basis. Hydrogen produced using renewable energy (see section 6.1) is likely to be a major enabler of zero-emission shipping. Beyond its direct use as a fuel, it is an enabler for other **net zero-emission fuels** such as ammonia and electricity, or synthetic fuels produced by combination with carbon dioxide sources. However, to date, most hydrogen is produced from natural gas without CCS (Carbon Capture and Storage) and given the low demand of hydrogen as a fuel, there is no infrastructure for its distribution. This low market volume constitutes the main barrier for the uptake of hydrogen in shipping.

While batteries or fuel cells are unlikely to play an immediate role in propelling deep-sea vessels, the development of hybrid or fully electrified power trains will enable innovative vessels layouts, further energy efficiency, the integration of renewables as well as zero-emission applications in short-sea segments.

Those fuels that can be blended with conventional fuels or used as full substitutes (drop-in fuels), thereby leveraging existing engines and infrastructures will have a competitive advantage. Prototypes and pilot projects will be essential to confirm the benefits of the proposal technological solutions, in terms of emissions, safety and competitiveness. Short-sea vessels could be used to assess and validate technologies and their potential for deep-sea applications.

5.7. COASTAL TOURISM

5.7.1. BACKGROUND

Europe continues to stand as the most-visited region, welcoming half of the world's international tourist arrivals. Within Europe, the EU accounts for the bulk of the region's international arrivals, some 81 % of Europe's total and 40 % of the world's figure. Tourism plays an important role in many EU Member State economies, with wide ranging impact on economic growth, employment and social development.

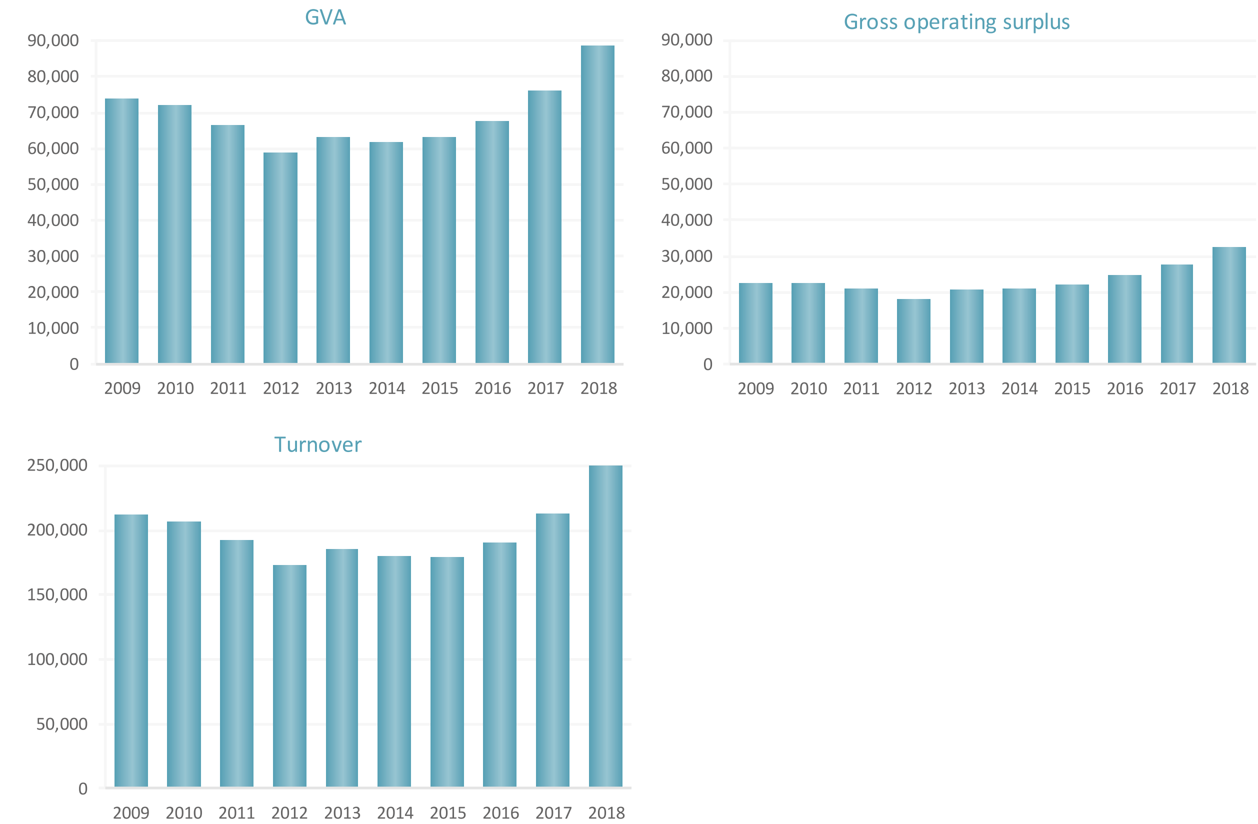
According to a study by the European Commission,[244] the EU welcomed 500 million international tourist (overnight visitors) in 2017, accounting for 40 % of the world's total. International tourism receipts reached €342 billion, representing 31 % of worldwide tourism earnings.

In 2018, just over half (51.7 %) of the EU's tourist accommodation establishments were located in coastal areas. Visitors to coastal areas were generally higher in southern EU Member States, which are generally more conducive to beach holidays due to climatic conditions. In 2018, coastal areas accounted for more than three quarters of the total nights spent in tourist accommodation across Malta, Cyprus, Greece, Croatia, Portugal and Spain.[245]

The three most popular tourist destinations in the EU, all located in coastal areas, were the Canary Islands and Catalonia in Spain and the Adriatic coastal region of Jadranska Hrvatska in Croatia.[246] The increasing number of tourists have led to concerns around the sustainable development of coastal areas, especially those characterised by high-density building and expanding environmental footprints.

242 Lloyd's Register (2019) — Zero-Emission Vessels: Transition Pathways.
243 DNV GL (2019) — Energy Transition Outlook, Maritime Forecast To 2050.
244 European Commission. 2018. European Union Tourism Trends (https://ec.europa.eu/growth/tools-databases/vto/content/2018-eu-tourism-trends-report).
245 This was also the case for Estonia (77.6 %) and Latvia (83.5 %), largely due to prime destinations Tallinn and Riga being coastal municipalities.
246 Sources: https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Tourism_statistics_at_regional_level.

Figure 5.38 Size of the EU *Coastal tourism* sector, € million



Note: Turnover should be interpreted with caution due to the problem of double counting throughout the value chain. Gross investment is not available for Coastal Tourism.
Source: Eurostat (SBS) and Commission Services.

Coastal tourism includes beach-based tourism and recreational activities, e.g. swimming, sunbathing, and other activities for which proximity to the sea is an advantage, such as coastal walks and wildlife watching. Maritime tourism covers water-based activities and nautical sports, such as sailing, scuba-diving and cruising.

For the purpose of this report, Coastal tourism also refers to maritime tourism and is broken down into three main expending categories:

(1) **Accommodation**,

(2) **Transport** and

(3) **Other expenditures**

Overall, Coastal tourism accounted for 62% of the jobs, 41% of the GVA and 34% of the profits in the EU Blue Economy in 2018.

5.7.2. MAIN RESULTS

Size of the EU Coastal tourism sector in 2018

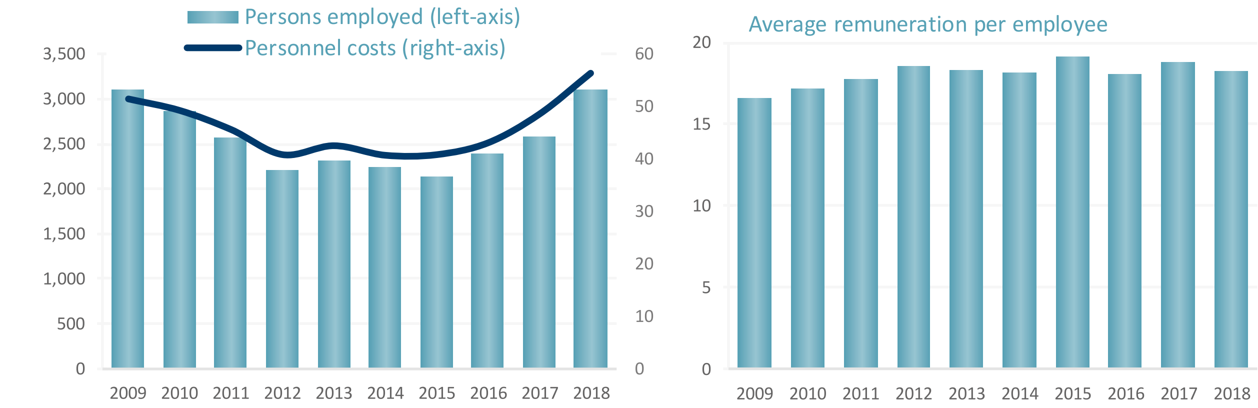
GVA generated by the sector amounted to just under €88.6 billion, a 20% rise compared to 2009[247]. Gross operating surplus was valued at €32.3 billion (+44% compared to 2009) (Figure 5.38). Turnover amounted to €249.6 billion, 18% more than in 2009.

Around 3.1 million people were directly employed in the sector in 2018 (up by 13.5% compared to 2016) and personnel costs reached €56.4 billion, up from €51.5 billion in 2009 (Figure 5.39), amounting to an average wage of €18210 in 2018, a 10% increase from €16600 in 2009. The sector was impacted by the global economic and financial crisis, which saw a gradual decrease in employment over the period 2009 to 2015. However, in the last three years a strong recovery can be seen. Personnel costs have followed a similar trend; hence, average wages have remained relatively stable during the period.

Spain leads Coastal tourism with 24% of the jobs and 27% of the GVA, followed by Greece and Italy. The sector is recovering and growing.

[247] In 2017, a few countries (e.g. Denmark and Sweden) changed the methodology for the collection of tourism statistics and therefore, there is a break in the series. Growth rates have been estimated by adjusting for the change of methodology.

Figure 5.39 Persons employed (thousand), personnel costs (€ million) and average wage (€ thousand) in the EU *Coastal tourism* sector



Source: Eurostat (SBS) and Commission Services.

Results by subsectors and Member states

Employment: Other expenditures generated over 1.4 million jobs, corresponding to 46 % of the Coastal tourism direct employment, Accommodation employed 1.2 million persons (39 %) and transport a further 453 800 jobs (15 %). Compared to 2009, all sub-sectors, apart from other expenditure that increased by 18 %, saw a decrease in persons employed: -14 % in Accommodation and -6 % in Transport. The top employers are Spain offering 24 % of the jobs (749 020 persons), followed by Greece with 15 % (453 274 persons) and then Italy with 10 % (308 445 persons).

Gross value added: Most of the value added is generated by Accommodation: €41.1 billion (46 % of the total), followed by Other expenditure €26.8 billion and Transport €20.7 billion. Compared to 2009, all sub-sectors saw substantial increases in GVA: +11 % in Accommodation, +28 % in Other expenditure and +29 % in Transport.

Gross profit: The bulk of profits are generated by Accommodation (€17.4 billion, 54 %), followed by Other expenditure (24 %) and Transport (22 %). Compared to 2009, gross operating surplus increased for all sub-sectors: +45 % in Accommodation, +18 % in Other expenditure and +93 % in Transport.

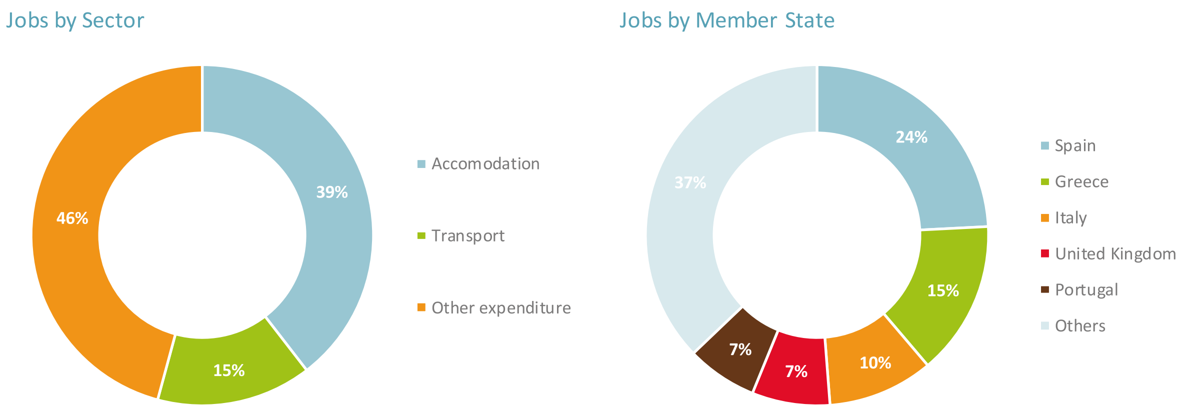
Turnover: Other expenditure generated €94.4 billion in turnover, followed by Accommodation with €84 billion and then Transport (€71.2 billion). Compared to 2009, all sub-sectors saw a turnover increase: +11 % Accommodation, +24 % Other expenditure and +19 % Transport.

5.7.3. TRENDS AND DRIVERS

EU policy aims to maintain Europe's standing as a leading tourist destination while maximising the industry's contribution to growth and employment. As part of EU's Blue Growth strategy, the coastal and maritime tourism sector has been identified as an area with special potential to foster a smart, sustainable and inclusive Europe. Sustained growth in tourism has been instrumental in supporting the economic recovery of many EU Member States, largely contributing to job creation, GDP and the balance of payments.

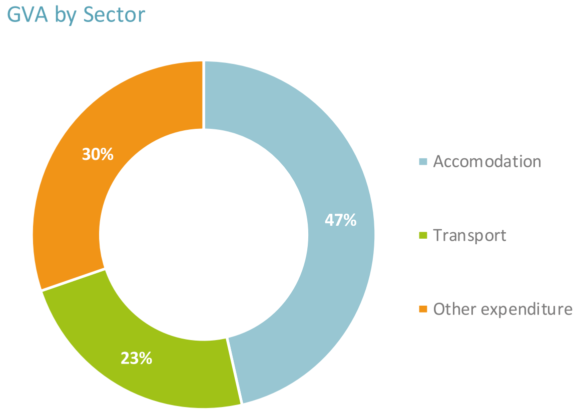
The rate of growth in the sector has accelerated since the recession, positively impacting the EU economy. Besides intra-European tourism, the United States and China are two key markets that have contributed to the growth. While good for development, the increase in tourist numbers has brought its own challenges, as many destinations, in particular coastal areas and small islands, look to find sustainable ways to cope with the high intensity of tourists.

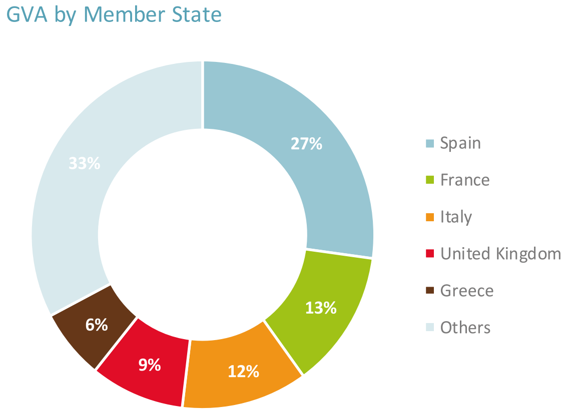
Figure 5.40 Share of employment in the EU *Coastal tourism* sector, 2018



Source: Eurostat (SBS) and Commission Services

Figure 5.41 Share of the GVA generation in the EU *Coastal tourism* sector, 2018





Source: Eurostat (SBS) and Commission Services.

Coastal communities, mainly composed of SMEs and micro-enterprises, are particularly vulnerable to economic, financial and political changes. Regional and structural EU funds and EU instruments can help finance project planning and implementation for the sector to take up the challenges and invest in modernisation and innovation.

In addition, coastal areas are especially prone to a number of climate change related impacts, such as flooding, erosion, saltwater intrusion, increase in temperatures and droughts. These can have severe direct and indirect effects on coastal and maritime tourism. Coastal defence is of prime importance to counter coastal erosion and flooding and maintain tourism facilities and activities.

While tourism was expected to continue to grow in 2020, the outbreak of COVID-19 in Europe in February 2020 has put the tourism industry under unprecedented pressure. Due to the travel restrictions, there are few new bookings for tourism services while at the same time, the industry is flooded with claims for refunds on cancellations and the non-performance of services. Whilst the European Commission and national governments are implementing measures in an attempt to mitigate the effects, the true extent of economic impact remains to be seen. Jobs and revenues are already showing signs of major disturbances.

5.7.4. INTERACTIONS WITH OTHER SECTORS

Coastal and maritime tourism depend highly on good environmental conditions and in particular on good water quality. Any maritime or land-based activity deteriorating the environmental can negatively affect tourism. Coastal areas may also be directly or indirectly affected by a number of climate change related impacts, such as, flooding, erosion, saltwater intrusion, increase in air and seawater temperatures and droughts.

Ports are crucial for the economic growth of coastal and inland areas. Passenger and cruise transport are important means for maritime and coastal tourism development while freight transport can be seen as a competing activity in terms of space. An example of this weak balance appears in cruise tourism (see section 5.7.5). The EU Commission promotes a pan-European dialogue between cruise operators, ports and coastal tourism stakeholders to enhance synergies in the sector, targeting best practice sharing in innovation, competitiveness and sustainability strategies.

Synergies may emerge through alternative activities, including eco-tourism and marine protected. Co-existence with other Blue Economy sectors, such as the extraction of *Marine living* and *non-living resources* may depend on direct spatial conflicts, while synergies may also exist. For example, *Marine renewable energies* such as offshore wind farms may help to mitigate environmental impacts by reducing carbon and other greenhouse gas emissions but may imply a trade-off with aesthetic benefits.

The natural resources and beauty of coastal areas have made them popular destinations for visitors. A healthy natural environment is a huge asset but tourism generates lots of pressures on local environment and ecosystems, such as higher water use, increased waste generation and accumulated emissions from air, road and sea transport in peak seasons.

5.7.5. CRUISE TOURISM

The cruise industry is an important and growing segment within *Coastal tourism*. Its economic impact derives from several sources, including, the direct expenditure by passengers and crew when they embark, disembark, or port of call stops to visit the cities, the purchase of food and other supplies by the cruise company, port taxes and other fees paid by the cruise company and the potential source of employment as a crew member.

Europe is the largest cruise ship builder, the second largest market for cruise source passengers, and the world's second most popular cruise destination. As indicated in Section 5.4, cruise building is a niche sector where EU's shipyards are specialised, accounting for the construction of most ships in the global market.

On the other hand, the success and rapid development of cruise holidays now pose risks of saturating some specific destinations, with associated potential negative effects. To cope with the flux of tourists, some destinations have started to manage or apply some restrictions on the arrival of cruise passengers.

Table 5.10 Economic impact of the cruise industry in the EEA per sector, 2017

Industry	**Total impact** (direct + indirect + induced)			**Direct impact**		
	Output	**Employment**		**Expenditure**	**Employment**	
	€ million	**Jobs**	**Compensation** € million	€ million	**Jobs**	**Compensation** € million
Agriculture, Mining & Construction	2,655	19,722	381	23	244	5
Manufacturing	17,390	98,091	3,795	9,591	52,536	2,071
Wholesale & Retail Trade	2,841	38,043	700	887	12,554	255
Hospitality	1,496	19,418	448	467	7,287	167
Transportation & Utilities	8,375	51,836	1,995	4,307	26,470	975
Financial & Business Services	11,220	77,090	2,814	2,002	15,794	553
Personal Services & Govt.	2,207	30,349	962	748	11,284	322
Cruise Line Employees	1,674	69,072	1,674	1,674	69,072	1,674
Total	**47,858**	**403,621**	**12,769**	**19,699**	**195,241**	**6,022**

Notes: Manufacturing data represents that of durable and nondurable goods.
Source: CLIA. 2018. The Contribution of Cruise Tourism to the Economies of Europe in 2017.

Table 5.11 Economic impact of the cruise industry in the EEA per Member State, 2017

Member State	**Total impact** (direct + indirect + induced)			**Direct impact**
	Output	**Employment**		**Expenditure**
	€ million	**Jobs**	**Compensation** € million	€ million
Italy	13,210	119,052	3,686	5,463
United Kingdom	10,390	82,410	3,159	3,850
Germany	6,432	48,490	1,804	3,140
France	3,516	19,973	925	1,679
Spain	4,252	31,233	959	1,481
Finland	1,573	10,756	405	703
Netherlands	1,058	8,992	270	563
Greece	913	10,721	204	546
Sweden	532	3,385	141	269
Rest of EEA	5,982	68,609	1,216	2,002
Total	**47,858**	**403,621**	**12,769**	**19,696**

Source: CLIA. 2018. The Contribution of Cruise Tourism to the Economies of Europe in 2017.

The global cruise industry has grown in the upper double digits over the last decade. Where 2008 saw a total of 16.3 million sourced passengers, this number has grown by 75 % to 28.5 million passengers in 2018. In 2015, a total of 7.2 million passenger embarked from a European port, a growth of 60.4 % in ten years.[248]

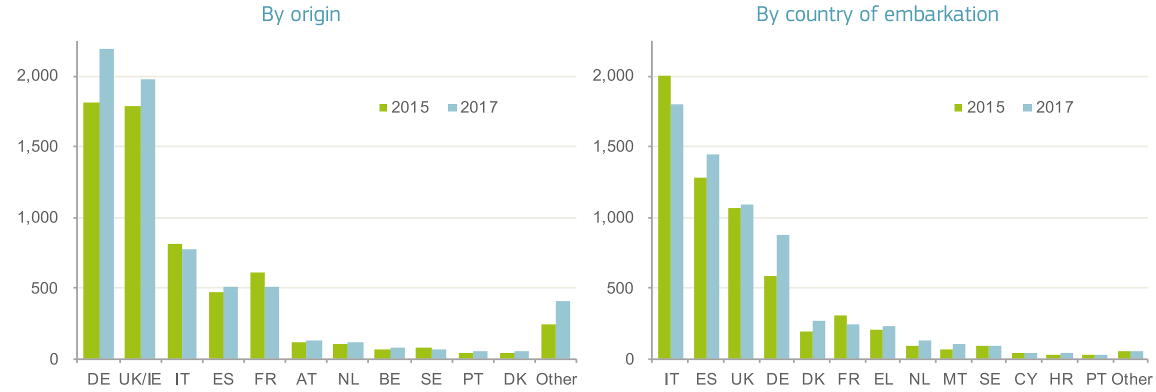
In 2017, there were 137 cruise ships in operation by 40 cruise lines based in the EEA. These ships had a total capacity of approximately 164 000 lower berths.[249] In addition to these ships, another 75 cruise ships were in operation in EEA by cruise lines that domicile outside the EEA. These ships allotted an additional capacity of 95 000 lower berths.

According to the latest data available,[250] the direct economic impact of the cruise industry in the EEA amounted to €19.7 billion in 2017, involving over 195 000 jobs and €6 million in employee compensation. Direct expenditures were highest in Italy (€5.5 billion), followed by the United Kingdom (€3.9 billion), Germany (€3.1 billion), France (€1.7 billion), and Spain (€1.5 billion).

The total economic impact (incl. direct, indirect and induced impacts)[251] amounted to €47.9 million in 2017, an increase of 16.9 % compared to 2015 figures. This implies that for each euro of direct impact by the cruise sector generates almost one and a half euros of additional impacts in the form of indirect and induced effects. The sectors that benefitted most in terms of output were manufacturing (€17.4 billion), financial businesses and services (€11.2 billion), and transportation and utilities (€8.4 billion) (Table 5.10). The countries that had the highest output in 2017 were Italy (€13.2 billion), the United Kingdom (€10.4 billion), Germany (€6.4 billion), Spain (€4.3 billion) and France (€3.5 billion) (Table 5.11).

248 CLIA. 2019. The Contribution of the International Cruise Industry to the Global Economy in 2018. [https://cruising.org/-/media/research-updates/research/global-cruise-impact-analysis---2019--final.pdf]
249 Lower berths is a term used in the cruise industry to refer to a 2 guest cabin capacity.
250 CLIA. 2018. The Contribution of Cruise Tourism to the Economies of Europe in 2017. [https://cruising.org/-/media/research-updates/research/economic-impact-studies/contribution-of-cruise-tourism-to-the-economies-of-europe-2017.pdf]
251 Indirect accounts for spending by businesses, that are directly impacted, on goods and services needed to support the cruise industry (i.e. the industry suppliers). Induced accounts for impacted employees spending on household goods and services.

Figure 5.42 EEA Cruise Passengers, thousands



Notes: The split between UK and Ireland is not available for the breakdown by origin.
Source: CLIA. 2018. The Contribution of Cruise Tourism to the Economies of Europe in 2017.

Table 5.12 Number of port of call visits in EU ports, thousands

Member State	2015		2017	
	Number	Percentage	Number	Percentage
Italy	6,800	25%	6,796	23%
Spain	5,932	22%	6,672	23%
Greece	4,177	15%	4,090	14%
France	2,390	9%	3,014	10%
United Kingdom	1,361	5%	1,820	6%
Portugal	1,278	5%	1,260	4%
Croatia	1,142	4%	1,090	4%
Sweden	519	2%	591	2%
Malta	530	2%	565	2%
Denmark	447	2%	557	2%
Estonia	490	2%	544	2%
Finland	450	2%	497	2%
Belgium	233	1%	396	1%
Germany	332	1%	390	1%
Netherlands	319	1%	330	1%
Ireland	232	1%	262	1%
Poland	232	1%	139	0%
Latvia	83	0%	86	0%
Other EU	82	0%	204	1%
Total	**27,027**	**100%**	**29,301**	**100%**

Notes: A passenger may call in several ports during the same trip; the table reflects the total number of visits/calls. United Kingdom includes data of Gibraltar. Ports of embarkation and disembarkation are not included.
Source: CLIA. 2018. The Contribution of Cruise Tourism to the Economies of Europe in 2017.

These economic activities supported over 400 000 jobs, most of which originated in the manufacturing sector (98 000), followed by financial services and businesses (77 000) and cruise line employment (69 000) (Table 5.10). Most jobs were filled in Italy (119 000), followed by the United Kingdom (82 410) and then Germany (48 490) (Table 5.11). Of the total economic impact, 26.7 % totalling €12.8 million was in the form of employee compensation. Each job created by the cruise sector generated another job in the EEA economy through indirect and induced effects.

Around 6.8 million residents in the EEA booked a cruise trip in 2017 (Figure 5.42, left-hand panel), an increase of 2.5 % per year compared to 2012 and 2015 figures. EEA residents represent approximately 26 % of the total cruise passengers worldwide.

In 2017, most cruise passengers originated from Germany (2.19 million), followed by the United Kingdom and Ireland (1.97 million), Italy (0.77 million), Spain (0.51 million) and France (0.50 million).

More than 5.4 million passengers from the EEA and 1 million passengers from outside the EEA embarked on their cruise journey from an EEA port (Figure 5.42, right-hand panel). This total of over 6.4 million passengers represents an increase of 6.2 % compared to 2015. In terms of passengers by country of embarkation, Italy saw the highest volume of passengers (1.8 million), followed by Spain (1.45 million), the United Kingdom (1.09 million), Germany (0.88 million), and Denmark (0.27 million).

Table 5.13 Order book for cruise ships in EU and global shipyards, 2018–2021

Member State	Ships	Capacity	Cost	
	Number	Lower Berths	€ million	Percentage
Italy	18	49,008	8,982	32%
Germany	14	47,358	8,819	31%
France	8	33,794	6,111	22%
Finland	5	21,164	3,077	11%
Croatia	4	945	458	2%
Spain	2	596	356	1%
Poland	1	126	108	0%
Portugal	1	176	81	0%
Netherlands	1	100	65	0%
Total EU	**54**	**153,267**	**28,057**	**100%**
Norway	12	2,922	1,383	-
China	2	-	-	-
Total global	**68**	**> 156,189**	**> 29,440**	**,**

Source: CLIA. 2018. The Contribution of Cruise Tourism to the Economies of Europe in 2017.

Europe[252] ranks second globally in terms of cruise destination popularity, behind the Caribbean. In 2017, EU ports saw more than 29 million port of call visits (intermediary cruise stops), an increase of 8.4% compared to 2015. The most popular ports of call destination were those in Italy with 6.8 million visits, followed by those in Spain (6.67 million), Greece (4.09 million) and France (3.01 million) (Table 5.12).

The construction of new cruise ships has a significant economic impact on EU shipyards. In 2017, 68 cruise vessels were on the tally to be constructed globally in the 2018–2021 period. Of these vessels, 54 ships with a total value of over €29.4 billion were foreseen to be constructed in the EU. Of the remaining 14 ships, 12 were on tally in Norway and two in China (Table 5.13).

[252] These data include the EEA, Montenegro, Russia, Turkey and Ukraine.

BLUE BIOECONOMY

TURNOVER
(direct and indirect)
€350 MILLION

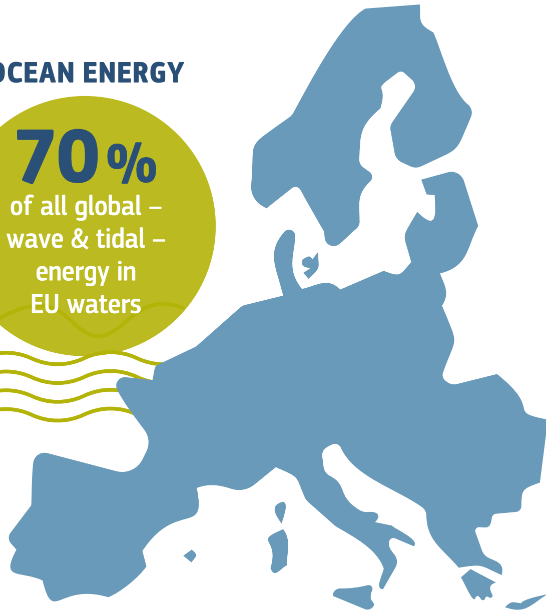
MARITIME DEFENCE

EMPLOYMENT
177 000 people

Defined as an emerging sector because data for it are currently emerging.

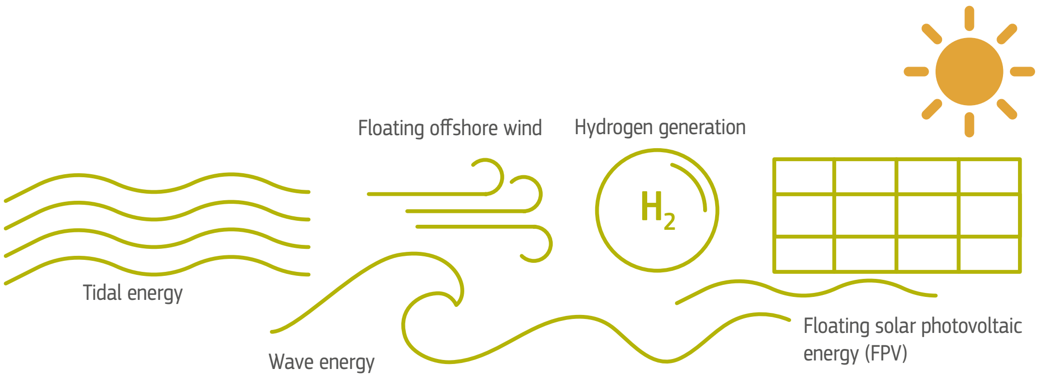
OCEAN ENERGY

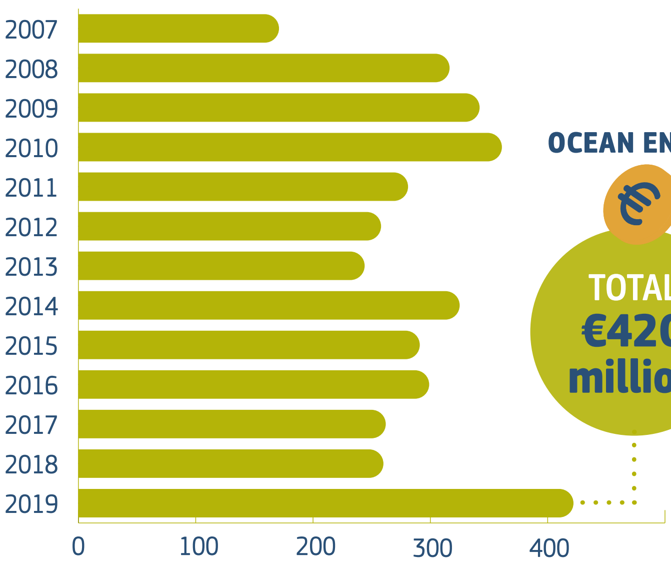
70% of all global – wave & tidal – energy in EU waters



BLUE ENERGY EMERGING SECTOR

includes:





EU R&D expenditure on ocean energy

OCEAN ENERGY

TOTAL
€420 million

DESALINATION

TOTAL
€520 million

520m of contracted investments from 2019-2024.

CHAPTER 6

EMERGING SECTORS

This chapter presents the various emerging and innovative sectors of the Blue Economy[253]. It offers an analysis of the socio-economic impacts and/or benefits deriving from the sectors to extent where possible. Gradually, more data is becoming available so that measuring more niche activities is becoming somewhat less complex. However, it is worth mentioning that data gaps still exist and that a straightforward evacuation of these sectors, as seen for the established ones is not yet entirely possible. Nevertheless, available data show interesting trends potential. In the absence of more common economic indicators (GVA, profits etc.), alternative ones such as output and production capacity or number of licences, among others, have been used.

This chapter provides an analysis of *Marine renewable energy* (i.e. floating off shore wind[254], wave and tidal energy, gloating solar energy and offshore hydrogen), followed by *Blue bioeconomy*, *Marine minerals*, *Desalination*, and *Maritime defence*. For the first time this chapter also presents a preliminary assessment of the *Submarine cables* sector.

Marine Renewable Energy includes various types of renewable energy, **Floating offshore wind,** although far behind its counterpart is beginning to expand. Member States have realised that in order to meet the renewable targets (especially in light of the European Green Deal) and to manage MSP, alternatives to fixed structures must be found. Although, there is little economic data for this, much testing is taking place in MS (e.g. France in the Mediterranean) in order to find the most suitable materials for the floating structures (cost efficient and less harmful to the environment).

Wave and Tidal energy, the main technologies comprised in the Ocean energy sector, continue to develop. The EU is a leader in the sector, hosting 58 % of global tidal energy technology developers and 61 % of the global wave energy developers. In 2019, 39.5 MW of global 55.8 MW ocean energy installed capacity were in EU waters. Other Blue Energy technologies, still at very preliminary stages (mostly in R&D and demonstration) include **floating Solar Photovoltaic energy** (i.e. floating Solar panels) and **Offshore hydrogen generation**.

The development activities of the **Blue bioeconomy** and bio-technology vary from one MS to another. The most notable subsector is the algae sector, which based on available data generated an estimated turnover of over €350 million in 2018 (including both companies and indirect jobs).

Another relevant sector, is **Desalination**. There are over 1 500 desalination plants in the EU (mostly spread across Mediterranean MS) producing almost 7 million cubic metres of water per day. As climate change leads to hotter and dryer summers, some countries, like Spain, must ensure water supply and hence have invested in desalination.

The importance of raw materials is part of the EU long-term strategy. The interest in seabed **Marine minerals**. In the future, marine minerals could contribute to ensure supply of raw materials, if and when appropriate technology is developed and environmental-friendly practices can limit negative environmental impact.

The **Maritime defence** sector although not an emerging activity as such, it has been categorised so because extensive comparable data are unavailable. The figures for EU Defence show the extent of its impact on the Blue Economy: EU maritime forces personnel were estimated at slightly over 177 000 in 2017.

Finally, a new sector in the report is **Submarine cables**. Their economic importance is due to their crucial role in global communications, channelling over 99 % of international data transfer and communication, including €10 trillion in daily financial transactions. According to estimations, there are more than 378 submarine cables spanning over 1.2 million kilometres globally, 205 of those are connected to EU MS.

[253] Please note that emerging sectors can be those which are new/innovative, but can also be those for which data is emerging (e.g. maritime Defence)
[254] Note that the fixed offshore wind has now transitioned into an established sector (Marine renewable energy, Section 5.3).

6.1. OCEAN ENERGY

The European Green Deal emphasises the key role marine renewable energy, and in particular offshore wind, will play in the transition to a climate-neutral economy In order to fully exploit the potential of offshore wind, the commercialisation of floating wind technology is expected to open up the market for offshore wind in the deep sea, allowing for the deployment of wind technology to take place in the Atlantic and Mediterranean sea-basins, in addition to current deployments in the North and in the Baltic Seas. Renewable ocean energy (wave, tidal) and floating photovoltaic are also expected to contribute to the climate-neutrality objective, in combination and possibly accompanied by storage and conversion facilities such as renewable hydrogen generation.

The *Marine renewable energy* sector comprises different technologies for the production of renewable energy: Offshore wind (with bottom-fixed foundation to the seabed or anchored floating devices), ocean energy (tidal and wave power), floating solar photovoltaic (FPV), and renewable hydrogen production offshore. Offshore wind (bottom fixed) represents the most advanced sector and has been analysed in Chapter 5 (see Section 5.3). Other technologies are at an earlier stage of development, with a significant focus in terms of technology research and development and of commercialisation. The market and supply chains of these technologies are not yet consolidated, therefore an analysis of their state of play is presented in this Chapter.

6.1.1. FLOATING OFFSHORE WIND

Floating offshore wind is a growing sector that is strengthening Europe's leadership in ocean energy. With a total installed capacity of 45 MW in 2019, Europe's floating wind fleet is the largest worldwide (70%). The development and commercialisation of floating wind technology will open up the possibility to harvest the most resourceful wind energy sites in Europe.

Nearly 80% of the wind in Europe blows in waters that are at least 60 meters deep, where it is too expensive to fix structures to the bottom of the sea. As such, JRC (2019)[255] estimates the technical potential for floating offshore wind in Europe with about 4540 GW, of which 3000 GW would be located in deep sea locations (water depth between 100 m and 1000 m). Moreover, the majority of shallow offshore regions for conventional offshore wind deployment are located in the North and Baltic Seas expelling countries that are not adjacent to this region.

Fortunately, it is possible to build floating platforms that are anchored to the seabed and allow harvesting the wind at greater sea depths. A main distinction criterion is the floating substructure used, which provides the buoyancy and thus the stability to a floating offshore plant, such as spar-buoy, semi-submersible, tension-leg platform (TLP), Barge or multi-platforms substructures.

So far, no concept prevailed over the others, however Equinor's spar-buoy concept has already been deployed in a commercial project (the 30 MW Hywind Scotland). Notably, through various instruments of EU-funding (e.g. the European Commission's FP7, H2020, NER300 programmes, the European Innovation Council's SME instrument or the co-financing of the EIB) several floating offshore wind technologies were brought from concept to a pre-commercial stage. This becomes pivotal, particularly when demonstrating the technology's capabilities in a deep water setting as in the case of a 2 MW floating prototype in France (Floatgen Project, generating 6 GWh in 2019) and the installation of the first of three wind turbines in December 2019 of a 25 MW floating wind farm in Portugal (WindFloat Atlantic (WFA)).

Table 6.1 European floating offshore wind projects and respective floating substructure concept

Project	Country	First Power	Capacity (MW)	Floating substructure
Hywind Scotland	UK	2017 (operational)	30	Spar-buoy
Floatgen Project[1]	FR	2018 (operational)	2	Barge
WindFloat Atlantic (WFA)[2]	PT	2019 (partly operational)	25	Semi-Submersible
Kincardine Offshore Windfarm Project	UK	2020	50	Semi-Submersible
BALEA[2]	ES	Earliest 2021 (2024)	26	
Nautilus Demonstration	ES	Earliest 2021	5	Semi-Submersible
DemoSATH - BIMEP	ES	2021	2	Semi-Submersible
SeaTwirl S2[3] **(VAWT)**	NO	2021	1	Spar-buoy
EolMed[4]	FR	2021	25	Barge
Seawind 6 demonstrator	UK	2021	6	Semi-Submersible
FWT Groix & Belle-Île	FR	2022	24	Semi-Submersible
FWT Provence Grand Large/VERTIMED[2]	FR	2022	25	Tension-leg platform
FWT Golfe du Lion	FR	2022	24	Semi-Submersible
Katanes Floating Energy Park - Pilot[5]	UK	2022	8	Semi-Submersible
Hywind Tampen	NO	2022	88	Spar-buoy
Seawind 12 demonstrator	UK	2024	12	Semi-Submersible
FLOCAN 5[2]	ES	2024	25	Semi-Submersible

[1] Funded by the EC's FP7 programme
[2] Funded by the EC's NER300 programme
[3] Received a €2.48 million grant from the European Innovation Council's SME instrument
[4] Co-financed by the European Investment Bank
[5] Combined wind-wave generator. Project will be further developed to 47MW
Source: JRC (2020). Technology Development Report LCEO: Wind Energy. Forthcoming

[255] CJRC, 2019) JRC: ENSPRESO — WIND — ONSHORE and OFFSHORE. European Commission, Joint Research Centre (JRC) [Dataset] PID: http://data.europa.eu/89h/6d0774ec-4fe5-4ca3-8564-626f4927744e

The next significant up-scaled project (88 MW Hywind Tampen) will be deployed by the energy company Equinor close to the Norwegian Gullfaks and Snorre fields to meet approximately 35 % of the annual power requirement of five oil and gas platforms. This would mean also an increase in the design of the spar-buoy platforms (weight, draught and catenary length) as compared to the initial Hywind Scotland design as the project will be located 140 km from shore at a water depth of about 260-300 m. A challenge for the uptake of floating offshore wind are the high investment and finance costs which so far can more easily be backed by major players (as exemplified in the case of Equinor)[256].

The choice of a substructure concept also has implications on the infrastructure of ports where assembly is taking place. Quay-side assembly and maintenance in ports are only possible for floating technologies with shallow draft (e.g. barge, semi-submersible and TLP) whereas the large draft of the most developed spar-buoy systems limits these activities to deep-water ports.

At a lower technology readiness level hybrid floating offshore platforms are announced (e.g. the wind-wave Katanes Floating Energy Park – Pilot) indicating the technology's capability for multiple use concepts or to other marine sectors.

Further development of floating offshore wind technologies will lower costs in the sector and increase output, leading to a significant drop in the cost of energy for floating offshore wind projects. Currently only 40 MW of floating wind capacity are operational however a further 300 MW are planned to be deployed between 2020 and 2022 (see Table 6.1).

6.1.2. WAVE AND TIDAL ENERGY

Wave and tidal energy are two of the few untapped sources for renewable energy. Their potential in the EU is vast, thus can play a key role in decarbonising energy supply and increasing energy security and fuelling economic growth in coastal regions. Five distinct technologies are comprised: wave energy, tidal stream energy, tidal range energy, ocean thermal energy conversion (OTEC) and salinity gradient power generation. All forms of ocean energy can be used to generate electricity. Salinity gradient and OTEC technologies will be able to produce base-load electricity. Other forms of ocean energy show variable generation, with different predictability.

- Wave energy converters derive energy from the movement of waves.
- Tidal stream turbines harness the flow of the currents to produce electricity.
- Tidal range uses the difference in sea level between high and low tides to create power.
- OTEC exploits the temperature difference between deep cold ocean water and warm surface waters to produce electricity via heat-exchanger.
- Salinity gradient power generation utilises the difference in salt content between freshwater and saltwater, found in areas such as deltas or fjords, to provide a steady flow of electricity via Reverse Electro Dialysis (RED) or osmosis.

In the EU, the highest resource potential for this type of energy exists along the Atlantic coast, with further localised exploitable potential in the Baltic and Mediterranean seas and in overseas regions (e.g. Reunion, Curacao). The theoretical potential of wave energy in Europe is about 2 800 TWh annually, whilst the potential for tidal current was estimated at about 50 TWh per year[257]. OTEC offers potential only for the EU overseas islands since its deployment is generally limited to tropical seas[258].

Given the resources available in the EU and the advancement of the technologies, it is expected that in the short-to-medium term (up to 2030), ocean energy development in the EU will be largely dependent on the deployment of tidal and wave energy converters.

At the end of 2019, the total global ocean energy installed capacity was 55.8 MW, with most of it located in EU waters (39.5 MW)[259]. The EU is the global leader hosting with 58 % of the number of tidal energy technology developers and 61 % of the wave energy developers[260].

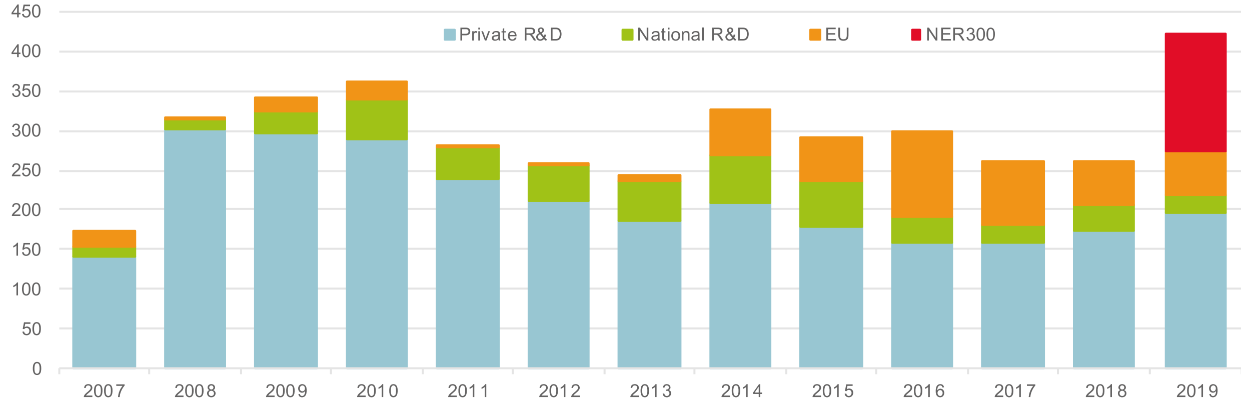
The development of ocean energy technologies is still primarily at the R&D stage, nevertheless some technologies have already progressed towards first-of-a-kind demonstration and pre-commercial projects. Tidal energy technology has made the most significant stride forwards with over 50 GWh of electricity generated from demo projects.

Between 2016 and 2019 considerable progress has been achieved in proving different kinds of tidal energy concepts. Turbines developed by Nova Innovation, Atlantis, Andritz Hydro-Hammerfest, Minesto, Orbital Marine, Schottel, Sabella, Sustainable Marine Energy, Tocardo have been operational in demonstration and pre-commercial projects in Europe and Canada. The reliability of the devices, and their ability to provide stable input to the grid has been proven beyond initial expectations, with devices achieving higher capacity factors than initially expected.

Wave energy technologies are lagging behind tidal energy in terms of performance, especially in terms of electricity generation. The Mutriku power plant, operational since 2011 in Spain, has been the most consistent wave energy converter in terms of electricity generation. In 2019 new devices were deployed including the WaveRoller in Portugal, the OPT Power-buoy and the ENI/Wave for Energy ISWEC in the Adriatic Sea[261].

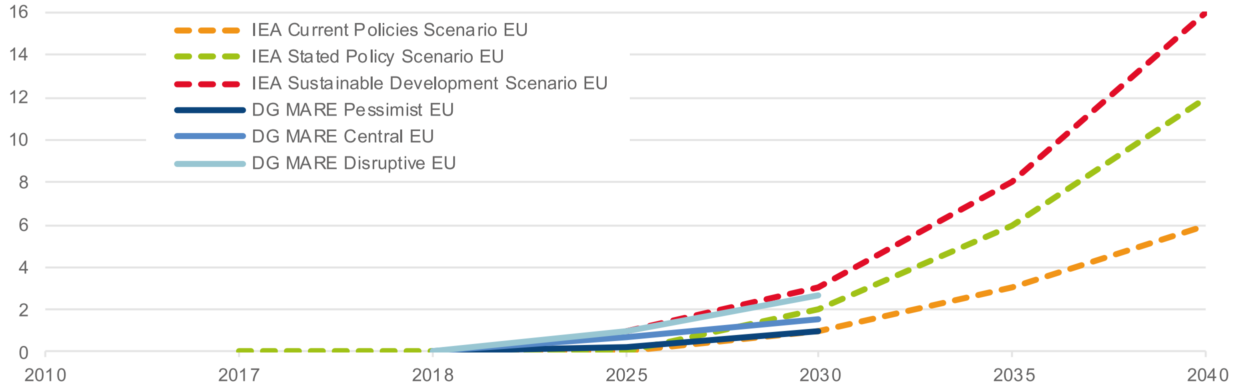
[256] JRC (2020). Technology Development Report LCEO: Wind Energy. forthcoming
[257] Or 395 TWh, figure includes France, the UK, Norway, Ireland, Spain – The Netherlands and Italy also have some potential but data is currently lacking for these two countries (Ocean Energy Europe);
[258] JRC (2014) – Ocean Energy Status Report.
[259] 27.7 MW of tidal stream, 11.8 MW for wave energy — Ocean Energy Europe (2020) Ocean Energy. Key trends and statistics 2019.
[260] JRC (2019). Technology Development Report LCEO: Ocean Energy.
[261] JRC (2020) Technology Development Report LCEO: Ocean Energy 2020 Update

Figure 6.1 EU R&D expenditure on Wave and tidal energy, € million



Notes: Data for 2017, 2018 and 2019 are estimates.
Source: International Energy Agency, European Patent Office and Commission Services.

Figure 6.2 EU Wave and tidal energy modelled installed capacity deployments, GW



Source: JRC, DG MARE, IEA World Energy Outlook 2019

Between 2007 and 2019, total R&D expenditure on wave and tidal energy amounted to a total of €3.84 billion with the majority of it (€2.74 billion) coming from private sources[262] (Figure 6.1). In the same period, national R&D programmes have contributed €463 million to the development of wave and tidal energy. EU funds, including ERDF and Interreg projects, amount to €493 million. A further €148 million have been made available through the NER300 Programme. On average, for the reporting period each €1 of public funding (EU+National) has leveraged €2.9 of private investments.

The trends in private and public investments are opposite. From 2010 until 2016, private investments in the sector decreased, with public national and EU R&D funds increasing instead. This inverse trend is due to two main causes. Firstly a number of OEM companies (Original Equipment Manufacturers) disinvested from the sector following the failure of ocean energy demonstrations that led to some technology developer's insolvency. At the same, and primarily due to the EU Horizon 2020 Framework Programmes, public funds for R&D on ocean energy technology have increased.

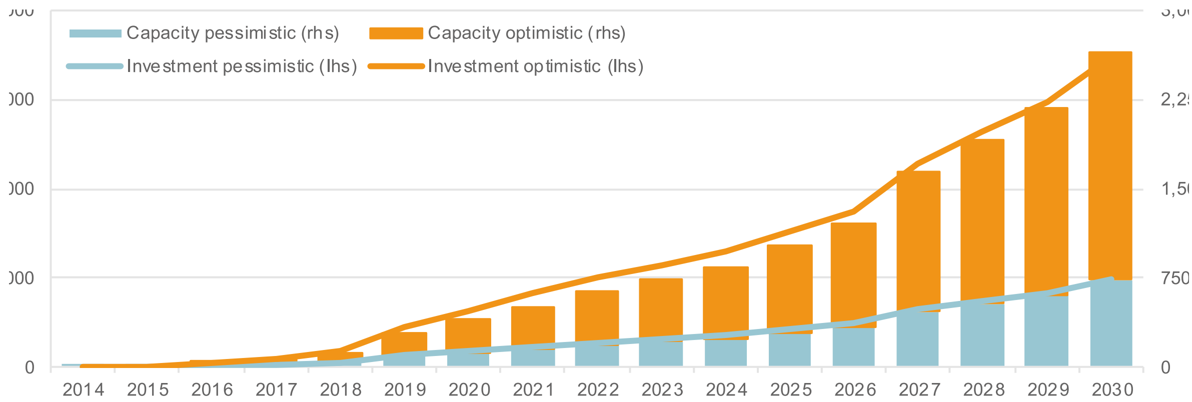
The progress witnessed in the sector, especially a low TRL, indicates that confidence in the sector is growing. A preliminary estimate based on patenting activity in the 6 most active Member States indicates that, between 2017 and 2019, private R&D investments increased again.

In the same period, national and EU support has decreased slightly. Difficulties in deploying demonstration projects, which require additional market measures on top of grants, and a shift towards other renewable energy sources to support the 2030 targets are the main reasons behind this reduction in public support.

The continuous development of wave and tidal energy technologies and the reduction in technology costs are expected to lead to a significant increase of the deployed ocean energy capacity in the near future. Market scenario assessments from the International Energy Agency (IEA)[263] indicate that depending on the cost-reduction and policy design, by 2030 the total European wave and tidal energy installed capacity could range between 0.5 GW and 2.6 GW by 2030

[262] Private investments are estimated from the patent data available through Patstat. Sources: Fiorini, A., Georgakaki, A., Pasimeni, F. and Tzimas, E., (2017) Monitoring R&I in Low-Carbon Energy Technologies, JRC105642, EUR 28446 EN and Pasimeni, F., Fiorini, A., and Georgakaki, A. (2019). Assessing private R&D spending in Europe for climate change mitigation technologies via patent data. World Patent Information, 59, 101927.
[263] IEA (2019) World Energy Outlook 2019.

Figure 6.3 Projections of investment needed (€ million) and installed capacity (GW) in the EU wave and tidal energy sector under a pessimistic and an optimistic scenario



Source: JRC, INNOSEA

(Figure 6.2), in line with previous assessments by the European Commission. To date, deployment projects announced for 2030 form a pipeline of about 5 GW[264].

The scenarios can be summarised as follows:

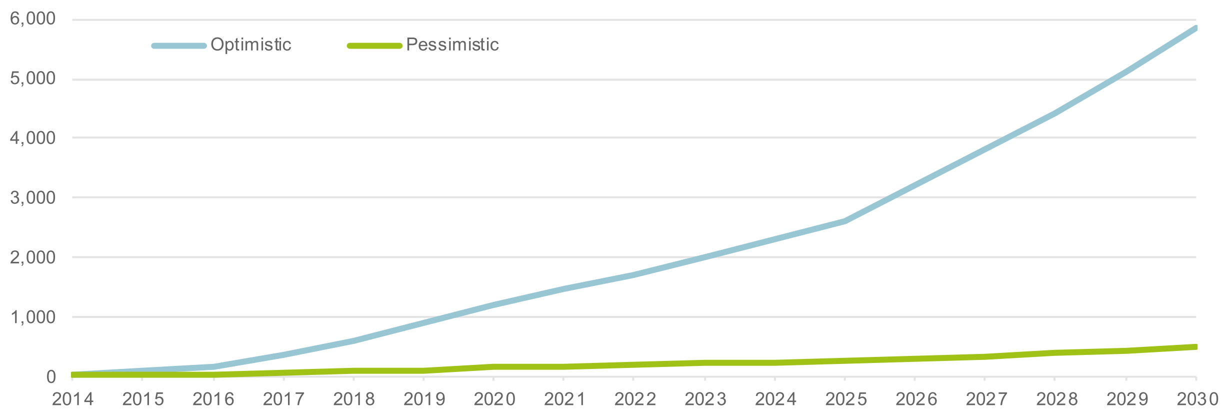
- **Current policy initiative**: maintaining the current status of energy policy, leading to an increase of CO_2 emissions. This scenario shows the same ocean energy capacity deployment trend of the DG Mare Pessimist scenario. In this scenario, the market uptake of ocean energy is limited, due to the high cost of the technology.
- **Stated policies scenario**: implementation of policies that have already been announced/implemented to reduce CO_2 emissions, which are expected to leader to a stabilisation of CO_2 emissions. This scenario shows the same wave and tidal energy capacity deployment trend of the DG Mare central scenario.
- **Sustainable development scenario**: actions and technologies needed to meet the Sustainable Development Goals and the Paris Agreement, towards zero CO_2 emissions. This scenario shows the same ocean energy capacity deployment trend of the DG Mare Disruptive scenario. This scenario favours market uptake of ocean energy, thanks technology learning and scaling up unlocking cost-reductions.

While these scenarios provide plausible development trajectories for wave and tidal energy, it shall be noted that actual deployment of this technology at the end of 2019 is lower than the one modelled by the pessimistic scenario.

From these scenarios, as a case study, the scale of investments needed, GVA and employment that could be generated by the development of ocean energy has been determined. In the pessimistic case, €2 billion will be required in order to install 750 MW of wave and tidal energy capacity. In the optimistic case, the investments needed to deploy 2.6 GW of ocean energy capacity amount to €7 billion (Figure 6.3).

Based on these scenarios the cumulative GVA generated from deployed wave and tidal energy by 2030 would range between €500 million and €5.8 billion (Figure 6.4), unlocking up to 25 000 FTE a year (Figure 6.5) and between 50 000 and 200 000 distributed

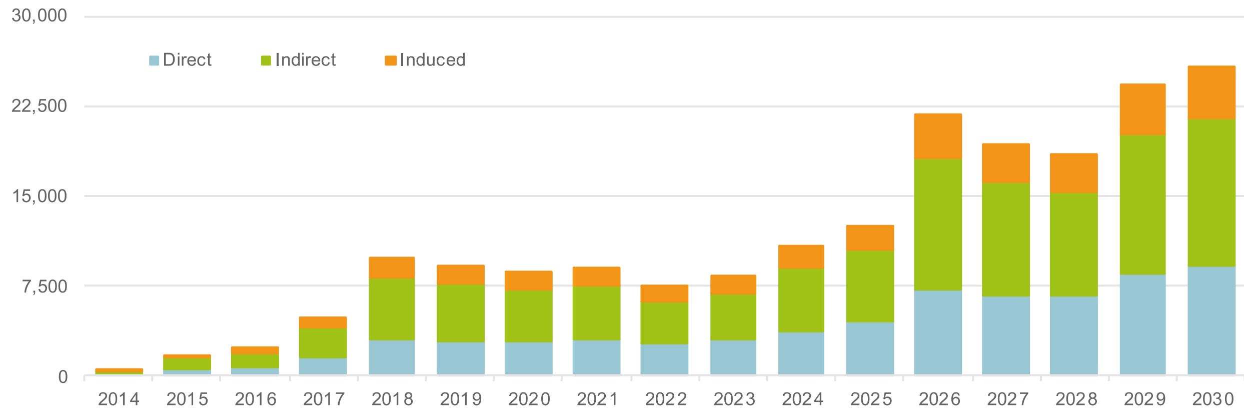
Figure 6.4 Projected GVA for wave and tidal energy in the pessimistic and optimistic scenario, € million.



Source: JRC, Innosea.

[264] JRC (2019).

Figure 6.5 Yearly jobs associated to the optimistic deployment scenario of 2.6 GW, number of FTEs



Source: JRC, Innosea.

in the next 10 years. At the end of 2019, over 430 companies in the EU are involved in different stage of the ocean energy supply chain, with an estimate of 2250 jobs generated by the sector across Europe, with no major change from last year's assessments.

R&D activity in ocean energy involves over 838 EU companies and research institutions in 26 Member States. In the EU, 51% of the ocean energy inventions patented are for wave energy technology, 43% for tidal energy, 2.7% on Oscillating Water Column (OWC, this represent a subset of wave energy technology), and 3% for Ocean Thermal Energy Conversion (OTEC). The EU is a leader in the filing of patents in international markets, seeking protection in all key markets such as the United States, South Korea, and China as well as Canada and Australia. Nevertheless, the EU receives only a small number of incoming patents applications from outside, primarily from the United States (Figure 6.6). The patent filings indicate that the EU is a net exporter of *Ocean energy* technology and innovation, and that European wave and tidal energy developers are well positioned to exploit the growth of the sector globally.

6.1.3. FLOATING SOLAR PHOTOVOLTAIC ENERGY

Floating solar photovoltaic (FPV) installations open up new opportunities for employing conventional photovoltaic installations whilst reducing the impact on land. Structurally, FPV consists of a floating structure on which traditional solar panels are installed. To date, most FPV structures have been installed on lakes and in the proximity of hydro-power reservoirs.

Deploying FPVs at sea requires overcoming a number of challenges related to the survivability of the structure at sea, as well as understanding the influence of the marine environment such as of algae growth, pollution, and salt deposits on the conversion system.

At the end of 2019, the state of the art of FPV offshore is predominantly at R&D and demonstration phase. Demonstrations are taking place in the Netherlands (Oceans of Energy, TNO) and in France (HelioRec), with the projects designed to validate technology design, to prove its efficiency conversion and survivability to harsh conditions. In terms of survivability, the 17 kW system designed by Oceans of Energy, has withstood different storms, including Storm Ciara (February 2020), with waves above 5m high. The developers are now looking to expand the project to reach a power rating of 50kW[265].

FPV installations are expected to provide additional value to different sectors of the Blue Economy such as aquaculture and to help remote coastal communities offset diesel generators, by providing direct access to electricity offsite. According to the World Bank, FPVs are of particular value for small island communities, to decarbonise energy demand, whilst overcoming the limitations due to the limited availability of land suitable for ground-mounted PV installations[266].

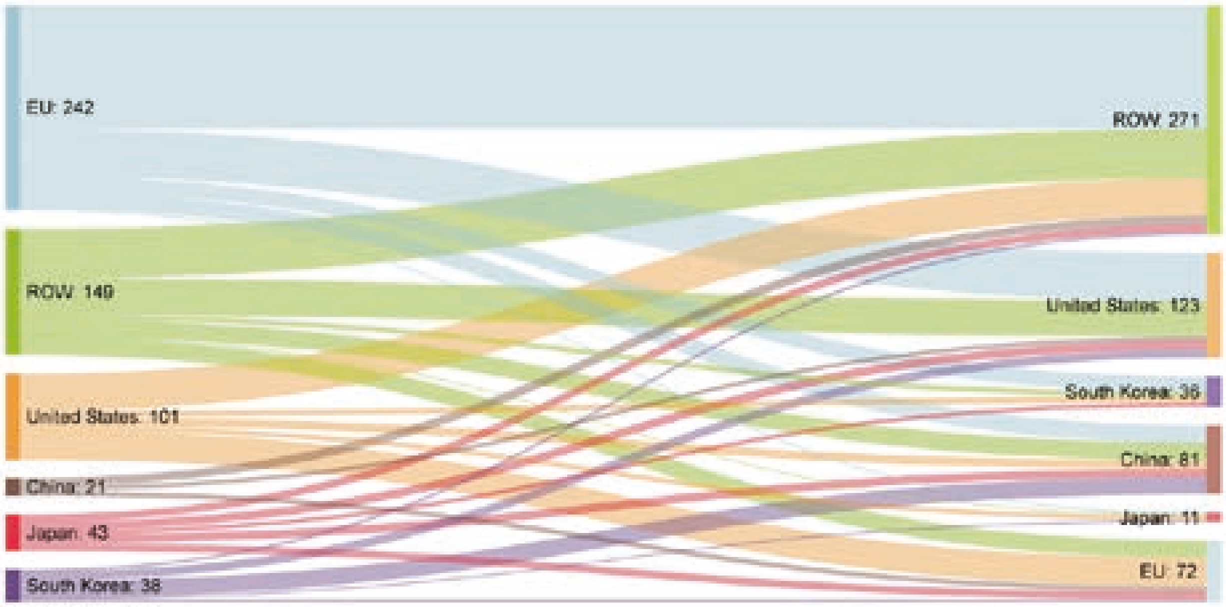
A number of challenges remain to be addressed in order to facilitate deployment of FPV at a commercial scale such as long-term reliability, costs, integration in the gird system and the development of substations. The technical viability in this harsh and remote environment and the potential for FPV production costs still needs to be demonstrated. Furthermore, a key step required for the commercialisation of FPV at sea is the assessment of its potential contribution to the EU Green Deal, and the interaction with other maritime uses to identify ideal sites for deployment.

6.1.4. HYDROGEN GENERATION OFFSHORE

The production of offshore electricity is confronted with a number of challenges related to the grid stability, and variability due to the temporal mismatch between the supply (e.g. when wind turbines are generating electricity) and the demand (when the electricity is required). The production of hydrogen by electrolysis from renewable sources can help overcome several of these challenges and provide alternatives for storing excess electricity generated at sea that is not immediately delivered to the grid. Once produced hydrogen could be employed for electricity generation (in fuel cells) or as fuel for car and ships (see Section 5.6.5).

265 https://oceansofenergy.blue/north-sea-1-offshore-solar-project/
266 http://documents.worldbank.org/curated/en/579941540407455831/pdf/Floating-Solar-Market-Report-Executive-Summary.pdf

Figure 6.6 Global patents flow in ocean energy, number of patents, cumulative 2007-2016



Notes: Intra-market patents are not included. 2016 is the latest full and validated year on Patstat.
Source: JRC calculations based on European Patent Office, Patstat 2019 Autumn version

The generation of hydrogen offshore has a number of advantages, both hydrogen transportation and storage can be done at a large scale and a relatively low cost. Furthermore, offshore oil and gas platforms could be re-purposed for renewable hydrogen production.

The foremost technical challenge for producing renewable hydrogen offshore is the development of an electrolyser module, which is compatible with the ocean environment, able to operate effectively when coupled with intermittent renewable power and is sufficiently compact to achieve very high rates of hydrogen production per platform or per device.

A number of projects are already exploring the possibility of specific options for the coupling of offshore energy and green hydrogen production. For example, by coupling hydrogen production with tidal energy, which is the most predictable form of marine renewable energy. The ITEG project[267] (funded under the Interreg program) combines the Orbital Marine O_2 2 MW tidal turbine with a custom built hydrogen electrolyser (500 kW, developed by AREVA) and an onshore energy management system to be deployed as an energy storage solution. The project aims to overcome the high costs associated with ocean energy demonstrator projects through the integration of hydrogen production solutions. Similarly, Sabella and Akuo Energy are developing an integrated renewable energy project intended to provide up to 80% of power to the island of Ushant through renewables. The Phares[268] project comprises two Sabella tidal turbines rate 500 kW, one 0.9 MW wind turbine, a 500 kW photovoltaic installation and a hydrogen-based energy storage systems to be deployed on island of Ushant. Both ITEG and Phares projects aim to demonstrate the viability of tidal energy for decarbonisation and its potential to provide grid stability, especially in islands ecosystems.

Specific to the Netherlands is the interest in the combination of offshore wind and hydrogen production. The potential reuse of existing gas infrastructure in a hydrogen supply chain has been investigated by the "Pre-Pilot Power to Gas Offshore" (3P2GO)[269] project, which has been followed by the pilot project PosHydon[270], led by TNO. The goal is the realisation of the world's first offshore power-to-gas pilot to produce hydrogen offshore and a test centre for other innovative power-to-gas technologies. The plan foresees a scale-up process for this type of system, starting at 1-10 MW, then 20-250 MW and ultimately >250 MW systems. The location chosen is an old oil and gas platform, located off the coast of The Hague. This platform is fully electrified, and in a first phase of the project, the megawatt electrolyser will be fed by main land power. The final goal is however, to generate green hydrogen from solar farms and the offshore wind farms located nearby. This project shall put the basis for a technology expected to grow synchronically to the planned future wind power in the North Sea.

267 For further information about ITEG project see: https://www.nweurope.eu/projects/project-search/iteg-integrating-tidal-energy-into-the-european-grid/.
268 Sabella (2020) — Phares Project https://www.sabella.bzh/en/projects/phares
269 Topsector energie. 2020. Pre-Pilot Power to Gas Offshore. Public summary, available at: https://projecten.topsectorenergie.nl/projecten/pre-pilot-power-to-gas-offshore-00031694 and https://projecten.topsectorenergie.nl/storage/app/uploads/public/5e5/f65/63d/5e5f6563d9095865360210.pdf (in Dutch)
270 TNO (2020), World first. An offshore pilot plant for green hydrogen https://www.tno.nl/en/focus-areas/energy-transition/roadmaps/towards-co2-neutral-fuels-and-feedstock/hydrogen-for-a-sustainable-energy-supply/world-first-an-offshore-pilot-plant-for-green-hydrogen/

A more visionary project is the Norwegian project Deep Purple[271] that envisages not only offshore hydrogen production from wind farm, but also its subsea storage. The electrolyser (fuel cell modules) are planned to be part of the windmill structure.

Similar conceptual studies are being performed by other countries with high wind power potential in the North Sea. For example, the UKCS Energy integration study of the UK Oil and Gas Authority[272] has assessed the potential of various offshore energy integration concepts, from simple platform electrification to offshore hydrogen from water electrolysis using power from renewable sources and reuse of old gas pipelines for transportation.

The technical viability in this harsh and remote environment and the potential for competitive hydrogen production costs still needs to be demonstrated.

6.2. BLUE BIOECONOMY AND BIOTECHNOLOGY

The *Blue bioeconomy* and biotechnology sector includes the non-traditionally exploited groups of marine organisms and their commercial biomass applications. These organisms comprise macroalgae (seaweeds), microorganisms (microalgae, bacteria and fungi) and invertebrates (e.g., sea stars, sea cucumbers, sea urchins). Algae and invertebrates are important resources that potentially strengthen the bio-based sectors and support the development of economic activities in coastal areas. Although some of these biomass sources have been traditionally been used as food, feed or fertilisers in the past, new commercial applications are under development. The extraction of high-value bioactive compounds has high market potential e.g. for nutra/ and pharmaceuticals as well as cosmetics. Other innovative applications are also in the pipeline such as for the production of biomaterials or biofuel (3rd and 4th generation) and for biomitigation services.

Besides their commercial benefits, algae and invertebrates have the potential to contribute to the sustainability of the food systems and releases pressure off of overexploited marine resources. Additionally, they provide environmentally sound solutions by removing nutrients in excess from the water.

The European Commission is supporting innovation by combining local action with place-based approaches. This policy action is concretised through the design and implementation of Smart Specialisation Strategies across the EU. To date, 12 Member States and 53 regions present linkages to the Blue Biotechnology in their Smart Specialisation Strategies. In most cases, marine biotechnology is mentioned as a research focus or a relevant technology field rather than as a priority area[273].

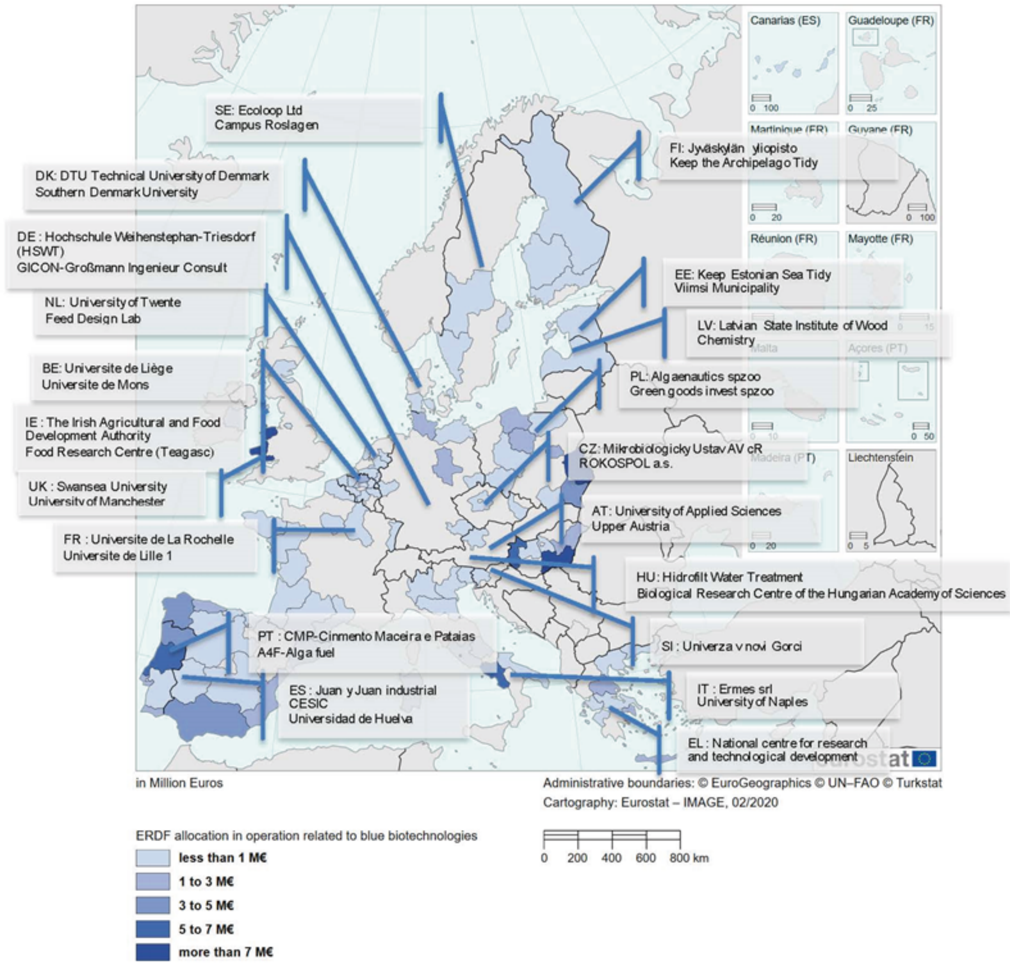
Table 6.2 Examples of Blue Bioeconomy innovative projects

Organism	Country	Company/Project	Product
Macroalgae	Belgium	AtSeaNova	Solutions for industrial seaweed farming
Macroalgae	Estonia	Vetik	Colorant for cosmetics
Macroalgae	France	EraNova	Bioplastics
Macroalgae	The Netherlands	Danvos	Biorefinery approach for seaweeds and use the products for protein, fertilizer and bioplastic production
Macroalgae	The Netherlands	Hortimare	Breeding & Propagation of seaweeds
Microalgae	Iceland	KeyNatura	Food supplements
Microalgae	Ireland	Microsynbiotix	Oral drug delivery technology
Microalgae	Sweden	Swedish algae factory	Silica used in solar panels and personal care products
Shrimp shells	Iceland	Genis	Food supplements, medical devices, pharmaceutical ingredients
Seagrass	Greece	Phee	Biocomposite material from dead leaves of seagrass
Mussels	Sweden	Musselfeed	Dried mussel meat powder for food, feed and fertilizer
Sponges and anemones	Portugal	Sea4Us	Pharmaceutics

Notes: The table includes projects with medium to high technology readiness level and close to or already at the commercialisation phase. Many other companies are commercializing products based on the emerging sectors biomass; the table illustrates some of the more innovative applications.
Source: Commission Services based on the Blue Bioeconomy Forum 2019.

[271] Energy Valley (2019). Deep Purple https://energyvalley.no/wp-content/uploads/2019/04/Deep-Purple-.pdf
[272] UKCS Energy Integration, Interim findings, https://www.ogauthority.co.uk/media/6257/ukcs-energy-integration-interim-findings.pdf
[273] JRC (forthcoming). Policy Brief Blue biotechnology in European Regions.

Figure 6.7 ERDF investment in Blue biotechnologies and first two beneficiaries per Member State, 2014-2019



Source: JRC ERDF beneficiaries' database (2019).

The Blue bioeconomy Forum[274] showcases several examples of the diversity of new applications and the innovation potential of the Blue bioeconomy in Europe (Table 6.2).

Between 2014 and 2019, the ERDF co-funded 355 projects addressing blue biotechnologies in the EU-28 with a contribution of €107 million. Project beneficiaries are diverse, which is not always the case for this type of EU support, standing from public research organisations, universities, public authorities, to private, (large or small, companies). This variety shows a particular interest from stakeholders in forming the research & innovation 'ecosystems' for the blue bioeconomy.

Among the main projects, two of them received more than €7 million funding. The first project (Poland, €7.4 million) supports the establishment of a Research and Development Centre to develop industrial algae cultivation technology in temperate climates. The second project (UK, €7.2 million) combines established expertise in algae conversion and hydrogen generation, to reduce carbon dioxide emissions from heavy industrial processes while producing high value products.

The range of activities covered by blue biotechnologies is broad. Among the topics funded through ERDF operations:

- Energy production (e.g. micro-algae biodiesel production integrated bio-refinery in *Lazio*, Italy);
- Agrofood and health (e.g. demonstration scale for the commercial production of two oilseed rich microalgae with expected health benefits in Lisbon, Portugal);
- Agriculture (e.g. scalable and self-controlled installation based on microalgae capable of handling liquid manure in Algarve, Portugal);
- Climate change (e.g. production of new microalgae products, also increasing CO_2 capture capacity in *Centro*, Portugal);
- Medicine (e.g. algae as nutrition component that stimulates the immune system in humans and animals in The Netherlands);
- Environmental remediation (e.g. valorisation of waste water with microalgae bacteria in *Andalucía*, Spain);
- Biomaterial (e.g. liquefaction pilot enabling the production of road binders from biomass such as microalgae, agro-industrial residues and pig slurry as alternative to the use of bitumen, *Rhone-Alpes*, France).

The emerging sectors still face several challenges and constraints. Among the most commonly cited are:

- complexity of the regulatory and administrative procedures;
- small size of the market;

[274] www.bluebioeconomyforum.eu.

Figure 6.8 Production methods most commonly used for algae biomass.

Source: Commission Services.
Note: For reproduction or use of this photographic material, permission must be sought directly from the copyright older

- consumer's awareness and acceptance;
- lack of reward schemes for the provision of environmental services to the marine ecosystems;
- lack of European origin certification and harmonisation of market requirements;
- the need for funding mechanisms;
- the optimisation of the production chain to reduce waste and valorise side materials.

6.2.1. THE ALGAE SECTOR

This section focuses on the algae biomass related sector in Europe which, at the moment, is the most developed of the emerging sectors of the Blue Bioeconomy. In this context, the term algae biomass will include microalgae, macroalgae (seaweeds) and cyanobacteria (Spirulina).

Macroalgae are harvested from wild stocks or cultivated at sea (coastal or offshore) or inland[275]. Spirulina is mainly produced in open ponds and microalgae are either produced in open ponds or closed systems like photobioreactors or fermenters (Figure 6.8).

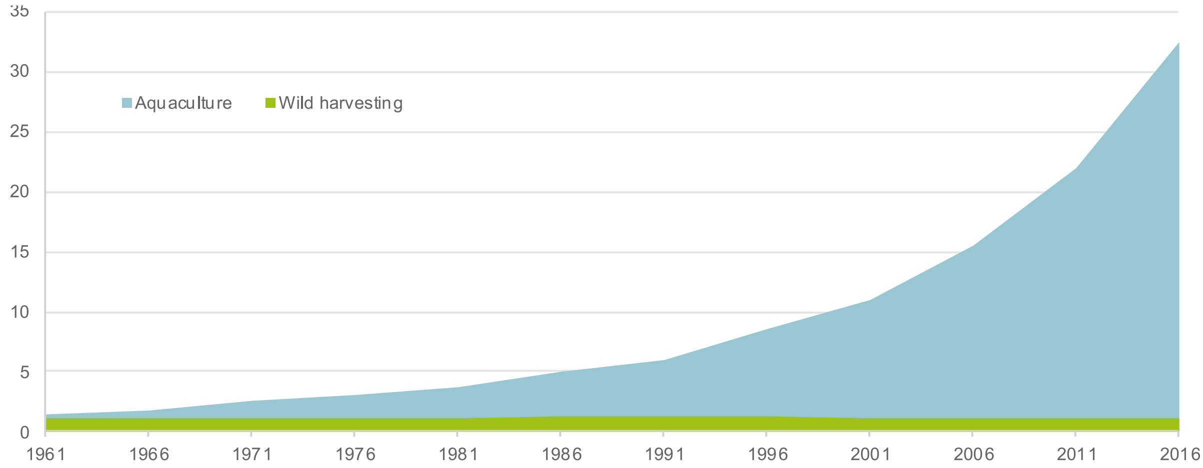
According to available statistics, algae biomass production is increasing worldwide and reached 33 million tonnes (wet weight) in 2016 (Figure 6.9), from which 0.57 % of the volume (0.2 million tonnes) was produced in Europe (EU 28+EEA)[276]. At the global level algae biomass is mostly supplied by aquaculture (96.5 % in 2016) while in Europe harvesting from wild stocks contributed in the same period to 98 % of the total algae production volume[277].

FAO statistics[278] show that in the last decade (2008-2017) the main suppliers at the global level were China and Indonesia (contributing to 91 % of the non-EU production) followed by South Korea. In Europe (EU-28+EEA countries), algae biomass is mainly supplied by Norway (71 % of the European production) followed by Ireland and France (Figure 6.10).

According to the JRC Algae database, in 2019, there were 126 microalgae and macroalgae-producing companies in the EU, running a total of 144 production plants, and 15 producing companies in other EEA countries with one plant each (Figure 6.11). From these, 57 % of the companies produced macroalgae and 43 % microalgae. France hosts the largest number of companies followed by Spain, Ireland and Germany. In France, Spain, Portugal and the Netherlands, the number of macro- and microalgae producers is approximately equal. Algae production in Germany, Italy and Austria is dominated by microalgae while in Ireland and Denmark macroalgae production is dominant[279]. Spirulina producers are not mapped yet, but based on JRC estimates, there are around 250 Spirulina farms operating in the EU of which approximately 150 are located in France.

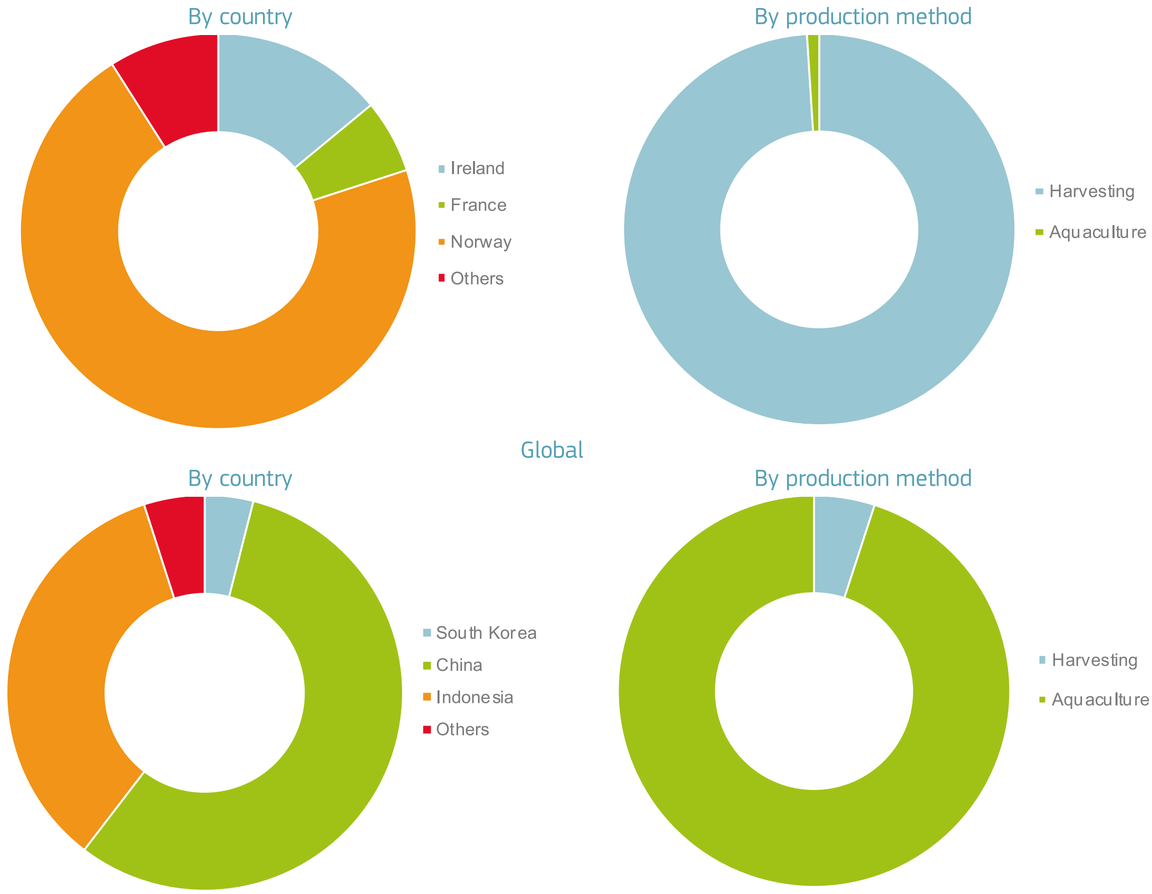
[275] Macroalgae may also be cultivated in photobioreactors, however, this is less common.
[276] European Commission (2019a). Brief on algae biomass production. ISBN: 978-92-76-12270-8.
[277] European Commission (2019a).
[278] FAO (2019). FishStatJ – Software for Fishery and Aquaculture Statistical Time Series. Food and Agricultural Organisation of the United Nations, Rome.
[279] European Commission (2019a).

Figure 6.9 Macroalgae biomass, global production, t million wet weight



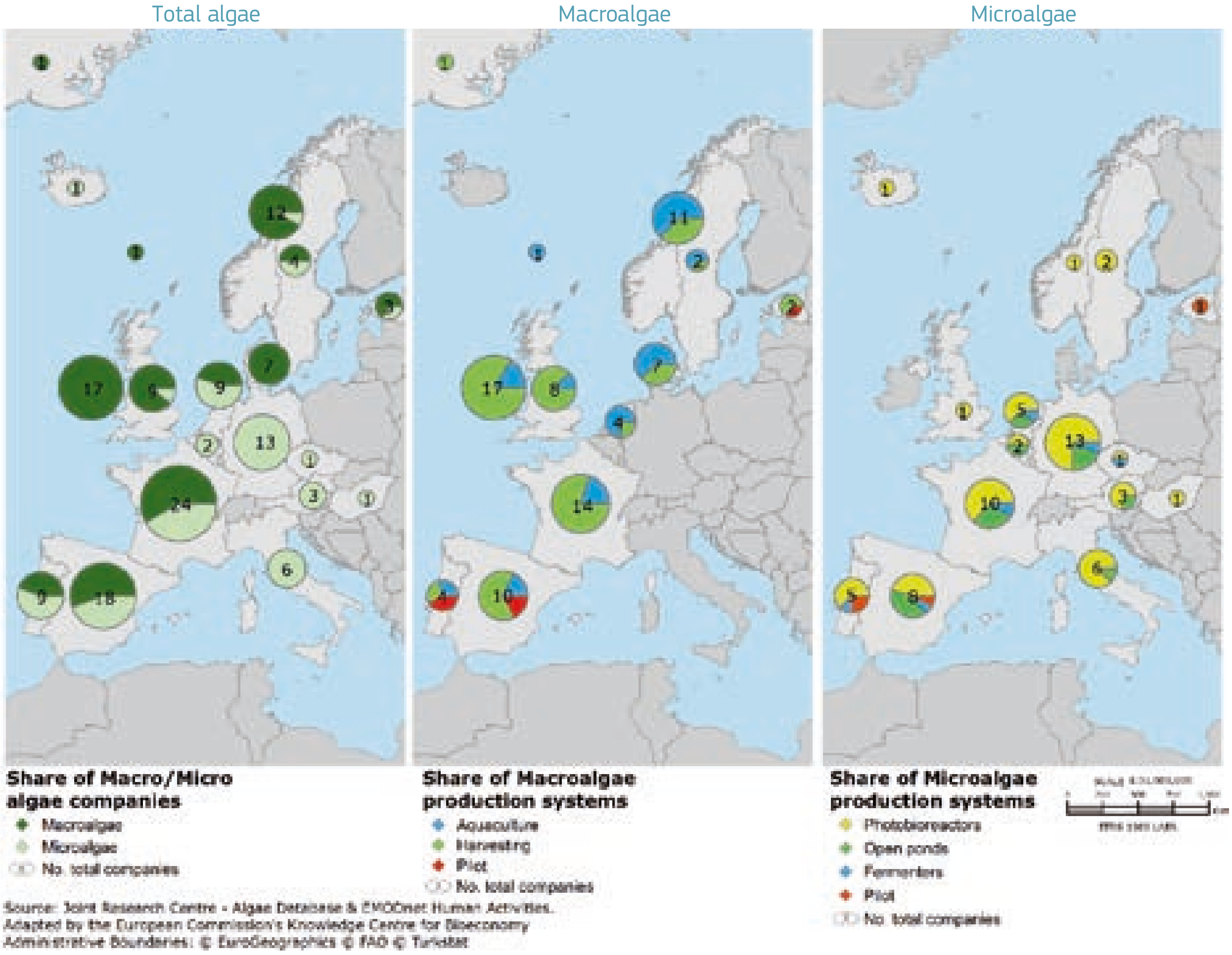
Source: European Commission (2019a).

Figure 6.10 Algae biomass production, 2008-2017, percentage



Source: Commission Services based on FAO 2017 database

Figure 6.11 Companies producing algae biomass



Source: JRC Algae Database and EMODnet Human Activities.

Based on a survey conducted by the JRC[280], the macro and microalgae production sector is mainly based on small size enterprises with less than 20 employees each (79% of the companies), working in mostly full-time (Figure 6.12). According to the data collected, the macro and microalgae biomass producing sectors have been estimated to employ approximately 3 000 people.

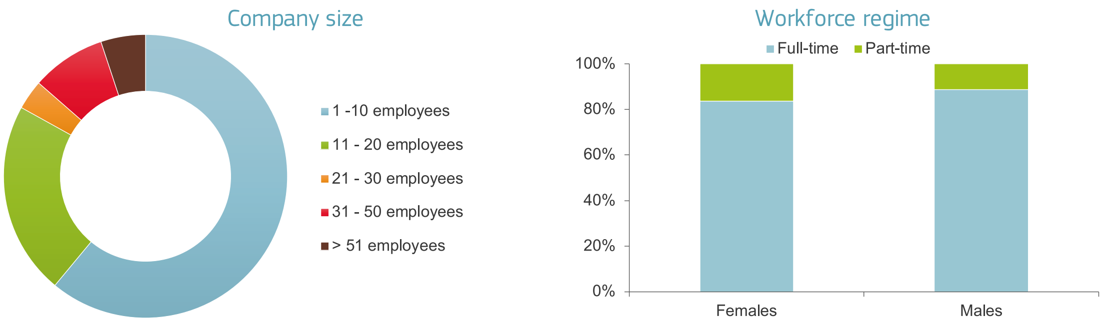
Algae biomass is widely used in Asia as food and is increasingly popular in western diets for human consumption or food applications[281]. Algae biomass has also been traditionally used in feed and fertilisers and more recently as a source of high added-value products for cosmetics, pharmaceuticals and nutraceuticals[282]. The use of algae biomass for bioremediation[283], biofuel production[284] and biopolymers (e.g. bioplastics) is currently under prospection and development (Figure 6.13).

According to the results of the JRC survey the biomass produced by the EU micro and macroalgae sectors is directed mainly at food related uses (direct consumption, food supplements and nutraceuticals and hydrocolloid production), feed and cosmetics. Commercial applications such as bioremediation, biofuels or biomaterials have still small significance in the EU[285] (Figure 6.14).

The other steps of the algae biomass related commercial chain such as the biomass processing and R&D related activities contribute also importantly to the economic turnover of the sector. These play also a central role in innovation, global food security, sustainability and creation of jobs in the context of the Blue bioeconomy.

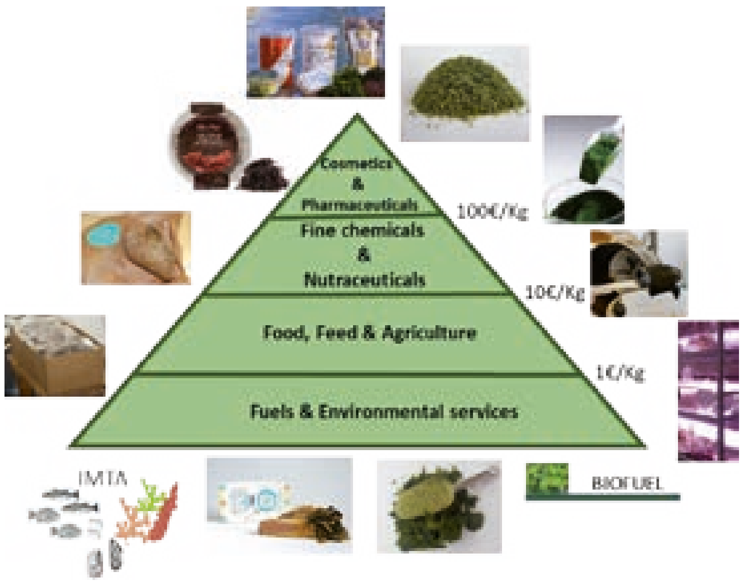
280 Vasquez Calderon et al. (forthcoming). Status of the algae producing sector in Europe.
281 Peteiro C (2018). Alginate production from marine macroalgae, with emphasis on kelp farming. In "Alginates and their biomedical applications", Rehm B.H.A. & Moradali F. (eds.), Springer, Singapore, pp. 27–66.
282 Milledge JJ, Nielsen BV, Bailey D (2016), High-value products from macroalgae: the potential uses of the invasive brown seaweed, Sargassum muticum. Rev Environ Sci Biotechnol 15: 67-88. Pinteus S, Lemos MFL, Alves C, Neugebaur A, Silva J, Olivier PT, Botana LM, Gaspar H, Pedrosa R (2018). Marien invasive macroalgae: turning a real threat into a major opportunity-the biotechnological potential of Sargassum muticum and Asparagopsis armata. Algal Research 34: 217-234.
283 Deng X, Li D, Xue C, Chen B, Dong J, Tetteh PA, Gao K (2019). Cultivation of Chlorella sorokiniana using wastewaters from different processing units of the silk industry for enhancing biomass production and nutrient removal. Journal of Chemical Technology and Biotechnology; Oliveira AC, Barata A, Batista AP, Gouveia L (2019). Scenedesmus obliquus in poultry wastewater bioremediation. Environmental Technology 40: 3735-3744.
284 Darda S, Papalas T, Zabaniotou A (2019). Biofuels journey in Europe: currently the way to low carbon economy sustainability is still a challenge. Journal of Cleaner Production 208: 575-588.
285 Vasquez Calderon et al. (forthcoming).

Figure 6.12 Structure of algae biomass producing firms in the EEA



Source: Commission Services based on a survey.

Figure 6.13 Value-volume pyramid of the algae biomass based applications



Sources: Commission Services. Images from Algaplus, Necton and Seaweed Energy Solutions.
Note: For reproduction or use of this photographic material, permission must be sought directly from the copyright older

Figure 6.14 Algae biomass commercial uses of EEA companies, share of the number of firms

Notes: HP: Hydrocoloid production; B: Bioremediation.
Source: Commission Services based on a survey.

Estimations by the European Algae Biomass Association point out that the microalgae sector generated a turnover of more than €350 million in 2018 considering both companies and indirect jobs, and more than €400 million when equipment and R&D are also considered.

According to the Blue Bioeconomy Forum report[286], as well as the results of the 2019 JRC "Community of Practice Workshop on Algae Production in Europe"[287], both the EU micro and macro-algae sectors face a number of challenges, which need to be addressed to allow the industry to scale up. The most prominent challenges relate to the policy and regulatory framework. The legislative requirements regarding different aspects of the production are not harmonised among Member States, while the high standards of EU legislation (EFSA; Novel Foods regulation) can create financial burden and inability of EU companies to compete with foreign markets. The high standards of the EU legislation should not be questioned as they are essential for food and consumer security. However, support to the competitiveness of the EU algae sector can be given through strategic regulatory choices and by creating tools that will allow holding foreign industries to similar standards. Other challenges of the sector include: access to viable financing, which will allow for the development of innovative cultivation/processing technologies and new products; need to improve consumer awareness and acceptance, as well as creation of successful value chains in the EU market; need for the development of specialised curricula, which will provide targeted technical and marketing skills for the algae sector and, finally, need for targeted investment in micro and macro-algae research, which among others can foster links between academia and industry.

6.2.2. CASE STUDIES: INITIATIVES FOCUSING ON THE ALGAE SECTOR FOR BLUE BIOTECHNOLOGY

European Interregional cooperation as supported through the European Structural and Investment Funds (ESIF) also contributes to unlocking the potential of the algae sector by promoting knowledge exchange and interdisciplinary approaches. The following cases represent examples of this cooperation in the macro-regional areas of Mediterranean, North-West Europe and Baltic. The cases reflect how multi-stakeholder cooperation can support: Life Cycle assessment methodological analysis, mapping of stakeholders and related initiatives, and mutualisation of knowledge in the domain of blue biotechnology.

MEDAlgae Project[288], transnational cooperation in the Mediterranean

The project MEDAlgae "Production of biodiesel from Algae in selected Mediterranean Countries" has worked on a Life Cycle Assessment methodology that includes all stages in the production of biodiesel from microalgae. Five pilots were established in several Mediterranean countries, delivering comprehensive analysis based on available data on microalgae in the participating countries. It includes a study on the available state-of-the-art technologies and also feasibility studies, based on the implementation of research activities. The project has worked at creating the conditions for the establishment of "The Mediterranean Regional Centre for Bio-production" which will be hosted by Alexandria University (Egypt).

EnAlgae Project[289], territorial cooperation in North West Europe

The EnAlgae project developed sustainable technologies for micro and macroalgae biomass production and assessed the potential and barriers for further development and commercialisation. The main outcomes of the project were:

- A mapping of 283 institutions working with algae in North-West Europe, showing an almost equal distribution of scientific and commercial stakeholders,
- An inventory of North-West European algae initiatives showing that most of the initiatives try to serve or aim at more than one market (for example a lot of initiatives are using waste stream to produce algae for one or more algae markets).

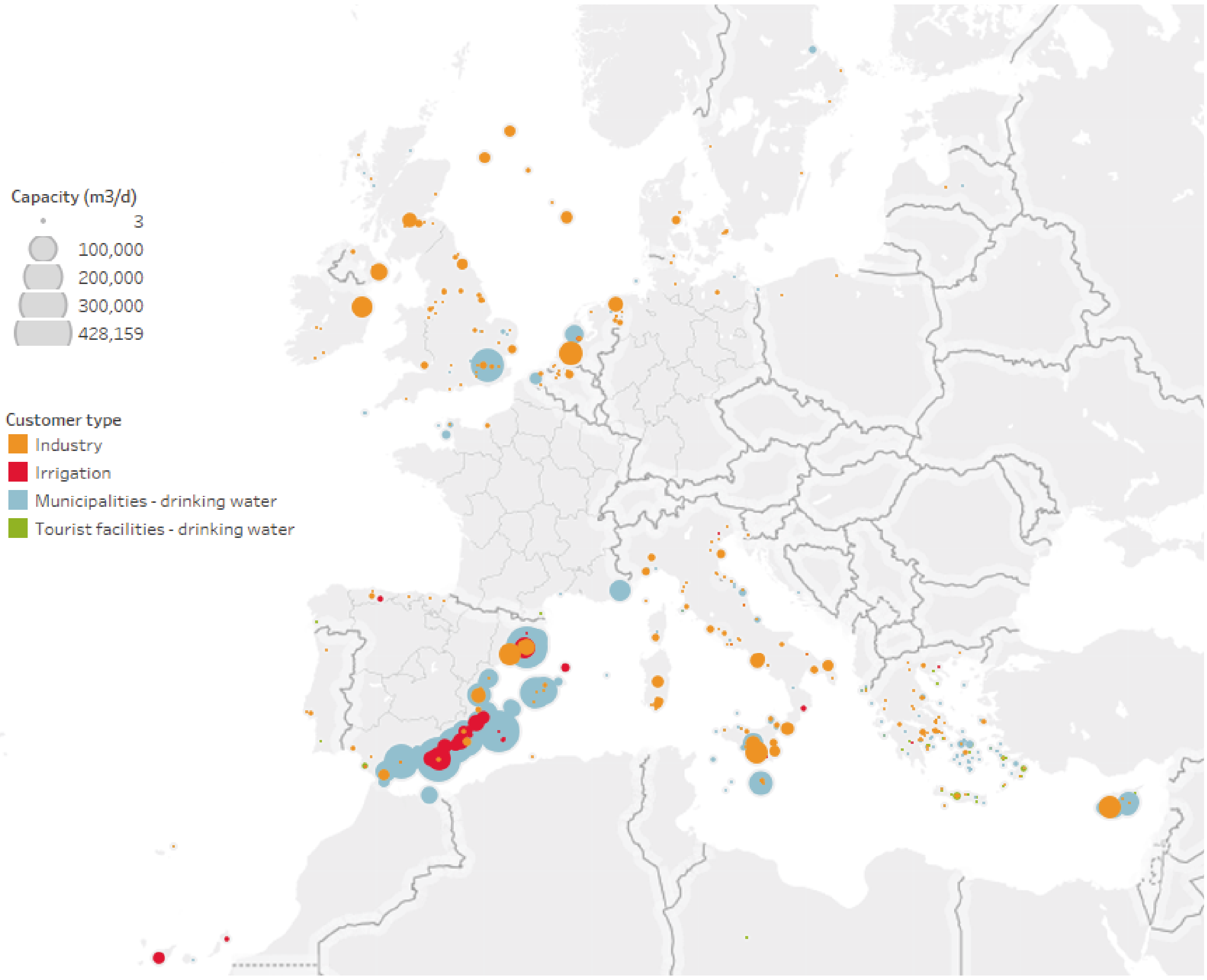
Baltic Blue Biotechnology Alliance[290], functional blue ecosystem actors

The Baltic Blue Biotech ALLIANCE is a project that pools collective knowledge of partners and stakeholders to facilitate product development in blue biotechnology. Together with Start-ups and SMEs, they have created a landscape of actors within the blue biotechnology sector.

A dedicated mentoring programme was established and more than half of the participating companies signed partnership agreements with partners across their value chain, within and outside the Alliance network.

286 Blue Bioeconomy Forum: Roadmap for the Blue Bioeconomy (2019). Publications Office of the European Union. Luxembourg. 978-92-9202-736-0. 10.2826/613128.
287 European Commission (2019b). Report on the Community of Practice Workshop: Algae production in Europe: status, challenges and future developments.
288 https://med-algae.com/about/ and https://www.idaea.csic.es/medspring/link/med-algae-project
289 http://www.enalgae.eu/
290 https://www.submariner-network.eu/balticbluebioalliance

Figure 6.15 Location of EU desalination facilities



Source: Desaldata.

6.3. DESALINATION

Desalination is a common technology and an alternative for water supply that can alleviate the growing pressure on freshwater resources. Currently, it is used to overcome water shortages in areas where freshwater resources are limited, such as in big coastal cities, islands and in offshore industrial processes where seawater cannot be used due to high salinity. In the longer term, it is expected that demand for desalination and other water management solutions such as water re-use to reduce the impact of climate change on freshwater availability. Many regions in the EU are expected to face severe water scarcity by 2050[291], including the coastal Mediterranean regions as well as regions in France, Germany, Hungary, Northern Italy, Romania and Bulgaria[292].

Desalination comprises different technological solutions: **reverse osmosis (RO)** systems remove salt from seawater exploiting the osmosis principle by transferring water through a series of semi-permeable membranes. **Electrodialysis (ED)** systems are also common in the EU, employing ionised membranes (with electrodes) to remove salt from feedwater. **Nanofiltration (NF)** is another type of membrane technologies that is normally employed to purify water with little saline content. Thermal desalination technologies, such as **multi effect evaporation desalination (MED)** and **multistage flash desalination (MSF)** employ heat to evaporate and condense water in order to purify it.

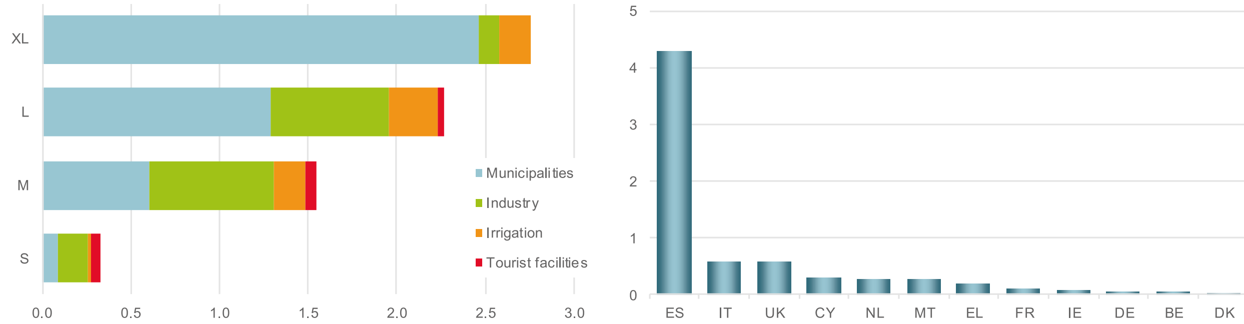
Desalination is an energy intensive process. Coastal desalination processes requires 18 TWh of energy each year. 38 % of the energy demand for desalination processes comes from European islands. Their path to carbon neutrality, as laid out in the EU “Clean energy for EU islands initiative[293]”, will require the development of viable technological solutions to power desalination with renewable energy sources.

This chapter provides an overview of the current state of play of the desalination sector in Europe.

291 Bisselink et al. (2018) Impact of a changing climate, land use, and water usage on Europe's water resources: A model simulation study. JRC Technical reports. Available at: https://ec.europa.eu/jrc/en/publication/impact-changing-climate-land-use-and-water-usage-europe-s-water-resources-model-simulation-study
292 JRC (2019) Water – Energy Nexus in Europe. JRC Science for Policy report. Available at: https://ec.europa.eu/jrc/en/publication/water-energy-nexus-europe
293 European Commission (2020) Clean energy for EU islands. Available at: https://ec.europa.eu/energy/en/topics/renewable-energy/initiatives-and-events/clean-energy-eu-islands#clean-energy-for-eu-islands-initiative

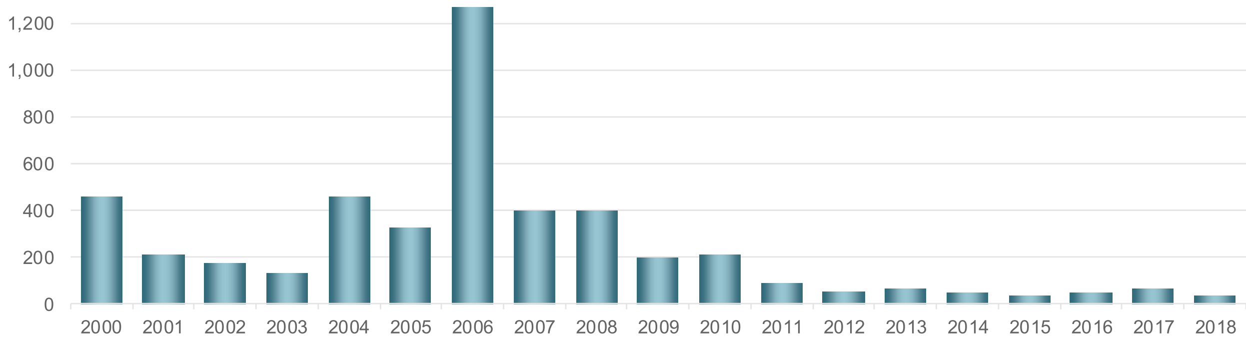
Figure 6.16 EU desalination capacity in coastal areas, million m³/day

By use and size | By Member State



Source: Desaldata

Figure 6.17 Investment in desalination facilities, € million



Notes: Investment based on awards data and derived from Engineering, Procurement and Construction data
Source: Desaldata, JRC analysis.

6.3.1. CURRENT DESALINATION CAPACITY

In 2019, in the European Union, there were a total of 1 573 operational desalination plants located offshore or in coastal areas[294]; producing a total of 6.9 million cubic meters per day (m³/day 2.5 billion m³/year) of fresh water from seawater and brackish water. 74.2 % of the desalination capacity is located in the Mediterranean Sea basin, with 821 active facilities supplying 5.1 million m³/day of freshwater. An overview of EU desalination facilities is presented in (Figure 6.15).

The bulk of desalination capacity (64.4 %, 4.4 million m³/day) is directed primarily at the production of water for public water supply managed by the municipalities. 2.1 % of the desalination capacity is employed in the production of drinking water to serve tourist facilities. The remaining desalination capacity is for industrial application (24 %) and irrigation purposes (9.5 %). (Figure 6.16). Currently 25 % of the desalination capacity is located on islands.

9 % of the EU desalination plants in coastal regions have a very large capacity (over 50 000 m³/day) or large capacity (10 000–50 000 m³/day) and supply 72.6 % (5 million m³/day) of the total desalination volume. The remaining 27.4 % of capacity is provided by 522 medium size (capacity of 1 000–10 000 m³/day) and 900 small (capacity below 1 000 m³/day) facilities.

About 62 % of the EU desalination capacity is located in Spain (Figure 6.16), with the remaining being located mainly in Mediterranean countries: Italy (8.4 %), Cyprus (4.3 %), Malta (3.9 %) and Greece (2.9 %). Some desalination plants located in Northern European countries like the UK (8.3 %), the Netherlands, Denmark and Germany, are mainly connected to the oil and gas sector, i.e. to provide fresh water employed for processing and treating oil products (e.g. extraction and refining).

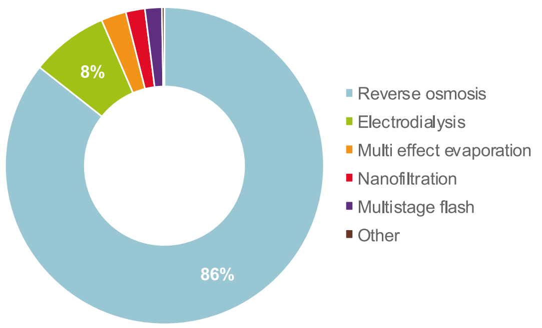
[294] The analysis presented here, focuses on the desalination plants within 50 Km of the coast and those supporting offshore activities (primarily O&G fields). In the EU there are 864 additional desalination plants, located inland. These plants are used for the production of drinking water and industrial water in area; often through a process of purification of saline/brackish water present in local aquifers.

6.3.2. DESALINATION COSTS

Desalination capacity in Europe has grown significantly over the first decade of the century, with 4.58 million m³/day of new capacity between 2000 and 2009 for a total Investment Engineering, Procurement and Construction (EPC), of €4 billion. Between 2010 and 2019 the new commissioned capacity was of 0.84 million m³/day with an investment of €630 million. Since 2010 most of the new capacity installed was in the form of small and medium size plants. It shall be noted that many of Large and Extra Large facilities commissioned between 2000 and 2010 were built to serve large coastal cities such as Barcelona and Alicante in Spain.

Reverse osmosis (RO) is currently the most widely used desalination technology in Europe (85.5 % of total capacity, Figure 6.18), with ED counting for 8 % of the total capacity.

Figure 6.18 EU desalination capacity by technology



Source: Desaldata.

Desalination is an energy intensive process. Membrane desalination technologies such have lower energy requirements than thermal technologies. MSF systems require roughly 83-84 kWh/m³ of energy, while largescale RO systems require 3-5 kWh/ m³ for seawater (Olsson, 2012)[295]. Given the lower operational costs, membrane systems are more widely employed in the EU. Thermal processes are widely employed in the Middle East, where low-cost fuels are more widely available.

Capital and operational costs associated with desalination plants depend on a number of factors, from the dimension of the plant, to the type of desalination technology employed and the salinity of the water to be treated. The costs of the plant determine the price of water that is provided for public consumption (Table 6.3). The average cost of one cubic meter (1 000 litres) of desalted water produced using RO technology is of €0.86. This means that the daily cost of supplying 5.9 million m³ of desalted water in the EU with RO is of €5.1 million, or €1.86 billion a year.

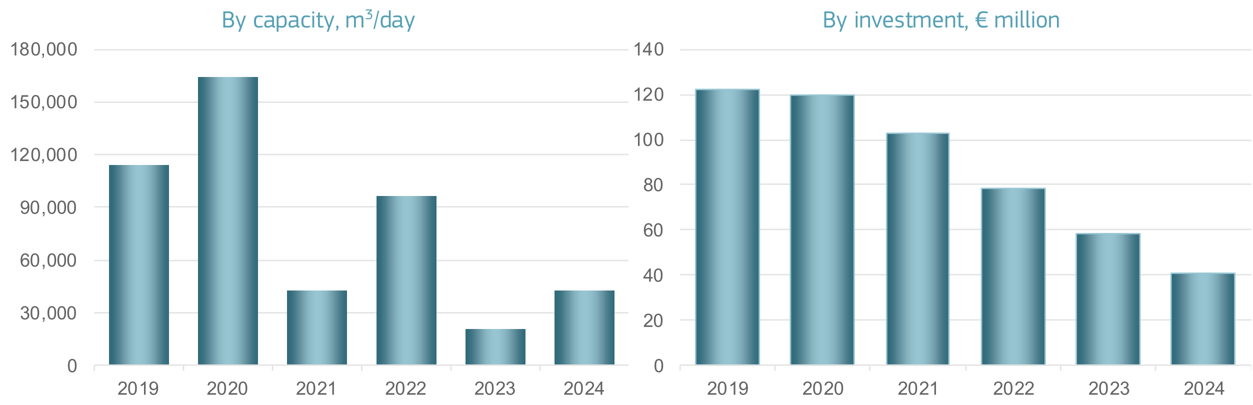
The total cost of desalination in EU coastal regions is estimated at €2.2 billion a year when including all technologies.

The Desalination sector is estimated to account for 3 % of the EU water supply sector. Estimates provided by Cetaqua[296] suggest that the labour cost of one m³ of water is €0.06. Therefore personnel costs in the European Desalination sector can be estimated at €129 million. Since the average personnel cost for water collection, treatment and supply in the EU[297] is €34 800, the Desalination sector is estimated to employ around 3 730 people for operation, i.e. excluding construction and R&D.

6.3.3. OUTLOOK

For the period 2019-2024, new desalination projects for a total capacity of 480 000 m³/day (Figure 6.19) and investments of €520 million have been announced (Figure 6.19). About 99 % of the new contracted desalination capacity is expected to employ reverse osmosis.

Figure 6.19 Planned desalination projects in the EU



Source: Desaldata.

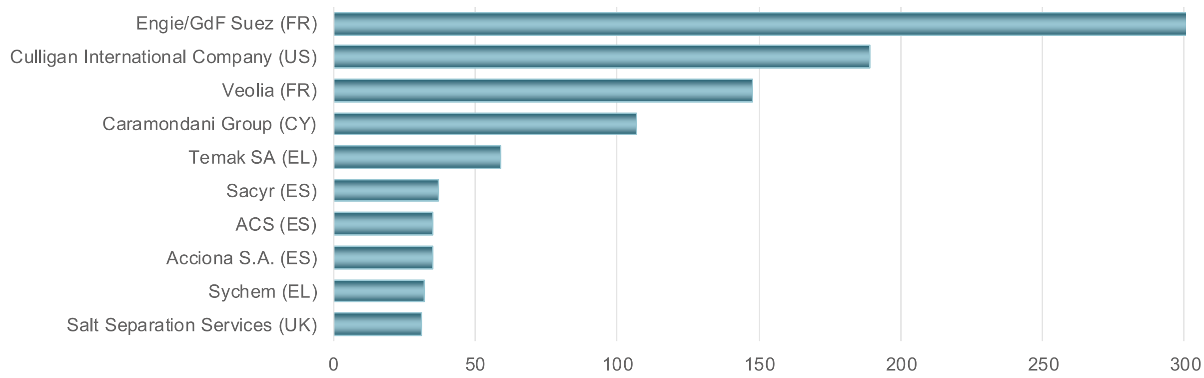
[295] Olsson, G. (2012) — Water and Energy: Threatsand Opportunities.
[296] CETaqua (2010) The Economics of Desalination for Various Uses (http://www.rac.es/ficheros/doc/00731.pdf).
[297] Eurostat (2020) Sectoral analysis of key indicators, Water supply; sewerage, waste management and remediation activities — https://ec.europa.eu/eurostat/statistics-explained/index.php/Water_supply,_sewerage,_waste_management_and_remediation_statistics_-_NACE_Rev._2

Table 6.3 Cost associated with desalination, 2016

Technology	Capital cost € million / 1 000 m³ a day		Operation and management cost, €/m³		Water production € / m³	
	Range	Average	Range	Average	Range	Average
Multi-stage Flash (MSF)	1.5-2.7	1.8	0.19-0.27	0.23	0.91-1.53	1.27
Reverse Osmosis	0.7-2	1.1	0.22-0.65	0.31	0.56-1.43	0.86

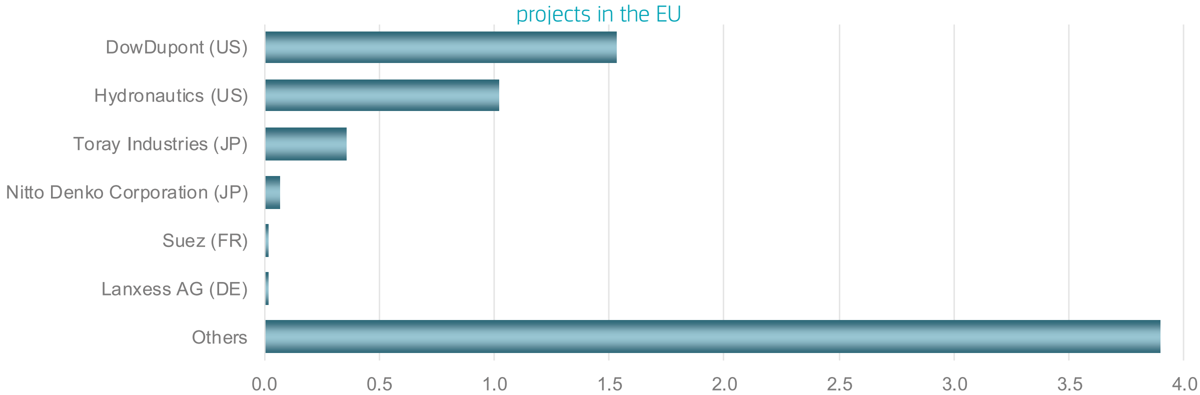
Note: Ranges take into account the variation for the given technology based on the capacity of the plant, salinity and the lifetime of the project.
Source: Almar Water Solution (2016) Desalination Technologies and Economics: CAPEX, OPEX & Technological Game Changers to Come, JRC Analysis.

Figure 6.20 Top 10 suppliers of EU desalination, number of facilities



Note: The country of origin of the suppliers is shown in brackets.
Source: Desaldata.

Figure 6.21 Top 10 suppliers of EU facilities, capacity of reverse osmosis membranes, million m³/day **Figure 6.19** Planned desalination projects in the EU



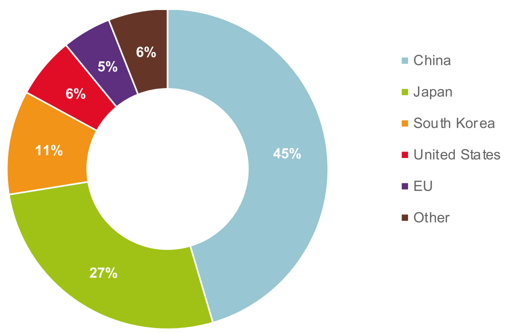
Source: Desaldata.

6.3.4. INDUSTRIAL LEADERSHIP AND R&D

Most of European facilities have been designed and built by European engineering firms, with Engie having been involved in the development of most European desalination plants (Figure 6.20). Nevertheless, when it comes to key components such as Reverse Osmosis membranes, the market is often dominated by non-European players (Figure 6.21).

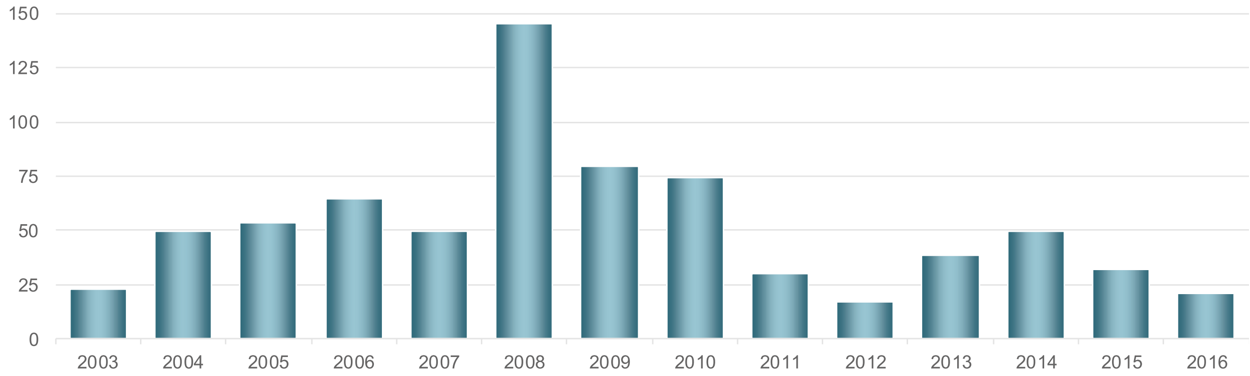
Reverse Osmosis membranes are among the most critical components of desalination plants, and one of the key R&D foci in the sector. Between 2003 and 2016 RO technology was the subject of 51 % of R&D inventions in the field of desalination based on patenting activity. The EU contribution to R&D on RO is modest, filing only 5 % of the inventions (Figure 6.22).

Figure 6.22 Patents applications for Reverse Osmosis innovation, 2000-2016, by country of the applicant



Source: JRC calculations based on European Patent Office, Patstat 2019 Autumn version.

Figure 6.23 Private R&D investment in Europe, € million



Source: European Patent Office and JRC calculations.

Table 6.4 Top 10 global patenting companies in Desalination powered by a renewable energy source, based on number of high-value inventions patented 2003-2016

Company	Country	Renewable Source
Hitachi LTD	JP	
Mitsubishi heavy industries LTD	JP	
G24 innovations limited	UK	Solar thermal or photovoltaics
Gea bloksma BV	NL	Wave energy
Ecospec global technology PTE LTD	SG	
Hydropath holdings limited	UK	Wave energy
Eukrasia srl	IT	Wind power
Seapower pacific PTY LETD	AU	
University of Florida research foundation INC	US	
Lopez SPAS	FR	Wind power

Notes: The data correspond to the Cooperative Patent Classification subclass CPC Y02A 20/138.
Source: JRC calculations based on European Patent Office, Patstat 2019 Autumn version.

Overall, the EU private sector ranks third globally in R&D desalination activities, behind China and Japan. Between 2003 and 2016 EU companies invested €730 million into Desalination R&D[298], meaning 10 % of the total R&D investments in the World belong to EU companies. However, since 2008, private investments in traditional desalination technologies have decreased from €140 million to €21 million in 2016.

Nevertheless, European companies rank among the top patenting companies when it comes to high-value inventions[299] related to Desalination powered by a renewable energy source (Table 6.4). The development of Desalination powered by wave energy or offshore wind technology can support several offshore blue economy activities.

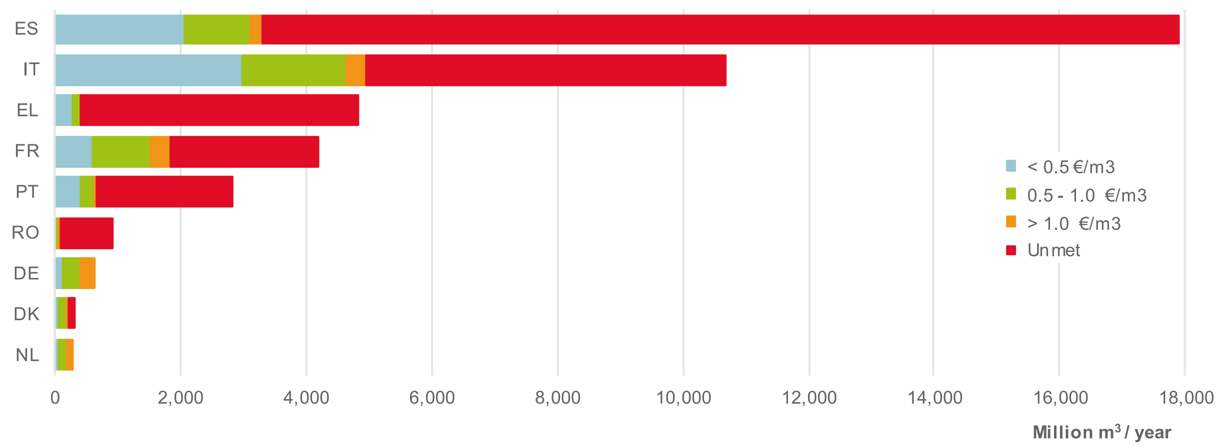
6.3.5. COUPLING DESALINATION AND WATER REUSE: A STRATEGIC OPTION FOR THE MEDITERRANEAN

Desalination is usually thought of as a solution to replace dwindling conventional water supply. Desalted water is eventually disposed of and treated as wastewater. In this way it reduces pressure on conventional water resources but does not add to the terrestrial water balance. However, if after its first use, desalinated water were to be further recycled into the environment (after appropriate treatment), it would contribute to the replenishment of water resources in the planet[300].

For each m^3 of terrestrial evapotranspiration, on average 57 % falls back on land as precipitation, and the process repeats itself in cycles. These cycles of evaporation and precipitation yield a total additional precipitation on average of between 800 and 1 300 litres per m^3 of additional evapotranspiration, and this effect is more pronounced in arid and semiarid regions such as the Mediterranean. Hence, the full benefits of desalinated water are obtained when the latter is reused in ways allowing

298 Private investments are estimated from the patent data available through Patstat. Sources: Fiorini, A., Georgakaki, A., Pasimeni, F. and Tzimas, E., (2017) Monitoring R&I in Low-Carbon Energy Technologies, EUR 28446 EN and Pasimeni, F., Fiorini, A., and Georgakaki, A. (2019). Assessing private R&D spending in Europe for climate change mitigation technologies via patent data. World Patent Information, 59, 101927.
299 High-value inventions refer to patent families that include patent applications filed in more than one patent office
300 Pistocchi A. et al. 2020 Seawater desalination can be a win-win fix to our water cycle. Under review.

Figure 6.24 Reclaimed water potentially reusable for irrigation, by range of costs

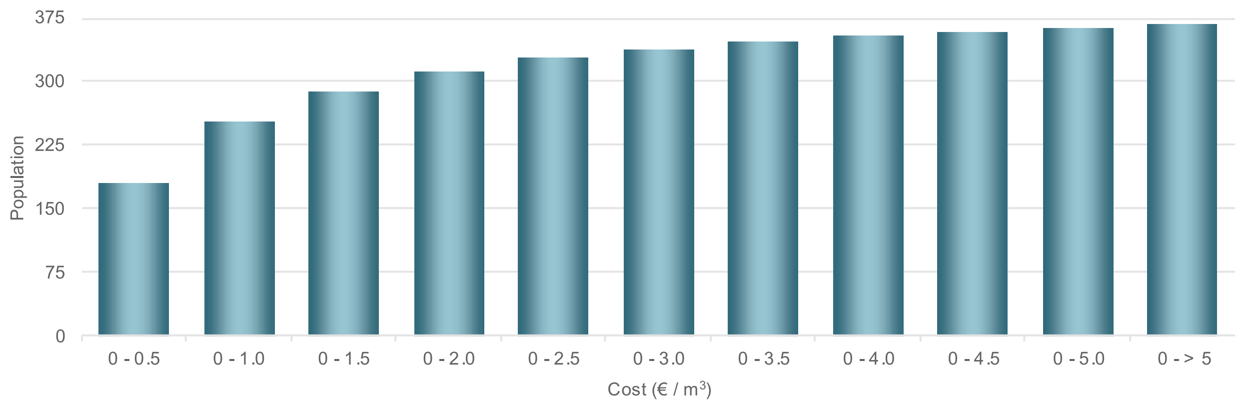


Note: "Unmet" refers to the share of irrigation demand that could not be covered by water reuse. For the rest of Member States, the value is below 200 million m³ a year.
Source: Pistocchi et al. (2018b)

evaporation, e.g. through crop irrigation. The coupling of desalination for urban demand and water reuse for irrigation can therefore be seen not just as an adaptation measure, but also as a way to mitigate the increasing water scarcity that climate change will cause[301]. Water reuse is now a common practice throughout the Mediterranean. About 6 km^3 of water per year could be reused at acceptable costs in Europe, up from todays about 1 km^3/year[302]. This corresponds to a significant share of irrigation water demand, particularly in large irrigated agricultural systems such as those in Italy and Spain (Figure 6.24).

In summary, if water supply comes from inland freshwater bodies, reuse reduces abstractions from rivers and aquifers, while also reducing the flows of treated wastewater returning to the rivers, hence water availability for other uses downstream. However, if the water supply comes from desalination, its reuse yields a net positive water balance. Desalination could supply freshwater for a large share of the population around the Mediterranean (Figure 6.25)[303], indicating that most of the water reusable for irrigation might also come from desalination. Under this scenario, irrigation with reused desalinated water could be a key strategic option to cope with water scarcity in the Mediterranean.

Figure 6.25 Population (million) that could be served by desalination depending on the cost of water transport



Notes: Population in the extended Mediterranean.
Source: Pistocchi et al. (2018b)

[301] Pistocchi et al (2020).
[302] Pistocchi, A. et al. (2018a) The potential of water reuse for agricultural irrigation in the EU. A Hydro-Economic Analysis, EUR 28980 EN, Publications Office of the European Union, Luxembourg, ISBN 978-92-79-77210-8, doi:10.2760/263713, JRC109870.
[303] Pistocchi A. et al. (2018b), Hydro-economic assessment of the potential of PV-RO desalinated seawater supply in the Mediterranean region: Modelling concept and analysis of water transport costs, EUR 28982 EN, Publications Office of the European Union, Luxembourg, ISBN 978-92-79-77211-5, doi:10.2760/8455, JRC109866.

6.4. MARINE MINERALS

The sea's mineral resources include **marine aggregates** (e.g. sand and gravel), other **minerals and metals in/on the seabed** (e.g. manganese, tin, copper, zinc and cobalt) and **chemical elements dissolved in seawater** (e.g. salt and potassium). The extraction of marine aggregates, as a long established activity, is discussed in Section 3.3. This section focuses on the potential of other marine minerals and metals.

In 2008, the Commission adopted the Raw Material Initiative[304], a strategy for tackling the issue of a secure access to sustainable raw materials for the EU. In general, securing reliable and undistorted access to raw materials has increasingly become an important factor for the EU's competitiveness. The raw materials policy was reinforced in the context of the EU Industrial Policy Strategy[305], which recognises raw materials as key elements for the industrial value chains. A good example of this new approach is the Staff working document "Report on Raw Materials for Battery Applications"[306], developed in the context of the Strategic Action Plan on Batteries[307]. The strategic importance of raw materials is also addressed by the 2050 long-term strategy[308]: "Raw materials are indispensable enablers for carbon-neutral solutions in all sectors of the economy. Given the scale of fast growing material demand, primary raw materials will continue to provide a large part of the demand". More recently, "The European Green Deal"[309] recognises the key role of raw materials – "Access to resources is also a strategic security question for Europe's ambition to deliver the Green Deal. Ensuring the supply of sustainable raw materials, in particular of critical raw materials necessary for clean technologies, digital, space and defence applications, by diversifying supply from both primary and secondary sources, is therefore one of the pre-requisites to make this transition happen." However, the European Green Deal also prioritises reusing materials, rather than extracting raw ones.

While the EU is the third largest producer of industrial minerals, the EU share of global production is low for iron and ferroalloys, non-ferrous metals and precious metals[310]. This makes the EU highly dependent on imports of metallic minerals. Moreover, the EU is highly reliant on imports of "high-tech" metals such as cobalt, platinum, titanium, and rare earth elements (REEs). Though often only needed in very small quantities, these metals are increasingly essential to the development of technologically sophisticated products in view of their growing number of functionalities. In this context, the Commission has identified a list of critical raw materials[311] with high supply-risk, high economic importance and lack of substitutes for which reliable and unhindered access is a concern to European industry and sustainable value chains.

High tech metals play a critical role in the development of innovative 'environmental technologies' for boosting energy efficiency and reducing greenhouse gas emissions. Therefore, these metals can play an important role in the general shift towards sustainable production and environmentally-friendly products as well as in the shift to a climate-neutral economy. Similarly, batteries are a key enabling technology for low emission mobility and for energy storage[312]. According to IET InnoEnergy, forecasts indicate that the demand for batteries will grow exponentially in the coming years.

Marine minerals could contribute to the future supply of the rapidly growing demand of raw materials, including certain metals as rare earth elements and cobalt. Marine aggregates, minerals and chemicals dissolved in seawater have been extracted for centuries. In addition, maerl beds (containing calcium, magnesium and other nutrient minerals) have been extracted for use as agricultural fertiliser by several Member States, including France, at rates of up to 500,000 t/ year. However, the extraction of minerals and metals, in seawater and on the seabed, has several challenges to face, including the mapping of reserves, developing appropriate technology and an adequate mitigation and management of the irreversible environmental impacts, including the carbon-intensive nature of the operations and the possibility that mining vessels may not fall under the IMO strategy to reduce GHG emissions by -50 % by 2050. These drawbacks require building up a better knowledge of the environmental impacts and putting in place robust environmental and legal frameworks.

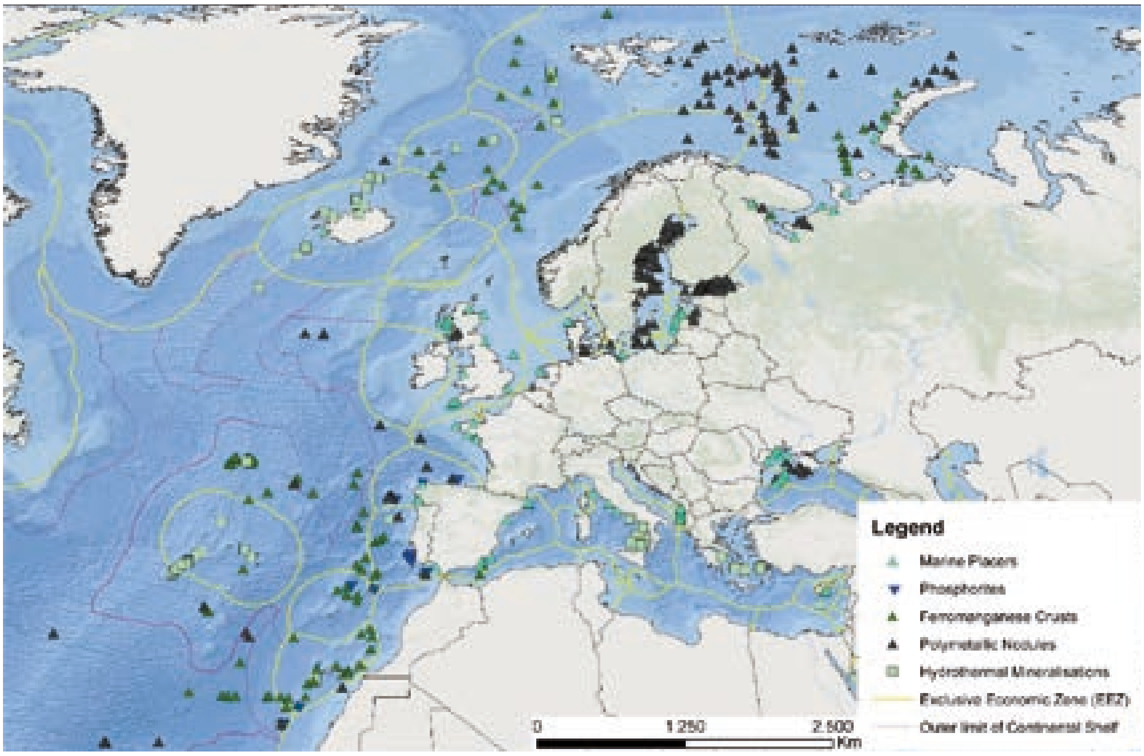
The potential of minerals and metals on the seabed

There are five main classes of mineral deposits[313] at different water depths and spatially associated with different geotectonic settings (Figure 6.26):

- ***Marine placers***,[314] typically found in shallow waters of the continental shelfs. Minerals found in marine placer deposits include zircon (Zr), monazite (Th and REE), ilmenite (Ti), rutile (Ti with minor Nb and Ta), magnetite (Fe), chromite (Cr), cassiterite (Sn) and fine-grained gold and platinum.
- ***Phosphorites***, form at depths between 95 and 1 950 metres. These deposits are economically important for phosphate and have potential for rare earth elements (REEs), including yttrium, all considered critical raw materials.
- ***Seafloor Massive Sulphides***, also known as polymetallic sulphides or hydrothermal mineralisation, form typically at depths between around 400 and 3 900 metres. These deposits have a high content of copper, zinc, lead, silver and gold. In addition, have economic potential for a wide range of high-tech metals as cobalt, tin, barium, selenium, indium, germanium, bismuth, tellurium and gallium.

[304] COM(2008) 0699 final — The raw materials initiative — Meeting our critical needs for growth and jobs in Europe.
[305] COM(2017) 479 final — Investing in a smart, innovative and sustainable Industry A renewed EU Industrial Policy Strategy.
[306] SWD(2018) 245/2 final — Report on Raw Materials for Battery Applications.
[307] COM(2018) 293 final — Strategic Action Plan on Batteries.
[308] COM(2018) 773 final — A Clean Planet for all — A European strategic long-term vision for a prosperous, modern, competitive and climate neutral economy.
[309] COM(2019) 640 final – The European Green Deal.
[310] Raw Materials Scoreboard 2018.
[311] COM(2017) 490 final. Note that, at the time of writing, the list is being reviewed. The updated list should be published still in 2020.
[312] European Commission: Report on Raw Materials for Battery Applications, SWD(2018) 245/2 final.
[313] Seabed Mineral Deposits in European Seas: Metallogeny and Geological Potential for Strategic and Critical Raw Materials (MINDeSEA), GeoERA European Union's Horizon 2020 research and innovation programme under grant agreement No 731166.
[314] Placer deposits have already been commercially exploited for decades in other parts of the world such as Namibia and New Zealand.

Figure 6.26 Marine mineral occurrences in EU waters



Notes: EEZ limits based on: Flanders Marine Institute (2019). Maritime Boundaries Geodatabase: Maritime Boundaries and Exclusive Economic Zones (200NM), version 11. ECS limits based on: http://continentalshelf.org/onesotpdatashop/6350.aspx. They do not necessarily correspond exactly with the officially recognised boundaries.
Source: GeoERA-MINDeSEA.

- ***Cobalt-rich ferromanganese crusts***, form at depths between 800 and 7 000 metres, although the thickest deposits occur at depths of about 800-2 500 metres. These deposits are rich on manganese and have potential for copper, cobalt, vanadium, niobium, nickel, titanium, platinum group elements (PGEs) and REEs. The distribution of these deposits within EU waters are shown in Figure 6.27.
- ***Polymetallic nodules*** occur in the so called abyssal plains at depths between 4 000 and 6 000 metres. These nodules are mostly rich on manganese but have economic interest for other elements such as nickel, cobalt, molybdenum, titanium, lithium and REEs. The distribution of these deposits within EU waters are shown in Figure 6.27.

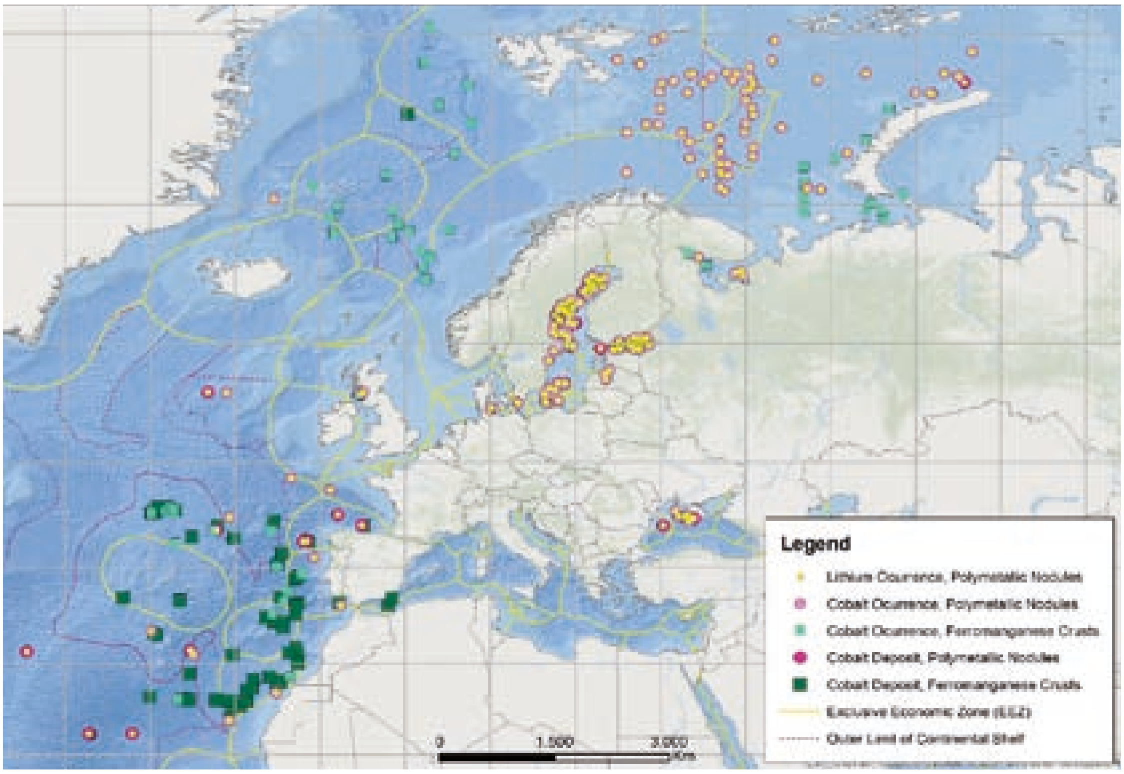
Conventional dredging has a theoretical depth limit of 150 metres (i.e. between the surface and the seabed); however, dredging deeper than 80 metres requires a high degree of innovation of the equipment and a significant amount of energy[315]. The technical, economic, financial and environmental challenges to be solved multiply when the exploitation of minerals and metals has to be performed at a depth of up to 6 000 metres. Therefore, marine mining activities at great depth remain on exploratory stage in both European and international waters.

As of the end of 2019, the International Seabed Authority (ISA)[316] has 30 contracts into force for exploration[317]: 18 for polymetallic nodules, 7 for polymetallic sulphides and 5 for cobalt-rich ferromanganese crusts in the seabed of areas beyond national jurisdiction (ABNJ or the Area). Exploration licences have been allocated to eight explorative areas, spread across the Atlantic, Pacific and Indian Oceans. Among the EU Member States, Belgium, France, Germany, Bulgaria, Czechia, Poland and Slovakia have sponsored licences in the Atlantic Ocean (Mid-Atlantic Ridge), the Indian Ocean and Pacific Ocean (Clarion-Clipperton Fracture Zone)[318].

For the time being, no commercial deep seabed-mining project exists in the Area[319] nor in the areas under national jurisdiction of the EU Member States. In this context, recent articles published in international scientific journals argue that biodiversity loss from deep-sea mining is likely to be inevitable and irrevocable, and thus most likely permanent[320]. This sentiment has gained some

[315] See Rozemeijer et al. (2018): Seabed Mining in Building Industries at Sea: 'Blue Growth' and the New Maritime Economy, River Publishers.
[316] The International Seabed Authority is an autonomous international organisation established under the 1982 United Nations Convention on the Law of the Sea and the 1994 Agreement relating to the Implementation of Part XI of the United Nations Convention on the Law of the Sea. The Authority is the organisation through which States Parties to the Convention shall, in accordance with the regime for the seabed and ocean floor and subsoil thereof beyond the limits of national jurisdiction (the Area) established in Part XI and the Agreement, organize and control activities in the Area, particularly with a view to administering the resources of the Area.
[317] https://ran-s3.s3.amazonaws.com/isa.org.jm/s3fs-public/files/documents/isba-26c-4-en.pdf.
[318] International Seabed Authority https://www.isa.org.jm/contractors/reserved-areas.
[319] According to UNCLOS, the Area means the seabed and ocean floor and subsoil thereof, beyond the limits of national jurisdiction, Art. 1 (1).
[320] Diva J. Amon et al, Insights into the abundance and diversity of abyssal megafauna in a polymetallic-nodule region in the eastern Clarion-Clipperton Zone, Scientific Reports (2016), available at https://www.nature.com/articles/srep30492 (accessed in March 2020); Ann Vanreusel et al. Threatened by mining, polymetallic nodules are required to preserve abyssal epifauna, Scientific Reports (2016), available at https://www.nature.com/articles/srep26808 (accessed in March 2020); Van Dover, C.,

Figure 6.27 Cobalt- and lithium-rich ferromanganese crusts and polymetallic nodules occurrences and deposits in pan-European seas



Notes: EEZ limits based on: Flanders Marine Institute (2019). Maritime Boundaries Geodatabase: Maritime Boundaries and Exclusive Economic Zones (200NM), version 11. ECS limits based on: http://continentalshelf.org/onesotpdatashop/6350.aspx. They do not necessarily correspond exactly with the officially recognised boundaries.
Source: GeoERA-MINDeSEA.

political traction. The European Parliament adopted a resolution on international oceans governance in January 2018, calling for a moratorium on deep-sea mining until the risks to the environment are fully understood.

On the knowledge base side, as a follow up of EMODnet Geology, the project MINDeSEA: Seabed Mineral Deposits in European Seas: Metallogeny and Geological Potential for Strategic and Critical Raw Materials aims at exploring and investigating seafloor mineral deposits. It consists of an integrative metallogenetic study of principal types of seabed mineral resources in the European Seas[321]. MINDeSEA has identified the occurrences of cobalt- and lithium-rich ferromanganese deposits in pan-European seas, which are crucial for low-carbon energy production and new technologies (Figure 6.26). However, additional investigation and exploration would be necessary to estimate reserves for all these marine deposits in Europe.

Most marine mineral occurrences are concentrated in the Arctic Ocean, Baltic Sea, Macaronesia, the Bay of Biscay and the Iberian Coasts (Table 6.5).

The interest in seabed exploration has fluctuated depending on market conditions (e.g. metal price hikes). In fact, only a few companies have made significant advances in the mapping of the area allocated to them in their exploration licences and in testing technology, including robotics for the deep-sea exploration.

Besides the exploration licences granted since 2001, the ISA is expected to finalise the 'Mining Code' a comprehensive set of rules, regulations and procedures that will also regulate the exploitation of marine mineral resources in the Area. The aim is to provide the framework necessary to go beyond the current prospecting and exploration stages and the necessary measures to ensure the effective protection of the marine environment from harmful effects, which may arise from mining activities. To support the ISA on its efforts to facilitate the development of a Regional Environmental Management Plan for the Area in the North Atlantic (the Atlantic REMP), the EU is funding the ongoing project "Areas of Particular Environmental Interest in the Atlantic"[322]. This notwithstanding, further research and knowledge of the deep-sea environment, ecosystem structure and resilience are required to be able to move from the exploration phase into the exploitation phase.

Ardron, J., Escobar, E. et al. Biodiversity loss from deep-sea mining. Nature Geosci 10, 464–465 (2017), available at https://www.nature.com/articles/ngeo2983 (accessed in March 2020); Niner HJ, Ardron JA, Escobar EG, Gianni M, Jaeckel A, Jones DOB, Levin LA, Smith CR, Thiele T, Turner PJ, Van Dover CL, Watling L and Gjerde KM (2018) Deep-Sea Mining With No Net Loss of Biodiversity—An Impossible Aim. Front. Mar. Sci. 5:53, available at https://www.frontiersin.org/articles/10.3389/fmars.2018.00053/full (accessed in March 2020); An assessment of the risks and impacts of seabed mining on marine ecosystems, Flora and Fauna International, available at https://cms.fauna-flora.org/wp-content/uploads/2020/03/FFI_2020_The-risks-impacts-deep-seabed-mining_Report.pdf (accessed in March 2020). Simon-Lledó, E., Bett, B.J., Huvenne, V.A.I. et al. Biological effects 26 years after simulated deep-sea mining. Sci Rep 9, 8040 (2019), available at https://www.nature.com/articles/s41598-019-44492-w#citeas (accessed in March 2020).

321 For more information: http://geoera.eu/projects/mindesea/

322 https://www.isa.org.jm/workshop/workshop-regional-environmental-management-plan-area-northern-mid-atlantic-ridge.

Table 6.5 Occurrence records in European marine regions for the different deposits

Sea basin or marine region	Polymetallic nodules	Ferromanganese crusts	Hydrothermal mineralisation	Phosphorites	Placers	Total
Arctic Ocean	66	24	47		9	146
Baltic Sea	223				9	232
Black Sea	14				12	26
Bay of Biscay and the Iberian Coasts	84	8	1	30	8	131
Great North Sea					6	6
Celtic Sea	26	1			16	43
Aegean Sea			26		3	29
Macaronesia	30	57	25	16		128
Central-NE Atlantic Ocean	36	19				55
Adriatic Sea					16	16
Norwegian Sea		16	5			21
Western Mediterranean Sea		2	21		10	33
TOTAL	**479**	**127**	**125**	**46**	**89**	**866**

Source: GeoERA-MINDeSEA.

The scale and potential severity of mining-impacts requires innovation and environmentally friendly technology that could limit the generation of plumes and other adverse environmental impacts during mining as well as developing adjusted policies[323]. The European Union has financed a series of studies and projects aimed at increasing knowledge of deep-sea marine resources and ecosystems, gaining a better understanding of mining's potential environmental impacts and how to mitigate them:

- MIDAS: Managing Impact of Deep-Sea Resources Exploitation, 2013-2016, €9 million.
- Blue Mining: Breakthrough Solutions for the Sustainable Exploration and Extraction of Deep Sea Mineral Resources, 2014-2018, €10 million.
- VAMOS: Viable Alternative Mine Operating System, 2015-2018, €9 million.
- Blue Nodules: Breakthrough Solutions for the Sustainable Harvesting and Processing of Deep Sea Polymetallic Nodules, 2016-2020, €8 million.
- ROBUST: Robotic Subsea Exploration Technologies, 2015-2020, €6 million.

Additionally, the Joint Programming Initiative Healthy and Productive Seas and Oceans (JPI Oceans) has funded the MiningImpact projects (1 and 2): Ecological aspects of seabed mining, 2013-2022, €22.9 million.

Although the industry players active in the field have in general expressed their confidence in future developments, the outlook for seabed mining at great depths remains uncertain. In particular regarding the extent to which the seabed will be tapped of its resources on a commercial scale. Since the costs are known to be very high, and while the benefits compared to the potential environmental impacts and its sustainability are still unclear, the actual commercial activities of extracting minerals have not yet commenced, and projects have been repeatedly delayed[324].

Most recently, the EU has funded two projects to recover metals from the seawater, which may offer an alternative, less environmentally damaging, route to extracting metals from the sea:

- SEA4VALUE — Development of radical innovations to recover minerals and metals from seawater desalination brines. This project will deliver a Multi-mineral Modular Brine Mining Process (MMBMP) for the recovery of valuable metals and minerals from brines produced in sea-water desalination plants. The project will test the feasibility of the next generation technologies (including advanced concentration and crystallisation processes and highly selective separation processes) for recovery of Mg, B, Sc, In, V, Ga, Li, Rb, Mo and set the basis for their future assimilation in already existing sea-water desalination plants and those yet to come. —
- SEArcularMINE — Circular Processing of Seawater Brines from Saltworks for Recovery of Valuable Raw Materials. This project will build on the ancient and still widely used process of saltworks, where seawater goes through natural evaporation and fractionated crystallisation in shallow basins. This process produces sea salt and a brine (bittern) free of calcium as a by-product, which is 20 to 40 times more concentrated than seawater in some crucial elements. The SEArcularMINE project uses this bittern, targeting magnesium, lithium and other trace elements belonging to the alkali/alkaline earth metals (e.g. Rb, Cs, Sr) or transition/post-transition metals (e.g. Co, Ga, Ge) group.

[323] See Gjerde et al. (2016). Implications of MIDAS results for policy makers: recommendations for future regulations. 46pp and Ketels et al. (2017). Priority Sector Report: Blue Growth. European Cluster Observatory. 16pp.
[324] European MSP Platform. Technical Study: MSP as a tool to support Blue Growth. Sector Fiche: Marine aggregates and Marine Mining. Final version: 16/02/2018 (and references therein). /www.msp-platform.eu.

6.5. MARITIME DEFENCE

This chapter covers the *Maritime defence* sector, navies in particular. Although this sector does not include new activities as such, the data available is scarce and slowly emerging, and it is for this reason that it is under the emerging sectors chapter. This edition also includes a box on the multiplier effect of the Spanish Navy, as a brief case study.

The total defence expenditure of the members of the European Defence Agency (EDA) in 2018 amounted to € 224 billion (1.4 % of GDP); a 3 % increase over 2017, of which € 44.5 billion were defence investments.

Total defence expenditure has grown 2014 in the aftermath of the economic and financial crisis; and by 2018, it had reached similar levels to those observed in 2007.

6.5.1. NAVIES

By mid-2018, figures remained unchanged compared to 2017; European navies account for at least 564 of commissioned warships with a total tonnage in the region of 1.5 million.

According to data from the European Defence Agency, the total number of maritime personnel was estimated at 177 090 in 2017, showing a decrease from 2006 (227 309). The largest annual decrease took place in 2011 and 2013 (-4.2 % and -4.7 % respectively). The maritime sector represented 13.5 % of all EU military personnel in 2016 and 14.14% in 2017 (up from 12.4% in 2006). Additionally, out of the three branches of the armed forces, this sector suffered the least in terms of personnel cuts.

Naval shipbuilding

As regards *naval shipbuilding*, the yearly turnover of European naval shipbuilders is more than €10 billion for newbuilding and more than €4 billion for maintenance and repair. The European Naval shipbuilding industry is an innovation-driven industry and it is one of the sectors with the highest investment intensity in Research, Development and Innovation with 8.7 % of naval industry sales being invested in RDI against an average of 4.2 % of the GDP.[326]

The economic impact of the Spanish Navy in the Spanish Economy

The Spanish Navy recently published a paper[327], which attempts to calculate the economic impacts of the Navy in the Spanish economy for 2017 using input/output tables and data.

The Navy's expenditure for that year was €1.34 billion; of which €1.21 billion was paid to Spanish recipients and €132 million to foreign recipients. The total impact on production was €2.77 billion, specifically € 1.21 billion of direct impact and € 1.56 billion in terms of indirect impact.

It is worth noting that, a total of € 1.16 billion (42 %) was on strategic sectors, both high-tech sectors and knowledge intensive sectors.

The Spanish navy accounted for a total of 19 176 jobs, of which 8 433 derived from activities and 10 743 from indirect ones. The strategic sectors were responsible for 41 % of the jobs in the Spanish navy sector (7 816).

The information above indicates that for every €1 invested in the Navy, €2.3 are generated for the Spanish economy. Additionally, it increases gross value added by €2.2 and multiplies employment by 2.3 (multipliers shown in Table 6.7). These values are in fact higher than those for the entire Spanish public administration[328].

Table 6.6 Personnel and main equipment of the top EU Navies

Member State	Personnel 2006	Personnel 2017	Aircraft carriers	Major amphibious vessels	SSBN	SSN	SSK	Fleet escorts	Patrol escorts	MCMV
France	41,700	35,439	1	3	4	6		17	15	14
UK	34,770	32,570	(2)	5	4	7		19	-	13
Italy	35,000	30,431	1+1	3	-	-	8	18	2	10
Spain	21,594	20,887	-	3	-	-	3	11	-	6
Germany	19,387	16,011	-	-	-	-	6	9	5	10
Greece	20,301	15,631	-	-	-	-	11	13	-	4
Netherlands	9,209	7,569	-	2	-	-	4	6	-	6

Notes: In France it is a carrier vessel nuclear (CVN in NATO classification). In the UK, one aircraft carriers is still to enter into service. In Italy, one carrier vessel (CV) and one carrier vessel light (CVL). One of the Spanish amphibious vessels is a multi-purpose amphibious assault ship (LHD) – carrier vessel. France's Charles de Gaulle is equipped with Catapult Assisted Take-Off Barrier Arrested Recovery (CATOBAR) planes and helicopters. The rest, UK's Queen Elisabeth and Prince of Wales, Italy's Giuseppe Garibaldi and Cavour and Spain's Juan Carlos I are equipped with vertical/short take-off and landing planes (V/STOL) and helicopters.
SSBN: Sub-surface ballistic nuclear submarine. SSN: Nuclear powered attack submarine. SSK: Attack submarine. Fleet escorts include multipurpose destroyers (DDG) and frigates (FFG). Patrol escorts include smaller frigates (FFG) and corvettes (FS, FSG). MCMV: Mine countermeasures vessel.
Sources: EDA Defence Data 2005-2017 for military personnel. World Naval review 2019[325] for fleet strengths (data for mid-2018).

[325] World Naval Review 2019. Editor C. Waters. Seaforth Publishing, 2018.
[326] Information from SeaEurope.
[327] Valiño Castro, A. et al. 2019. "El impacto Económico de la Armada en la Economía Española en 2017", in Revista General de Marina. July 2019. Pp.73-82.
[328] Ibid.

Table 6.7 Corresponding multipliers for Spain

Production	GVA	Employment
2.3	2.2	2.3

Source: Valiño Castro et al. (2019).

In conclusion, the total impact of the Spanish Navy represented 0.13% of Spain's GDP, 0.11% of its GVA and 0.11% of overall employment in Spain. This methodology could be explored further in order to establish whether it can be replicated in other MSs as well.

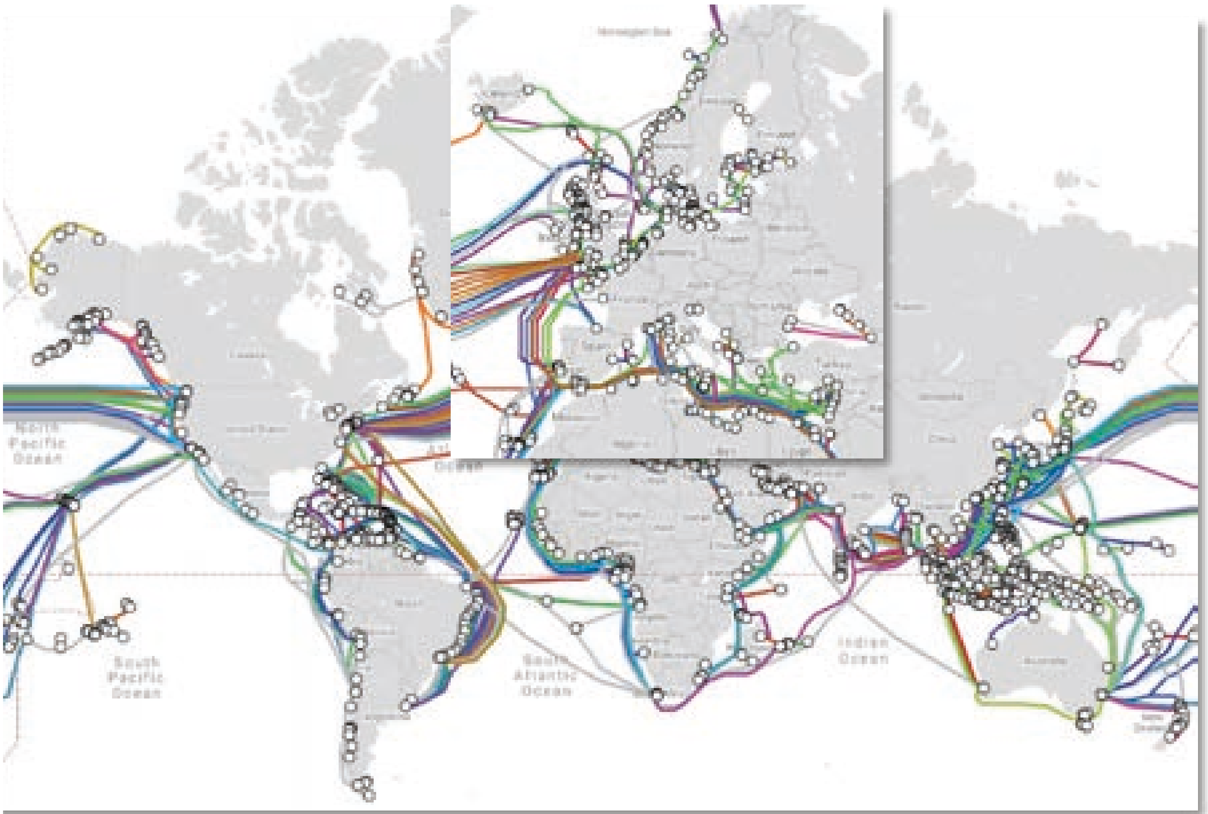
6.6. SUBMARINE CABLES

Submarine cable networks ensure that data, telecommunication, and power transmission connections are possible within the EU and between the EU and third countries. As critical infrastructure, they are essential for the rapid linkage between the EU's economy and the global economy[329].

According to estimations, there are more than 378 submarine cables spanning over 1.2 million kilometres globally (Figure 6.28)[330]. The economic importance of submarine cable networks is linked to their crucial role in global communications as they channel more than 99% of international data transfer and communication, including more than €10 trillion in daily financial transactions[331]. They can also help transfer energy (see Box 6.1).

The international framework for the governance of submarine cables traces back to 1888, when the *International Convention for the Protection of Submarine Telegraph Cables* entered into force[332]. The framework has expanded on numerous occasions since, and is now contained through the United Nations Convention of the Law of the Sea (UNCLOS)[333]. Government administrations

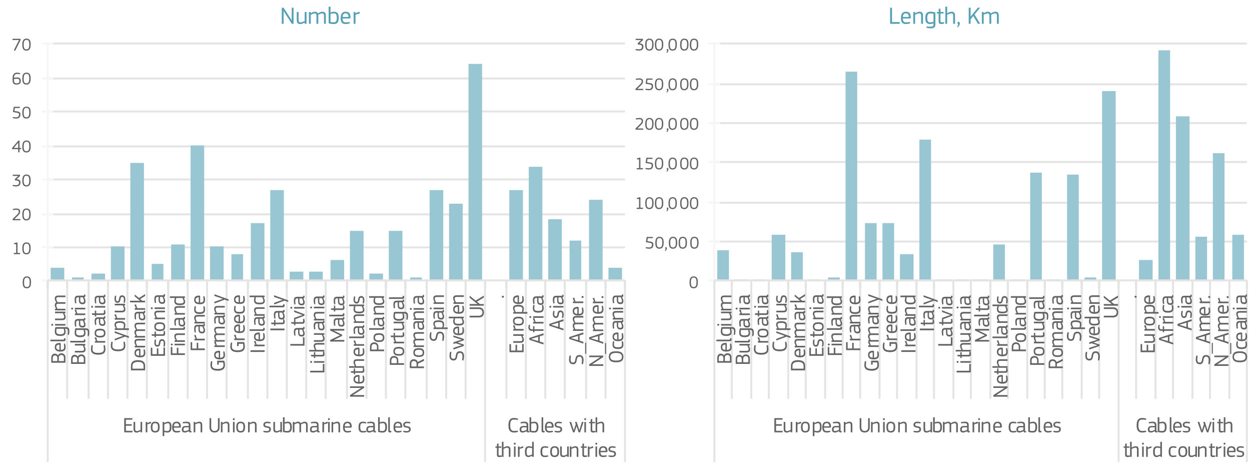
Figure 6.28 World submarine cables and European zoom



. Source: Submarine Cable Map (www.submarinecablemap.com).

329 Carter, L., and Burnett, D. 2015. "Subsea telecommunications". Routledge handbook of ocean resources and management. Routledge. [pp. 349 — 365] [Chapter 23].
330 Telegeography. "Submarine cable frequently asked questions" [https://www2.telegeography.com/submarine-cable-faqs-frequently-asked-questions].
331 Brake, D. 2019. "Submarine Cables: Critical Infrastructure for Global Communications". Information Technology & Innovation Foundation and Sechrist, M. 2012. "New threats, old technology: vulnerabilities in undersea communications cable network management systems". Discussion Paper. Harvard Kennedy School Belfer Center.
332 For more information, see Burnett, D, Beckman, R, Davenport, M. 2014. "Submarine Cables: The Handbook of Law and Policy". Martinus Nijhoff Publishers. Leiden. [pp. 63 – 90] [Chapter 3].
333 Carter and Burnett (2015) [Chapter 23].

Figure 6.29 Submarine cables connected to EU Member States by country or region of connection



Notes: Connections to EU Member States includes Outermost Regions (ORs) and Overseas Countries and Territories (OCTs) of the EU. Each submarine cable may be counted several times, depending on the connections, but is only counted once per country/continent even if they have several connection in a single Member State.
Source: Submarine Cable Map (www.submarinecablemap.com) and Commission Services.

and private parties that have a stake in the Submarine cable sector also come together through the International Cable Protection Committee (ICPC). The ICPC provides a forum that allows its members to exchange technical, environmental and legal information, with an aim to enhance the security of submarine cables.[334]

Submarine cable networks consist of: i) landing points where submarine cables connect with terrestrial power and telecommunication grids; ii) telecommunication cables that provide both telecom and data connections; iii) power cables for energy transfer; and iv) scientific cables that transfer data from marine or remote areas for the purpose of scientific research.

Out of the 378 cables in service in 2019, 205 submarine cables were connected to EU Member States, including Outermost Regions (ORs) and Overseas Countries and Territories (OCTs). Of these cables, 105 cables were connected only among EU MS, ORs and OCTs, and 100 cables were connected to third countries across most corners of the globe. These “EU” cables amount to approximately 564 000 kilometres in length, of which approximately 518 000 kilometres were connected to third countries.

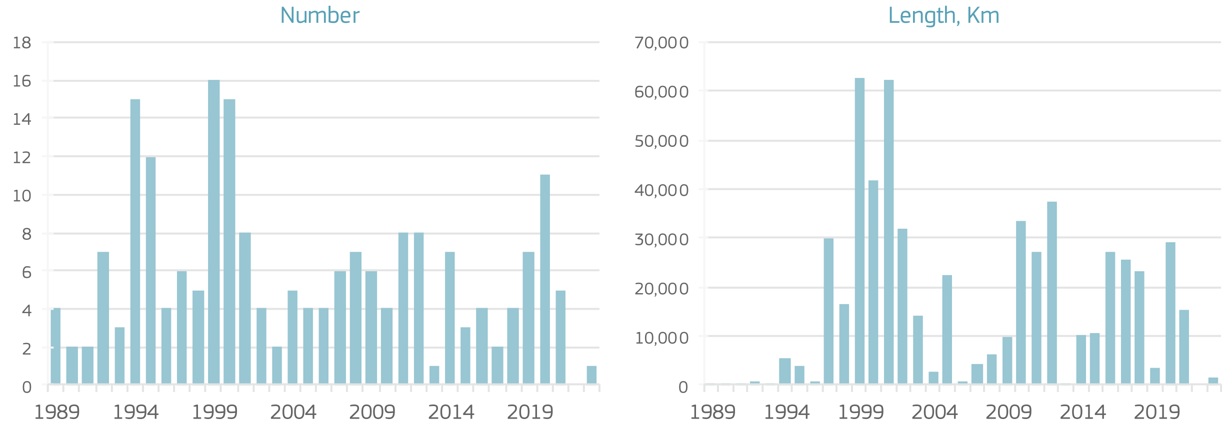
The UK is connected to the most number of cables (64 cables), followed by Denmark (32), Italy (27), Sweden (23), and France (21). The UK is also connected to the largest network of submarine cables in terms of length (241 000 Km) followed by France (206), Italy (179), Portugal (137), and Spain (77) (Figure 6.29).

In general, submarine cables are designed to last 25 years; however, because cables with a greater capacity continue to be released at lower costs, they are often replaced before the end of their life cycle[335]. Submarine cables that are no longer used can: i) remain on the ocean floor in an inactive state, ii) be recovered and recycled for their raw materials, and iii) can be repositioned to new routes. Repositioning can be an economical option for stakeholders who have less capacity to install new submarine cable networks[336]. A large number of submarine cables connected to EU MSs (including ORs and OCTs) were laid in the early 2000s or before (more than 100 cables with a length above 275 000 Km). This implies an important requirement for producing and replacing those cables in the next few years (Figure 6.30).

Cable ships (or cable layers) are maritime vessels that carry out either cable repair activities, laying new submarine cables, or other activities that ensure submarine cable functioning. Most cable ships are equipped with remotely operated vehicle(s) (ROV) and/or ploughing equipment to carry out their repair and cable-laying services. According to ICPC data, the EU plays and important role in terms of the 21 cable ships that are registered in the EU (out of 54 worldwide), which together have a total cable capacity of 83 000 tonnes (out of 193 000 tonnes). The EU has 15 cable ships docked in its ports, with a total cable capacity of 56 000 tonnes. Asia has the most docked cable ships (19), followed by the EU (15), and North America (8) (Figure 6.31).

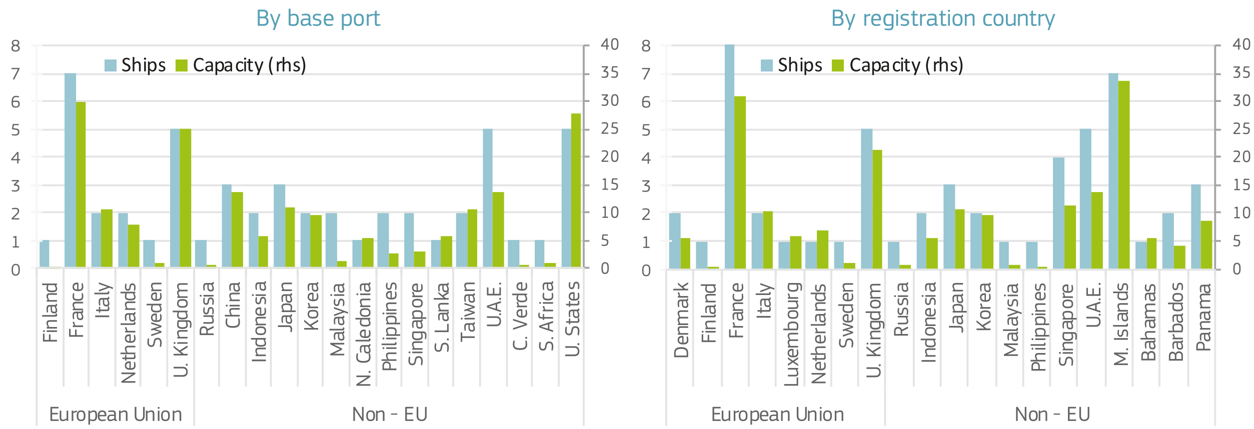
[334] International Cable Protection Committee. “About the ICPC” [www.iscpc.org/about-the-icpc/, accessed on 4 March 2020].
[335] Telegeography. “Submarine cable frequently asked questions” [https://www2.telegeography.com/submarine-cable-faqs-frequently-asked-questions].
[336] ICPC, “About the ICPC”.

Figure 6.30 Submarine cables connected to EU Member States by date of installation



Notes: Data includes Outermost Regions (ORs) and Overseas Countries and Territories (OCTs) of the EU. Each submarine cable is counted once.
Source: Submarine Cable Map (www.submarinecablemap.com) and Commission Services.

Figure 6.31 Cable ships (number) and capacity (thousand tonnes), 2019



Notes: The data compiles some of the major submarine cable ships. The capacity for two ships is not available.
Source: International Cable protection Committee (ICPC)

BOX 6.1: THE FIRST SUBMARINE POWER LINE BETWEEN FRANCE AND SPAIN

The Gulf of Biscay project is on track to develop the first submarine electricity interconnection between Spain and France. The interconnection will connect the two countries via Gatika (Bilbao, Spain) and Cubnezais (Bordeaux, France). Currently, there are difficulties transferring Spanish surplus wind energy to France because the exchange capacity between the two countries is too low. With an expected increase in capacity from 2 800 to 5 000 MW, the extant energy transfer bottleneck should be overcome. The project started in 2017 and is scheduled to conclude in 2025. EMODnet is supporting the project's environmental impact assessment with data from the Seabed Habitats, Bathymetry, and Human Activities portal[337].

[337] For more information: www.inelfe.eu/en/projects/bay-biscay and www.emodnet.eu/emodnet-plays-role-building-first-submarine-electricity-interconnection-between-spain-and-france.

CHAPTER 7

CASE STUDIES

As in prior editions, this report explores additional Blue Economy elements, sectors and/or activities in the form of case studies, which illustrate examples and best practices. These cases help depict the broadness and variety of the Blue Economy, which goes beyond what is discussed in previous chapters. Future editions of this report and specific sections will incorporate new case studies or may look at following up on some of those addressed in previous editions.

The first case study shows the importance and impact of education and skill development in the Blue Economy by presenting the results of the MENTOR project in Romania, Bulgaria, Greece and Cyprus.

A second case study looks at the use of Multi-Purpose platforms and the socio-economic benefits of combining several activities in one platform. It explores the concrete example of the PLOCAN project in the Canary Islands, Spain.

The third case study illustrates how marine observation activities can contribute to bolster a sustainable development of the Blue Economy in the EU.

The case study that follows provides an example of funding for research and development undertaken at a regional level, and initiatives to transfer innovation to all economic sectors in the Blue Economy, specifically in Catalonia, Spain.

The fifth case study is on the socio-economic impact of the recreational boating industry in the European Union, while also providing a brief overview of what the sector entails.

A final case study presents the national satellite accounts and provides the results for the Portuguese Sea Satellite Account, Portugal being one of the pioneer MS in setting them up.

7.1. EDUCATION AND SKILLS IN THE BLUE ECONOMY

Although, the Blue Economy sector is of high importance for the European Union, and it may have great potential for growth and innovation, along with positive social and environmental impacts, there is lack of well-trained professionals and high-level personnel working in these industries. The current dynamic is changing by taking into account the shifts that will occur in upcoming years, e.g. automated ships, ocean energy, and coastal tourism.

The Blue Economy covers a wide range of commercial activities linked to the sea, such as *Maritime transport*, *Coastal tourism*, *Marine living resources* and *Mineral resources*. In the context of the EMFF, project "MENTOR — Blue Career Centre of Eastern Mediterranean and the Black Sea", undertook an in-depth analysis with regards the growth, professions, skills and the qualifications of the labour force. Project MENTOR ended in February 2019 (after 2 years) and established a Blue Career Centre in Cyprus along with the three branches (one for every participating country, i.e. Bulgaria, Greece and Romania). It undertook a series of actions to make blue careers more attractive to students and young professionals in the wider area of the Eastern Mediterranean and Black Sea.

An extensive market analysis and a survey were produced in order to identify current and future (10 years' time) market needs as well as the desired blue professional profiles. MENTOR also catalogued the maritime education/training offer in the region and successfully organised a series of activities (Blue Career Days, school visits, career guidance etc.) contributing to increased general public awareness in all four countries. The following section summarises the outcomes of the MENTOR Project with a focus on jobs, education and skills in Greece, Bulgaria, Cyprus and Romania in relation to Maritime transport, the cruise industry and Aquaculture sectors.

Aquaculture

As the Food and Agriculture Organisation (FAO) stated in 2018, "between 1961 and 2016, the average annual increase in global food fish consumption (3.2%) outpaced population growth (1.6%)"[338]. In Europe, aquaculture accounts for about 20% of fish production and employment estimates are at about 75 000 persons for around 12 500 businesses (most of them SMEs)[339]. Production is mainly concentrated in five countries, Spain, France, Italy, the United Kingdom, and Greece.

The aquaculture sector is important for many MSs, not least Bulgaria. Its eastern region borders the Black Sea and the Danube River in the north, thereby making the sector a key to the national economy, contributing to a high level of employment in the coastal regions. For Cyprus, as an island nation, aquaculture is an important industry for its economy. In the last years, it has seen overall increase in production and this trend is expected to continue. Greece is one of the most important MSs for aquaculture production in the EU. Romania has a 250 km coastline along

338 The state of world fisheries and aquaculture, FAO, 2018.
339 Scientific, Technical and Economic Committee for Fisheries (STECF), The Economic Performance Report on the EU Aquaculture sector (STECF-18-19), 2018.

the Black Sea and its fishery production component is represented by aquaculture. Below is a summary of the current most in demand profiles in the Aquaculture sector. (Table 7.1).

Table 7.1 Aquaculture — Jobs (now)

Jobs	Bulgaria	Cyprus	Greece	Romania
Low-level	75%	67%	33%	
Scientific staff	25%	17%	37%	75%
Technicians		17%		17%
Managers			22%	
Engineers				17%

Source: Mentor project.

What makes a candidate successful in the aquaculture sector?

Essential technical skills, at this moment, are project management, testing, inspection and verification, machinery damage and repair, seamanship, diving, driving specialised vehicles, navigating specialised vessels, welding/materials and NDE, hardware, technical writing, big data analytics, diagnostic engineering, languages, occupational H&S. In the next ten years, the technical skills expected are navigation of specialised crafts, machinery damage and repair, hardware/ computer/ IT, technical writing and reporting, project management, machinery damage and repair, occupational health safety, operating systems, risk assessment, electrical and control, hatchery, seamanship, testing inspection and verification, big data analytics.

Key behavioural competencies, now, are considered to be, teamwork and collaboration, personal motivation, flexibility and adaptability, deciding, planning and organising, leading, analysing/ problem solving, adherence to principles and values. In the next decade, these soft skills will be almost the same, flexibility/ adaptability, teamwork and collaboration, adherence to principles and values, analysing/ problem solving, communicating orally, deciding, leading, networking, personal motivation, planning and organising, resilience, persuasive. In the following tables, the results of the project are presented briefly.

Maritime transport

Maritime transport is one of the leading drivers of globalisation and constitutes a major international transport network that supports supply chains and enables international trade. Maritime transport is divided into short sea shipping and deep-sea shipping. In Bulgaria, Cyprus, Greece, and Romania there is a predominance of short sea shipping of goods over deep-sea shipping[340]. Present demand exhibits a need for engineers and technically skilled personnel (E/R personnel/technicians) as presented in Table 7.3. These technical competences needs to be coupled with communication skills, incorporating that competence within the corporate and regulatory environment (technical writing, management systems). Demand for specific professions and technical skills is in line with the general trend for the overall anticipated growth of the industry.

A significant part of the maritime economy in these countries consists of companies, which provide supporting activities to Maritime transportat (e.g. logistics, ship management, crew services, etc.) Romania is the most dominant of the four in the shipbuilding and repair sector.

Table 7.2 Aquaculture — Soft Skills in demand (now)

Skill	Bulgaria	Cyprus	Greece	Romania
Teamwork / Collaboration	100%	100%	75%	75%
Personal Motivation	100%			
Deciding	50%			
Planning and organising	50%		50%	
Leading		50%		
Analysing / Problem solving		50%		
Flexibility / Adaptability		50%		75%
Personal Motivation		50%		
Testing, Inspection and Verification			63%	
Adherence to principles and values				50%

Source: Mentor project.

Table 7.3 Maritime Transport top three jobs in demand (now)

Jobs	Bulgaria	Cyprus	Greece	Romania
Engineers	20%	25%	45%	14%
Port Operation Staff	13%			
Lower ranking E/R	11%			
Operation Staff	11%			
Technicians	11%			
Onshore officers		15%	16%	
E/R Officers		10%		18%
Managers			10%	
Bridge Officers				14%

Source: Mentor project.

[340] Maritime transport statistics — short sea shipping of goods

Table 7.4 Maritime Transport Soft skills (now)

Skill	Bulgaria	Cyprus	Greece	Romania
Teamwork / Collaboration	100%		40%	38%
Deciding		30%		
Planning and organising	36%	43%		30%
Leading	36%	30%	60%	38%
Analysing / Problem solving	36%		40%	
Flexibility / Adaptability	36%			
Personal Motivation		30%		
Testing, Inspection and Verification				
Adherence to principles and values				
Customer Orientation	36%			38%
Communication skills	36%	43%		
Resilience	36%			

Source: Mentor project.

Table 7.5 Maritime Transport Technical Skills needed (future)

Skill	Bulgaria	Cyprus	Greece	Romania
Teamwork / Collaboration	100%		40%	38%
Deciding		30%		
Planning and organising	36%	43%		30%
Leading	36%	30%	60%	38%
Analysing / Problem solving	36%		40%	
Flexibility / Adaptability	36%			
Personal Motivation		30%		
Testing, Inspection and Verification				
Adherence to principles and values				
Customer Orientation	36%			38%
Communication skills	36%	43%		
Resilience	36%			

Source: Mentor project.

What are the future challenges for maritime professionals?

Factors influencing maritime transport include digitalisation, cyber-security, ballast water management and emissions regulations. Table 7.5 summarises the most sought after technical skills for professionals in the maritime transport sector in the next 10 years.

Cruise industry

The cruise tourism sector continues to experience a dynamic increase. In 2018, European cruise passenger numbers grew by 3.3 % compared to 2017, i.e. up to 7.17 million. A significant increase is observed in cruise passengers travelling to the Eastern Mediterranean, up 8.5 % to 746 000 passengers[341]. In the cruise industry, professional roles vary and can include hospitality, retail, medical, or maritime (Table 7.6).

Table 7.6 Cruise Industry Job type demand(2018)

Job type	Bulgaria	Cyprus	Greece	Romania
Food & Beverage	53%			
Housekeeping	20%	11%		
Personal Care				12%
Lower ranking E/R	7%			
Engineers	7%	33%	45%	
Hotel Admin	7%			
E/R Officers	7%	11%	9%	19%
HR Staff		11%	18%	
Bridge Officers		11%		12%
Operation Staff		11%		
Consultants			9%	
Leisure activity				15%

Source: Mentor project.

Table 7.7 Cruise Industry –Job type demand (future)

Job type	Bulgaria	Cyprus	Greece	Romania
Food & Beverage	53%			
Housekeeping	18%			12%
Personal Care				28%
Engineers		43%	47%	12%
Managers			5%	
E/R Officers	12%		26%	12%
Office Staff			5%	
Bridge Officers	12%		5%	
Onshore Officers			5%	
Marketing/PR		14%	5%	
Technicians		14%		

Source: Mentor project.

[341] 2018 Europe Market Report, CLIA

The above data show a link between current and future jobs in the sector. A reason for this might be that the industry estimates future needs, based on present hiring needs. Based on the data, only Romania seems to differentiate between the four countries, as "Lower ranking E/R crew" takes the first place from "E/R Officers" as the most in-demand job in the future. As regards technical skills, there is a diverse landscape. Good verbal skills, teamwork and problem solving are the most important skills in the cruise sector.

Education and training offer in the four Member States

In the Eastern Mediterranean and the Black Sea regions there are plenty of institutes for marine and maritime studies, whose graduates become 'blue professionals'. Mapping academic institutions as well as investigating their relation with Blue Economy sectors led to various conclusions to understand in what sectors graduates found opportunities.

Bulgaria: has 68 training/educational centres relevant where the selected Marine and Maritime Economic Activities (MEAs) have been identified offering Blue Economy related curricula. There are 22 establishments that offer education and training for the Maritime transport sector, 43 establishments that offer education and training related to the Cruise tourism sector and 7 establishments that offer education and training for the Aquaculture sector.

Cyprus: A total of 27 training/educational centres relevant to the MEAs have been identified. The majority of the mapped centres offer training/education in Cruise tourism (23) and Maritime transport (20). It is interesting to note that currently, there are no training/educational centres for aquaculture in Cyprus. It hosts three marine land-based hatcheries offering (direct) employment to approximately 250 persons, while a much larger number of people are employed in related/similar professions.

Greece: There are 321 Institutions offering training and education in the selected MEAs. The majority of the mapped centres offer training/education in the field of Cruise tourism (264), followed by Maritime transport (142) and Aquaculture (30).

Romania: A total of 61 training/educational centres relevant to the selected MEAs have been identified. The majority of the mapped centres offer training/education in Cruise tourism (45), Aquaculture (9) and Maritime transport (7).

7.2. ACTIONS TO CATAPULT MULTI-USE OFFSHORE APPLICATIONS

The World's population is forecasted to grow up to 10 billion people by 2050, requiring copious amounts of food, water, energy and space. In order to meet these needs, the oceans will see an increasing development of maritime infrastructures, including offshore wind farms, offshore aquaculture farms and offshore ports, either as stand-alone infrastructures, or as multi-use platforms (MUPs) to provide enhanced efficiency and to lower the impact on the ocean environment. Although the need for such developments will be required to avoid an over-exploitation of coastal resources and ecosystems, it is essential to guarantee that offshore developments are also sustainable. The development of these structures is based on the know-how and technology drawn from a wide range of disciplines, to reduce social and economic costs and to minimise impacts on marine ecosystems. MUPs can help meet the above demands more efficiently, thus helping support actions towards the implementation the Sustainable Development Goals (SDGs), particularly, SDG 2 "Zero Hunger", SDG 13, "Climate Action", and SDG 14, "Life Below Water'.

In 2011, the European Commission allocated €12 million, to an FP7 programme entitled "Oceans of Tomorrow" (OoT, OCEAN.2011) to identify new concepts and technologies (*blue sky*) to simultaneously harnessing resources from the marine environment and technology readiness level (TRL) below 4[342], in a call for projects known as *Multi-use offshore platforms* (OCEAN.2011-1). This also aimed at creating synergies between disciplines and sectors by creating opportunities in the maritime sector. It generated a multi-disciplinary and cross-fertilising approach, involving tech companies and developers, all within the framework of the Commission Communication "A European Strategy for Marine and Maritime research[343]". Three projects were funded under the OCEAN.2011-1, to design multi-use platforms and solutions. The results of these ensured progress in designing new, innovative concepts was made, and it highlighted the needs, opportunities and ways of encouraging further development of the sector. Potential zones for setting up MUPs were identified, as were the conditions required for them[344].

The Horizon2020 programme (2014-2020), and the Blue Growth initiative, have provided continuity in underpinning the foundations needed to develop multi-use platforms. The MUP-related actions in the programme contributed to the awareness of the regulatory and technological barriers, along with business models, to reduce operator and investor risk by highlighting the need to develop and implement pilot projects that showed MUPs in a real setting. Several funded projects tackled aspects pertaining to legislation (MUSES), enabling technologies (MUSICA) or socio-economic models (MARIBE)[345]. Along the same lines, the European Maritime and Fisheries Fund (EMFF) has fostered the development of enabling

342 For details about TRL, see www.sciencedirect.com/topics/engineering/technology-readiness-level
343 COM(2008) 534 final, available at: https://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2008:0534:FIN:EN:PDF
344 A detailed review of the projects showed promising designs that included technological proposals and models for combining the simultaneous harnessing of several resources in conditions of economic, technological and environmental feasibility. See Torres-Ortega, S. et al. 2016. Economic assessment of old Ocean of Tomorrow projects, available at: http://maribe.eu/download/2547.
345 The Multi-Use in European Seas (MUSES): https://cordis.europa.eu/project/id/727451; Multiple-use-of Space for Island Clean Autonomy (MUSICA): https://cordis.europa.eu/project/id/862252; Marine Investment for the Blue Economy (MARIBE): https://cordis.europa.eu/project/id/652629.

technologies and a road map for developing multi-use platforms through the ENTROPI project[346]. This project pays special attention to the formulae and investments needed to face the critical challenges throughout the value chain to provide support for developing multi-use platforms. A point was made to align investment plans with regional and national investments priorities and specialisation needs (RIS3) and funding resources from other sources.

In the ENTROPI project a comprehensive overview of the different potential value chains involved in MUPS was developed. The overarching value chain can be divided into 5 main parts: Feasibility and planning; Design and engineering; Production and fabrication; Installation and decommissioning; and Operations and maintenance. Within each of these 5 links, application-specific requirements (such as Concept Development or Case for Investment within the feasibility and planning link) and generic requirements (like Environmental Impact Assessment or Spatial Planning within the Feasibility and Planning link) were identified. This kind of analysis should be further developed and supported (taking into account factors like the price of energy/food sources, policy-making, regulations, indirect subsidies, direct investment, etc..) in order to test and prove its feasibility, sustainability and cost-effectiveness and hence foster offshore players strategic movements and positioning.

The next steps to roll-up market devices requires investment through public-private collaboration and fintech tools to provide real data using pre-commercial pilots and demonstrators, operating in real environmental conditions. This would enable technological progress, hence lowering the costs, but also in non-technological aspects relating to synergies in operations, certification of procedures and materials, safety and security, risk assessment, insurance, integrated engineering and logistics, among others.

Multi-purpose, modular offshore structures and experimental platforms are required to test the evolution of technologies, materials, standards and other aspects relating to the simultaneous harnessing of offshore resources, including energy, living resources and transport capacities. The sector needs large amounts of contrasted data in diverse and relevant environmental conditions to underpin technological and commercial viability, safety and security. Experimental platforms must have sensors, to generate large quantities of data on the different operating conditions, with a view to optimise operating conditions by applying artificial intelligence and learning technologies.

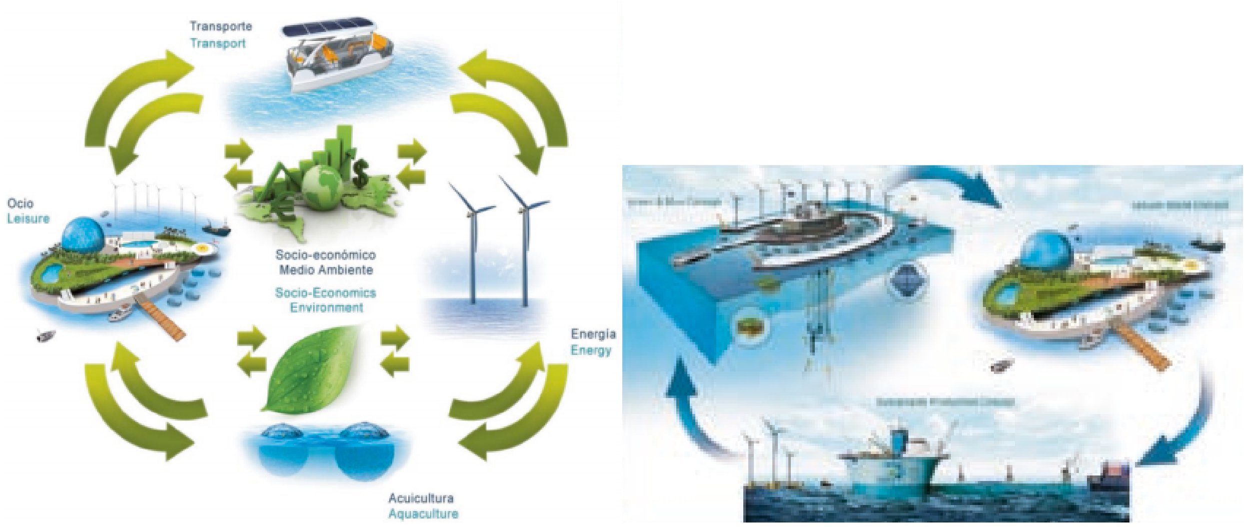
Future activities must overcome the following barriers:

- The independent development of technologies in silos of know-how and sectors that traditionally do not co-operate with each other (aquaculture, wind energy, transport, etc.). The same applies to ocean governance of marine resources.
- Lack of experimental multiuse pilot platforms and areas to provide data and evidence to help further installation procedures, logistics, innovative operations, behaviour in extreme conditions, variability on environmental interactions social perception, ad-doc regulations, safety conditions or risk assessment to ensure investments.
- Fintech tools to mitigate aversion to risk by the maritime sector (investors, ship owners, etc.), i.e. curbing aspects such as integrating communications technologies, decarbonisation, artificial intelligence or hybrid business models with no previous pilot experiences or demonstrators.

Cost is generally a major barrier to overcome if such integrated approach and facilities are to become economically attractive. Experience from the offshore wind sector, which has explored the concept of floating platforms, indicates that increasing productivity to cover fixed platform costs is critical. MUPs can tackle the cost challenge using three parallel methods:

- Increase the utility of the platforms to maximise the revenue potential.

Figure 7.1 Overview of the Tropos Project



Source: Tropos Project (www.troposplatform.eu)

[346] https://www.offshoreplatforms.eu/entropi.

- Lower costs by moving innovative solutions to key cost-centres within the platform value chain.
- Lower cost by achieving economies of scale and learning from already build platforms.

RECOMMENDATIONS

Taking into account the results of prior projects, key recommendations for further analysis and exploitation of MUPs are summarised below.

Stimulate political, governance and regulatory support

Legal and policy aspects remain an obstacle to the development of MUPs. The regulatory framework depends on both European, national and sometimes regional legislation, involving a substantial number of governing bodies. Problems arise in all Sea basins due to a lack of clear definition on administrative and legal proceedings related to the implementation of offshore projects. A clear and stable policy framework is necessary at all levels, to guide the development of MUPs, including perhaps licensing procedures that adhere to the principles of Maritime Spatial Planning.

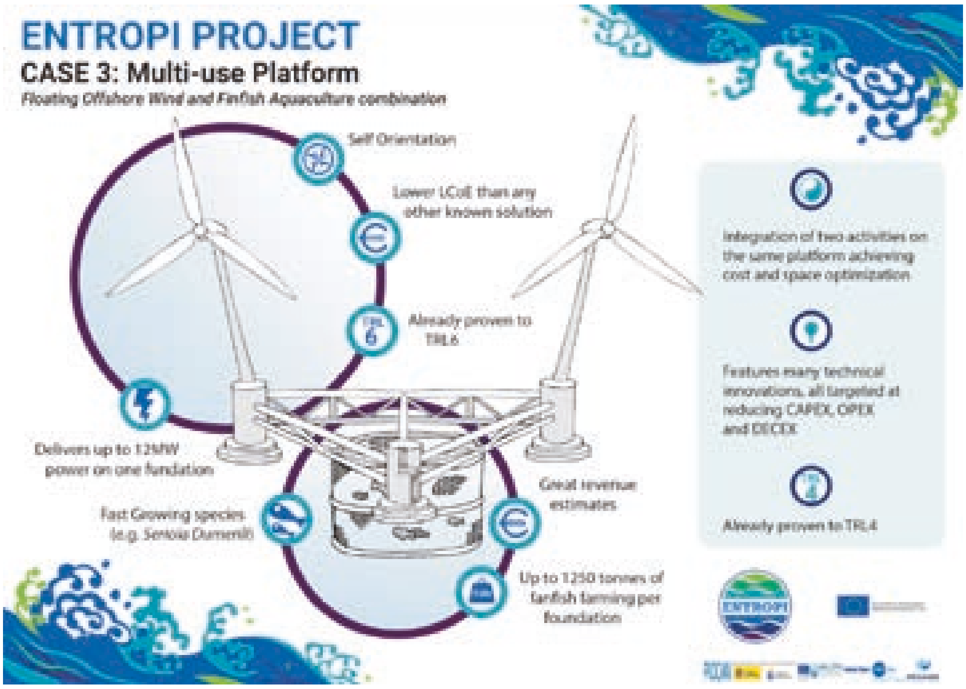
Incentives to infrastructure sharing and efficient use of the maritime space

Incentives are key and should promote the financing of multi-use platforms. Actions are needed to reduce investor uncertainty, limited access to bank loans or lack of insurance that will cover excess of risks that a combination of aquaculture and wind energy would incur.

Promoting technological development and innovation

Technology developments help decrease costs, improve safety and reliability and should be further supported to approach demonstration and commercialisation stages. MUPs design optimisation and innovative solutions should be addressed. Integration of key structural requirements and standardisation of MUP modules to achieve economies of scale, are critical. The tethering of floating facilities, especially in deeper offshore waters, is a strategic capability for both MUPs and other types of platforms, which requires enhanced investments. The need for an MUP to carry systems that protect it against threats can offer valuable services to third parties. Possible dual-use facilities include: surveillance (pollution, illegal activities); intervention (fisheries protection, narcotics); and communications (WiFi, AUV transmission).

Figure 7.2 Overview of the Entropi Project



Source: Entropi Project (www.offshoreplatforms.eu/entropi)

7.3. MARINE OBSERVATION

Marine observation refers to the exploration, observation and discovery activities that contribute to monitoring the marine environment, but also to generating novel knowledge about it. It includes observation activities that take place in oceans, seas, coastal areas, and other marine environments. New scientific knowledge and technologies allow for improved marine observation activities.

Rapid access to reliable and accurate information is vital in addressing threats to the marine environment, in the development of policies and legislation to protect vulnerable areas of our coasts and oceans, in understanding trends and in forecasting future changes. Likewise, better quality and more easily accessible marine data is a prerequisite for further sustainable economic development in the Blue Economy. Access to marine data is of vital importance for marine industries, decision-making bodies and scientific research.

In this context, the European Commission promoted and financed the Copernicus Marine Environment Monitoring Service (CMEMS)[347] and the European Marine Observation and Data Network (EMODnet). CMEMS is delivering ocean information services on the blue (ocean physics), green (ocean biogeochemistry) and white (poles) oceans. Namely, real time observations through in-situ or satellite data, ocean forecasts and ocean climate records from the past and future. In parallel and complementing this, EMODnet seeks to overcome marine data fragmentation by connecting over 150 organisations that work with marine observation data. Under the principle of "collect once and use many times" EMODnet is estimated to generate more than €1 billion in savings per year, including the development of standards and the processing and validation of data at different levels.[348]

Marine observation activities at EMODnet are grouped in the following themes:

- Bathymetry: data on bathymetry (water depth), coastlines and geographical location of underwater features (including wrecks).
- Physics: data on salinity, temperature, waves, currents, sea-level, light attenuation, and FerryBoxes[349]
- Biology: data on temporal and spatial distribution of species abundance and biomass from several taxa.
- Chemistry: data on the concentration of nutrients, organic matter, pesticides, heavy metals, radionuclides and antifoulants in water, sediment and biota.
- Coastal mapping: data on coastal areas across Europe, especially bathymetry and seabed mapping.
- Geology: data on seabed substrate, sea-floor geology, coastal behaviour, geological events, and minerals.
- Human activities: data on the intensity and spatial extent of human activities at sea.
- Seabed habitats: data on modelled seabed habitats based on seabed substrate, energy, biological zone, and salinity.

Among the benefits of an effective pan-European, marine data infrastructure encompassing CMEMS and EMODNET, the following could be mentioned:

- Enable effective and efficient marine spatial planning and legislation for environment, fisheries, transport, border control, customs and defence;
- Reduce uncertainty in our knowledge and ability to forecast the behaviour of the ocean and its ecosystem;
- Improve offshore operators' environmental footprint, efficiency and costs through the gathering and processing of marine data for operational and planning purposes;
- Stimulate competition and innovation in established and emerging maritime sectors;

Some examples can illustrate how marine observation activities can contribute to bolster a sustainable development of the Blue Economy in the EU.[350]

Powering tourist navigation

The SINDBAD+ project aims to develop an advanced operational service to support navigation in the Ligurian Sea (in the Mediterranean Sea). The project, which concluded its Beta testing phase in 2019, specifically focuses on developing an ICT Service Infrastructure that can support tourist navigation. SINBAD+ will provide weather predictions and analysis on the impact of such weather conditions on the various tourist boat characteristics (i.e. luxury or leisure). To operate, SINDBAD+ data forecast models make use of both the EMODnet Physics and the EMODnet Bathymetry data portals.[351]

Developing low-cost offshore wind energy solutions

A Danish company that designs offshore wind turbines with the specific aim of reducing the costs of offshore wind energy uses the EMODnet Human Activities portal, and the wind farm and hydrocarbon extraction datasets, as one of their main tools for their activities. The portal has provided, pooled and harmonised interoperable resources that have supported C_2Wind to provide sustainable solutions to the Blue Economy.[352]

[347] CMEMS provide information on essential variables such as currents, temperature, salinity, wind, waves, transparency, oxygen, plankton, primary production and up to 160 oceanographic data products. Further information in Section 6.2.in: European Commission, 2019. The EU Blue Economy Report. 2019. Publications Office of the European Union, Luxembourg.
[348] https://www.emodnet.eu/what-emodnet.
[349] A FerryBox is a system that can be installed on ships to measure chemical, physical, and biological data. For more information, see: EuroGOOS. Ferrybox [http://eurogoos.eu/ferrybox-task-team/].
[350] Additional use cases of using ocean information services from Copernicus are available at https://marine.copernicus.eu/markets/use-cases.
[351] For more information: www.sindbad-liguria.it/wp5.html and www.emodnet.eu/emodnet-bathymetry-physics-data-supporting-sea-situational-awareness.
[352] For more information: www.emodnet.eu/emodnet-datasets-to-support-wind-farm-projects.

Reducing costs for marine environment SMEs

High quality data sets in terms of resolution and accuracy are a key pillar for marine environment modelling. One example would be for the development of acoustic impact models, where it is important to understand how sound propagation affects the environment (such as sediments and bathymetry). Irwin Carr Consulting is an SME that used EMODnet geology and bathymetry data to power the development of dBSea, a software that can predict underwater noise. For example, the consultancy used the software for the Greenore port expansion project, to predict the impact that underwater noise would have on local marine wildlife. In addition, it was used at the Shannon Estuary, to ensure that underwater noise from wind turbine development would minimally disturb the local bottlenose dolphin population. The data that was available through EMODnet allowed Irwin Carr Consulting to reduce costs, save time, and be competitive; and it allowed them to develop "better impact assessments with more transparency"[353].

Wind wave modelling of the Mediterranean Sea

HyMOLab (University of Trieste) and DHI (a Danish international company) work together to develop a met-ocean database that provides data on wave and wind conditions in the Mediterranean. The database, named the Mediterranean Wind Wave Model (MWM), houses almost 40 years of hourly time series of wind and wave conditions at a very high spatial resolution. The model, calibrated and validated using EMODnet Physics data, can be a powerful tool for Renewable energy projects in the Mediterranean Sea[354].

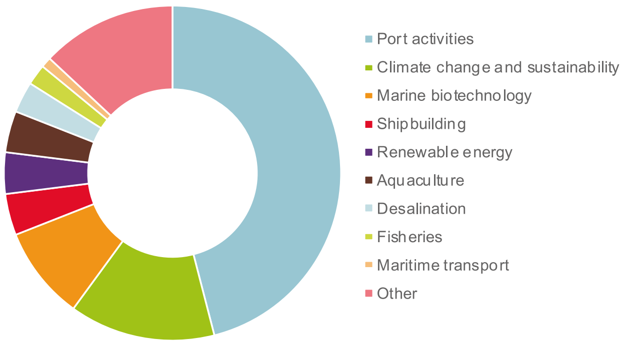
7.4. FUNDING AND R&D IN CATALONIA IN THE BLUE ECONOMY

Funds awarded by the EC contributing to the Blue Economy in Catalonia

The EC Financial Transparency System publishes the beneficiaries of funding from the EU budget directly administered by the Commission's departments, its staff in the EU delegations or through executive agencies; and from the European Development Fund. In the case of Catalonia, the main funded programs were Horizon 2020, Connect Europa and Life.

An exhaustive study of the data from 2014 to 2018 has identified the projects contributing to the Blue Economy in Catalonia and classified them into nine different sectors (Figure 7.3). A total of **123** projects have been identified during this period representing 26% of the total number of Blue Economy projects awarded to Spain and 4% of the total amount of projects awarded in Catalonia. A total of **67** Catalan organisations benefited from these projects, where some institutions obtained funding for more than one year. In terms of funding, organisations have received a total of **€80.6** million between 2014 and 2018, representing 23% of the total amount of European funding obtained by Spanish institutions for Blue Economy projects and 6% of the total funds procured by institutions based in Catalonia considering all funded projects.

Figure 7.3 Blue Economy Projects in Catalonia by sector



Notes: The topic "others" includes Coastal Management; Observation, Data Analysis and Modelling; and Marine Research.
Source: elaborated by the Centre for Agro-Food Economics and Development (CREDA) of Catalonia, based on data from the EC Financial Transparency System.

The Maritime R+D+I network of Catalonia – Catalan Network for Blue Innovation (BlueNetCat)

BlueNetCat is a platform created as an interdisciplinary environment and a bridge with the quadruple helix (scientists, private sector, society, and administration) in order to transfer innovation to all economic sectors in the Blue Economy and support its sustainable development in the context of the 2030 Maritime Strategy of Catalonia. This approach facilitates the definition

[353] For more information: https://irwincarr.com/services/underwater-noise/ and www.emodnet.eu/centralised-public-access-high-quality-bathymetry-and-sediment-data-facilitates-smes-both.
[354] For further information: www.emodnet.eu/mediterranean_wind_wave_model_0.

of cross-cutting proposals aligned with the Strategy, the WestMED Initiative, the EU's Blue Growth strategy, as well as the United Nations Sustainable Development Goals (SDG 14 directly and other SDGs indirectly).

A total of 64 research groups and over 400 scientists from seven renowned scientific institutions have already joined BlueNetCat. The network is structured in three working areas (training in technology transfer, internationalisation, and communication/dissemination), and four thematic areas (data collection and processing, marine technologies, heritage and natural resources, and social and maritime culture). The governance of the network aims at a shared responsibility and parity in participation.

7.5. THE RECREATIONAL BOATING INDUSTRY: MADE IN EUROPE

The European recreational boating industry is characterised by a diverse set of sub-sectors that fall under the blue economy. This includes manufacturing (boats and equipment) and tourism services (charters and marinas). Total employment is estimated at 280 000 across the industry with 32 000 companies[355]. Most of the sector is made up of Small and Medium-sized Enterprises (SMEs), approximately over 95 %[356], that are primarily situated in coastal and peripheral regions. The impact is felt across the value chain that creates employment and growth for local and regional economies.

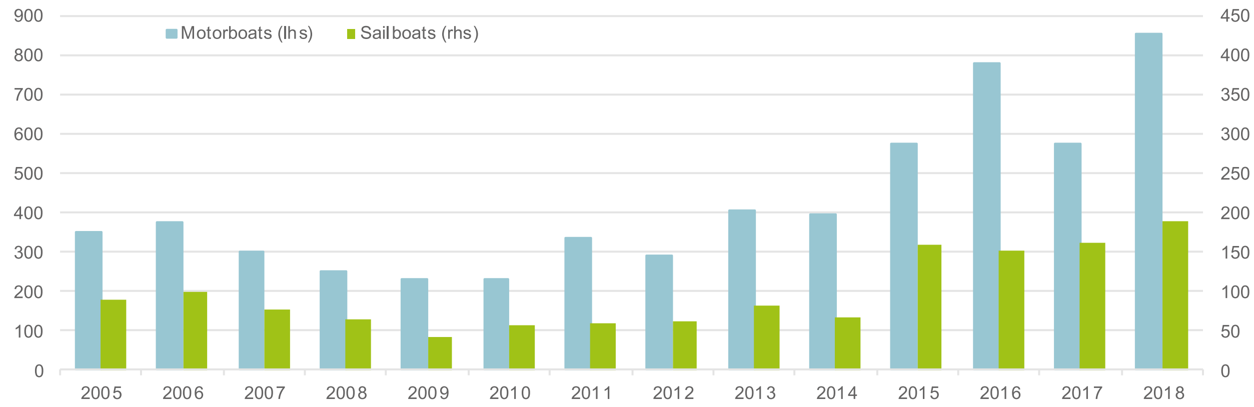
Within the maritime sector, the recreational boating sector is unique as manufacturing still predominantly takes place in Europe. Globally, European manufacturers are among the leading brands, and the "Made in Europe" label is perceived as sign of quality.

Recovery since economic crisis

The 2008 economic crisis had a profound impact on the industry with a high number of companies going out of business and employment decreasing. Economic recovery has however taken place in the sector and taking the Italian industry as an example, turnover increased by 92 % between 2014 and 2019 and employment by 20 % between 2017 and 2019[357].

Trade has been a key contributor to this recovery, in particular exports to the United States. In 2018, over 13 000 boats and watercrafts were exported with a trade value of over €1 billion[358]. Sailboats made up the largest share of units exported while motorboats held this position by trade value.

Figure 7.4 Exports of EU recreational boats, € million



Source: UN Comtrade database.

355 EBI data, http://europeanboatingindustry.eu/facts-and-figures.
356 ECSIP Consortium, Study on the competitiveness of the recreational boating sector, 2015.
357 Market data, CONFINDUSTRIA NAUTICA, 2019.
358 UN Comtrade data, 2018.

Table 7.8 Main features of the EU nautical tourism sector, 2015

Boating in European waters	Employment	Income
6 million boats	234,000 total jobs	€28 billion total revenue
36 million boaters	70,000 jobs marinas	€4 billion turnover in marinas
48 million citizens practice water sports		€6 billion turnover in charter boats

Sources: Assessment of the impact of business development improvements around nautical tourism, 2016; ECSIP Consortium, Study on the competitiveness of the recreational boating sector, 2015

Future challenges

While the industry has returned to a period of growth, challenges and risks remain. Consumer demand has started a shift from boat ownership to new sharing concepts that have positively influenced the charter sector and new business approaches (boat clubs, sharing platforms). This accompanies a move towards digitisation, with connected boats and marinas. The average age of a boat user has increased from 45 to around 55 years over the last ten years[359], which means that growing interest in boating among new generations is a key issue. Environmental sustainability and the connection of nautical tourism with a clean environment is an important area of attention. In this context, the industry is looking at new materials, end-of-life issues (dismantling, recycling, funding) and new engine types, such as electric, hybrid and hydrogen.

A key transversal concern of the industry is investment and access to finance, particularly for SMEs, although it can partially be addressed through EU research and innovation funds and EU regional funds. The sector has seen a substantial degree of harmonisation at EU level with the Recreational Craft Directive establishing requirements for recreational boats, personal watercrafts and certain components. Further harmonisation remains a crucial aspect for the future development of the industry when it comes to recognition of skipper qualifications, as well as rules for VAT of boats and berths.

Another key issue for the sector is lack of workforce and skills as well as the seasonality of jobs, which concentrate on the summer months. Initiatives moving towards decreasing seasonality can ensure a long-term stability in the sector.

7.6. THE PORTUGUESE SATELLITE ACCOUNT FOR THE SEA

Background

In May 2016, Portugal published its first *Satellite Account for the SEA* (PT SAS), for the period 2010-2013[360]. This constituted the first SAS created within the National Accounts (NA) framework in the world.

The setting up of a SAS aimed at estimating the size of the Portuguese sea economy and its production structure as well as its relative importance compared to the economy as a whole. One of the strengths of the SAS is a methodology in line with the NA concepts and methods, so that it can provide a complete, reliable, systematic and internationally comparable representation of the economy[361]. PT SAS was elaborated jointly by Statistics Portugal (INE) and the Directorate-General for Maritime Policy (DGMP) (Ministry of Sea).

The data provided by the SAS support decision and policy making related to the sea; the monitoring of the National Ocean Strategy 2013-2020 (NOS 2013 2020) in its economic component and support the Inter-Ministerial Commission for Maritime Affairs (ICMA). Moreover, SAS provides information in the context of the Integrated Maritime Policy (IMP), on the socioeconomic context of Marine Strategy Framework Directive (MSFD), as well as economic and social analysis in the core of OSPAR Convention for the Protection of the Marine Environment of the North East Atlantic. It also supports other processes where data for the Sea Economy are decisive, including for private decision-making or for awareness of the public.

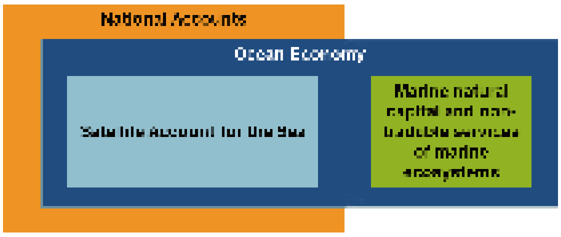
Definitions and scope

The Blue Economy (or the *Sea Economy* as it is called in the context of the PT SAS) encompasses all the economic activities that use the sea, directly or indirectly. It covers activities that are located in the maritime area as well as others located in coastal areas or in remote areas of the coast, if related to the sea (i.e. through the value chain). In other words, the activities or goods and services (products) related to the Sea Economy are those that, in the absence of the sea, would cease to exist in significant quantities, or its consumption would be significantly reduced.

[359] ECSIP Consortium, Study on the competitiveness of the recreational boating sector, 2015.
[360] See: Methodological Report — SAS PT 2010 — 2013, Press Release – SAS 2010-2013.
[361] Estimates considered the setup of a supply-use table for the 'sea economy', allowing the definition of an economic model of direct impacts and the future possibility of estimating indirect and, perhaps, induced impacts through IO analytical technics based on IO tables.

While marine natural capital and non-tradable services of marine ecosystems form part of the Sea Economy, they were not considered within the scope of the PT SAS since they are not included in the production boundary of NA as defined in ESA 2010 (Figure 7.5).

Figure 7.5 The Ocean Economy – Conceptual definition



Source: Methodological Report Portuguese SAS, DGMP.

The PT SAS is aligned with the methodological guidelines of the Portuguese NA, but also take into account the database for the IMP commissioned by Eurostat in 2009[362] and several studies carried on by the European Commission prior to the EU Blue Economy Report. Considering these references and the Portuguese reality, the PT SAS encompasses 65 products, which are grouped in activities and groups of activities (i.e. equivalent to "Sectors" in the Blue Economy Report). The information was also organised by observation level (Table 7.9).

Hence, the PT SAS encompasses nine groups of economic activities, reflected in nine value chains. Eight of them correspond to established activities (1. *Fisheries, aquaculture, processing, wholesale and retail of its products; 2. Non-living marine resources; 3. Ports, transports and logistics; 4. Recreation, sports, culture and tourism; 5. Shipbuilding, maintenance and repair; 6. Maritime equipment; 7. Infrastructures and maritime works* and *8. Maritime services*). The last group refers to *new uses and resources of the ocean*, which includes emerging activities (Table 7.9).

Methodology

The selection of the PT SAS reference population for the years 2010-2012 was based, at a starting point, in the universe of the Portuguese NA (Base 2011). The methodology[363] adopted allowed the estimation of the main macroeconomic variables measuring the size of the Sea Economy (e.g. Gross Value Added and Employment). Since SAS is in line with the European System of National and Regional Accounts (ESA) 2010[364], it uses tables system (SUT) for "sea" products was compiled. For the completion of this framework, it was necessary to calculate, by selected product, imports, exports, government consumption, private consumption, investment and intermediate consumption of the product.

The PT SAS compiles information from the following data sources: NA (SUT, Output and Intermediate consumption matrixes); government statistics; annual Survey on Industrial Production (IAPI); Household Budget Survey (HBS/IDEF); Labour Force Survey (LFS); Structural Business Statistics; Balance of Payments and International Trade Statistics and several administrative data sources. Whenever data sources allowed, SAS estimates values were obtained directly, without the use of coefficients.

Estimates for 2013 were based on a detailed study of the most relevant entities as information relating to external trade and detailed information from the definitive NA were not available.

Main results

In 2013, the economy of the Sea contributed to 3.1 % of GVA and to 3.8 % of employment in Portugal. In the period 2010-2013, the GVA generated by the Ocean Economy grew by 2.1 % in nominal terms. During this period, the relative weight of the Sea Economy in the total Portuguese output, GVA and employment increased by 0.4, 0.2 and 0.3 percentage points, respectively.

Characteristic activities represented 1.7 % of total GVA, while cross cutting activities add 0.6 % and activities favoured by the proximity of sea contributed to 0.8 %. Concerning employment, the three groups of activities represented, respectively, 2.8 %, 2.1 % and 0.7 % of the total economy. On average values (Table 7.9), *Recreation sports, culture and tourism* were responsible for 35.5 % of the GVA generated by the Sea Economy, followed by *Fisheries, aquaculture, processing, wholesale and retail of its products* (25.7 %) (Table 7.10).

There was a clear distinction in the relative importance of the different groups when analysing employment shares. The major component of employment, measured in Full Time Equivalent (FTE) was concentrated in group 1 — *Fisheries, aquaculture, processing, wholesale and retail of its products* (38.8 %), followed by group 4 — *Recreation, sports, culture and tourism* (28.6 %), group 8 –*Maritime services* (11.6 %), and group 3 — *Ports, transports and logistics* (9.4 %).

Despite the contraction in the level of private consumption in the national economy, as a result of the economic crisis that was felt in this period (a decrease of 5.4 % in GVA and 10.0 % in employment was registered during that period), private consumption in products related to the sea registered an increase of 7.3 %, on average. This highlights the resilience of the Portuguese Sea Economy.

Concerning international trade flows, exports of sea products show a continuous growth trend. Likewise, for imports, which grew at a lower rate. The trade balance of sea products registered a positive record (excl. 2010), which corresponded to a rate of coverage of imports by exports higher than 100 %.

In 2012 and 2013, international exchanges of sea products performed better than the national economy average. The highpoint was in 2013, when exports (+7.7 %) and sea imports (+1.7 %) improved their performance relative to the economy average (+1.9 %, in the case of exports, and +6 % in imports).

[362] Eurostat, 2009, Ifremer et al. "Study in the field of maritime policy — Approach towards an Integrated Maritime Policy Database".
[363] For further details, see: Methodological Report — SAS PT 2010 — 2013.
[364] European System of National and Regional Accounts (ESA 2010), Eurostat, 2013.

Table 7.9 Groups of economic activities SAS

Group	Activity	Operates in the ocean	Depends on the ocean	SAS aggregation	Area of intervention
1. Fisheries, aquaculture, processing, wholesale and retail of its products	Sea fishing	X		Characteristic	Living resources
	Inland fishing		X		
	Marine aquaculture	X			
	Inland aquaculture		X		
	Processing industry	X	X		
	Processing of fishery and aquaculture products	X	X		
	Marketing of fishery and aquaculture products		X		
2. Non-living marine resources	Research marine mineral resources	X		Characteristic	Non-living resources
	Research of conventional energy resources (oil & gas)	X			
	Sea salt extraction and refining		X		
	Exploitation of marine mineral resources	X	X		
	Operation of conventional energy resources	X	X		
	Capture and water desalination	X	X		
3. Ports, transport and logistics	Maritime freight transport	X		Characteristic	Infrastructure, uses and services activities
	Inland freight transport		X		
	Transport of passengers by ferry	X	X		
	Cruises	X	X		
	Ports and logistics	X	X		
4. Recreation, sports, culture and tourism	Boating (recreational and sport)	X	X	Characteristic	Infrastructure, uses and services activities
	Cultural activities (e.g. heritage, shows, events related to the sea)	X	X		
	Imputed rents (second homes)		X		
	Coastal tourism		X	Proximity of the sea	
5. Shipbuilding, maintenance and repair	Shipbuilding	X	X	Characteristic	Infrastructure, uses and industrial activities
	Naval maintenance and repair	X	X		
	Naval dismantling		X		
6. Maritime equipment	Machinery and marine equipment		X	Crosscutting	Infrastructure, uses and industrial activities
	Submarine cables and pipelines	X	X		
	Ocean Information Technology, Communication and Electronics (ICTE)	X	X		
	Maritime robotics	X	X		
	Other equipment (e.g. textiles, clothing, packaging)	X	X		
7. Infrastructures and maritime works	Coastal defense works	X	X	Characteristic	Infrastructure, uses and industrial activities
	Port infrastructure	X	X		
8. Maritime services	Education and R&D	X	X	Crosscutting	Infrastructure, uses and services activities
	Maritime information and communication services	X	X		
	Other services	X	X		
	Consulting and services to companies in the areas of the sea		X		
	Financing and marine insurance		X		
	Governance	X	X		Governance activities
9. New uses and resources of the ocean	Marine biotechnology	X	X	Characteristic	Living resources
	Earth observation services	X	X		Infrastructure, uses and services activities
	Unconventional energy resources (gas hydrates)	X			Non-living resources
	Marine renewables	X			
	Gas storage	X			

Notes: Some activities do not operate on the ocean but they depend on it or on the aquatic environment. Maritime equipment and maritime services encompasses transversal uses and activities to other groups.
Source: Methodological Report Portuguese SAS, DGMP.

PT SAS methodology limitations

While the PT SAS provides useful information, it also has some methodological limitations. Similarly, to the challenges encountered for estimating the EU Blue Economy, the limitations in the PT SAS derive from the satellite accounting framework itself and from country specificities and national statistical system.

First of all, the Portuguese NA framework (based on the ESA 2010), does not included in the production boundary the non-tradable services of marine ecosystems, which are therefore not included in the PT SAS. Secondly, only a small number of sea-based industries are explicitly recognised through industrial classification system and, therefore, are part of structural business statistics. Moreover, some sea-based classification codes cannot be isolated from its broad categories, since there is no specific information for it. In addition, in this context, there is always a *time lagging restriction* between the reference period and the compilation period.

With respect to the *Sea emerging activities*, despite the increasing of its relative importance, there is not a clear correspondence

Table 7.10 Main indicators by group (average values 2010-2013)

Group	**Output** (Turnover)		**Gross value added**		**Employment** (FTE)	
	€ million	%	€ million	%	Persons	%
1. Fisheries, aquaculture, processing, wholesale and retail of its products	3,347	28.9%	1,203	25.7%	62,414	38.8%
2. Non-living marine resources	204	1.8%	49	1.1%	2,333	1.5%
3. Ports, transport and logistics	2,500	21.6%	676	14.4%	15,086	9.4%
4. Recreation, sports, culture and tourism	3,337	28.8%	1,660	35.5%	45,950	28.6%
5. Shipbuilding, maintenance and repair	326	2.8%	119	2.5%	4,404	2.7%
6. Maritime equipment	547	4.7%	159	3.4%	9,028	5.6%
7. Infrastructures and maritime works	273	2.4%	65	1.4%	2,850	1.8%
8. Maritime services	1,030	8.9%	742	15.8%	18,615	11.6%
9. New uses and resources of the ocean	11	0.1%	7	0.2%	88	0.1%
Total of satellite account for the sea	**11,575**	**100.0%**	**4,680**	**100.0%**	**160,767**	**100%**
Pro memoria: National economy	*318,148*	*3.6%*	*152,425*	*3.1%*	*4,409,186*	*3.6%*

Source: DGPM, based in press release, SAS 2010-2013, Statistics Portugal.

Table 7.11 Main results of SAS and the total economy (National Accounts)

Indicator	Unit	**Level** (2013)		**Increase** (2012-2013)		**SSA/NA** (%)
		SAS	**National**	**SAS**	**National**	**2010-2013**
GVA	€ million	4,715	149,768	0.6	1.6	3.1%
Employment (FTE)	Number	157,286	4,178,797	-2.4	-2.5	3.6%
GVA/FTE	€ thousand	30.0	35.8	3.1	4.1	84.2%
Compensation of employees	€ million	3,110	76,280	0.2	1.3	3.9%
Employees (FTE)	Number	141,008	3,582,077	-2.2	-2.1	3.8%
Average compensation of employees	€ thousand	22.1	21.3	2.8	3.4	102.7%
Compensation of employees/GVA	Percent	66.0	50.9	-0.3	-0.3	127.9%
Private comsumption (households)	€ million	6,723	107,717	0.4	-0.5	5.9%
Public comsumption	€ million	802	32,501	5.1	4.2	2.5%
GFCF (products)	€ million	408	25,122	-20.6	-5.8	2.3%
Exports	€ million	1,979	67,284	7.7	6.0	3.1%
Imports	€ million	1,862	65,573	1.7	1.9	3.2%
External balance	€ million	116	1,711	0.0	0.0	3.3%

Source: Press Release, SAS 2010-2013, Statistics Portugal.

with any activity classification. There is also the question regarding the inexistence/limited data for some activities, such as R&D, whose relative importance is growing in the sea economy. As for Portugal's country characteristics, the compilation of SAS should consider NUTS I estimations regarding the specificities of the island/outermost regions of the Azores and Madeira, which might pose specific challenges.

Future developments

A new edition of the PT SAS is planned for the reference period 2016-2018; at NUTS I level in 2020, which will try to address also the insularity questions.

The new PT SAS is expected to provide more disaggregated data for *Fisheries, aquaculture, processing, wholesale and retail of its products*, regarding the split of aquaculture activities; for *Ports, transports and logistics activities*, regarding shipping industry; and Maritime Services. This will provide a better support to policy decision making and for the sectors' *stakeholders*.

The collection of new/additional data for Marine Renewables and a more detailed treatment of R&D statistics are two major aspects regarding data requirements that are being considered. Portugal also intends to develop a feasibility study regarding the compilation of an Ecosystem Services Account.

CHAPTER 8

REGIONAL ANALYSIS

This chapter is split into two main sections. The first section provides an overview of the impact of the Blue Economy in the EU at sea basin level. Building on previous editions of this report, this section now presents results for employment and GVA at sea basin level resulting from the seven Blue Economy established sectors.

The second, novel section aims at analysing the EU Blue Economy in contrast with some of its major counterparts. This year, it provides a comparison with the Blue Economy in the United States, as reported by the National Oceanic and Atmospheric Administration (NOAA). This section seeks to put the EU Blue Economy results into perspective, vis-à-vis major world actors.

8.1. SIZE OF THE BLUE ECONOMY BY SEA BASIN

Introduction and background

There is a growing need to provide economic analysis at a regional level to better understand and monitor the socioeconomic specificities of each large sea region. This can help in exploiting their particular strengths and in addressing their concrete weaknesses. Last year, the *EU Blue Economy Report* provided an overview of the EU sea basins through socioeconomic indicators such as population, GDP, GDP per capita and employment for the overall economy of those regions. This year, estimated figures are provided to show the size of the Blue Economy and its seven Established sectors in terms of employment and GVA. The regional data in this section correspond to the geographies participating in the following EU strategies:

Macro-regional strategies:

- Adriatic and Ionian Seas: EU Strategy for the Adriatic and Ionian Region – EUSAIR.
- Baltic Sea: EU Strategy for the Baltic Sea Region – EUSBSR.

Sea basin strategies[365]:

- Atlantic: Atlantic Strategy.
- Western Mediterranean: Initiative for the sustainable development of the blue economy in the western Mediterranean – WestMED.
- Black Sea: Common Maritime Agenda for the Black Sea.

A "sea basin strategy" means an integrated framework to address common marine and maritime challenges faced by Member States in a sea basin or in one or more sub-sea basins. Sea basin strategies also promote cooperation and coordination in order to achieve economic, social and territorial cohesion. These strategies are developed by the Commission in cooperation with the Member States concerned, their regions and other stakeholders as appropriate (e.g. third countries). The strategies encompass existing inter-governmental initiatives and regional bodies and move from political declarations to integrated projects and investments.

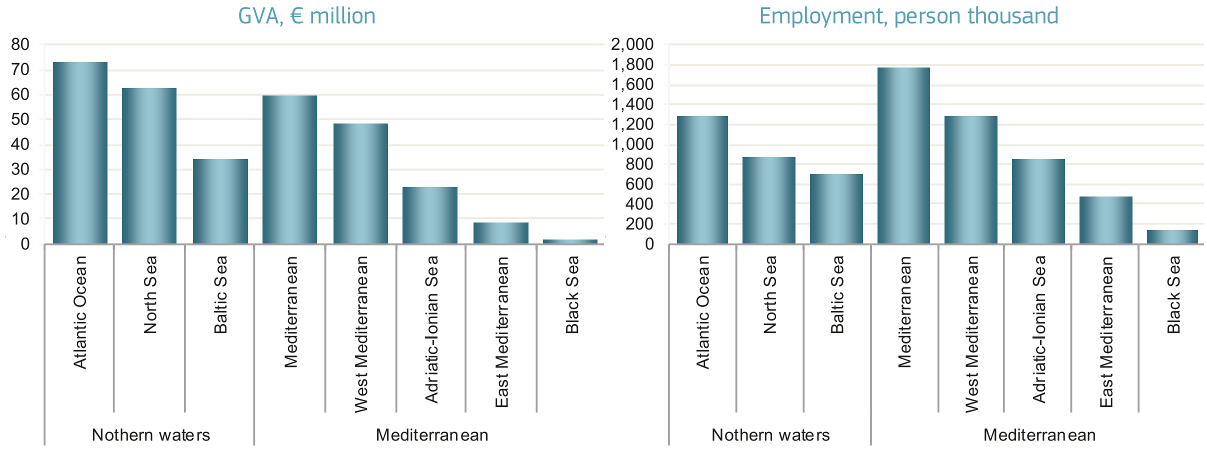
Table 8.1 Member States participating in the different sea basins

Northern Waters			Mediterranean				Black Sea
Atlantic	North Sea	Baltic Sea	Mediterranean	West MED	East MED	Adriatic-Ionian	
Strategy	*Sea basin*	*Strategy*	*Sea basin*	*Strategy*	*Sea (sub)-basin*	*Strategy*	*Sea basin*
ES	BE	DE	CY	ES	CY	EL	BG
FR	DE	DK	EL	FR	EL	HR	RO
IE	NL	EE	ES	IT		IT	
PT	UK	FI	FR	MT		SI	
UK	DK	LT	HR	PT			
	SE	LV	IT				
	FR	PL	MT				
		SE	SI				

Source: Commission Services.

[365] In the case of the Western Mediterranean and the Black Sea, the participating countries have preferred to name them respectively Initiative and Agenda; however, both have been developed as sea basin strategies.

Figure 8.1 The EU Blue Economy by sea basin, 2017



Source: Eurostat (SBS), DCF and Commission Services.

Member States may participate in several strategies (e.g. Spain, France, and Portugal participate in both the Atlantic and the West Mediterranean strategies). In turn, some strategies may cover more than one sea basin and may overlap with other strategies or sea basins (e.g. Western Mediterranean with the Atlantic).

In addition to the five strategies, data have also been collected and analysed for other sea (sub-) basins that are not concerned with any strategy, in order to provide a full picture. The North Sea, the Mediterranean and the Eastern Mediterranean are therefore also considered in this section (See Table 8.1 for the countries considered in each sea basin).

Relative size of each sea basin

In this edition of the *EU Blue Economy Report* provides estimates of the distribution of the size of the established sectors in terms of GVA and employment across sea basins. The goal is to give an indication of the relative size of each sea basin and its specialisation in terms of activities. Figures should thus not be taken as precise values but as an indication of their magnitude.

The national values of the Blue Economy and their sectors have been assigned to the corresponding sea basin and subsequently aggregated. For Member States with access to more than one sea basin, the proportion of their coastal NUTS 3 regions belonging to a given sea basin were used to estimate the size of the national Blue Economy corresponding to that sea basin. NUTS 3 proportions for GDP and employment were used for the estimation of Blue Economy GVA and employment. Further details on the methodology are explained in Annex 3.2.

In 2017, the largest sea basin in terms of GVA was the Atlantic Ocean (€73.4 billion or 36 % of the EU Blue Economy GVA), followed by the North Sea (€63.0 billion, 31 %) and the Mediterranean (€59.6 billion, 29 %). However, the size in terms of employment was inversed: 40 % of the Blue Economy employment is located in the Mediterranean (1.78 million employees), 29 % in the Atlantic Ocean (1.29 million employees) and only 20 % in the North Sea (0.87 million employees). These differences in GVA and employment are explained by the specialisation of each sea basin (see below)[366].

Table 8.2 The EU Blue Economy by sea basin, GVA, € billion

	Total Blue Economy	2009	2010	2011	2012	2013	2014	2015	2016	2017
	European Union	**189.8**	**193.5**	**188.3**	**178.9**	**182.8**	**183.6**	**193.0**	**185.5**	**205.6**
Nothern waters	**Atlantic Ocean**	33.1%	33.5%	34.8%	36.2%	36.1%	36.5%	36.1%	34.5%	35.7%
	North Sea	29.3%	29.6%	30.0%	32.4%	32.0%	31.8%	32.0%	30.2%	30.6%
	Baltic Sea	15.6%	17.0%	17.8%	17.9%	18.1%	17.9%	17.9%	16.7%	16.6%
Mediterranean	**Mediterranean**	32.7%	31.3%	29.2%	26.5%	26.5%	26.9%	27.0%	29.7%	29.0%
	West Mediterranean	23.3%	23.0%	22.6%	21.4%	21.6%	21.7%	21.9%	24.1%	23.4%
	Adriatic-Ionian Sea	14.5%	13.4%	11.2%	9.5%	9.6%	9.9%	9.9%	11.0%	11.0%
	East Mediterranean	7.5%	5.7%	4.4%	3.2%	3.5%	3.8%	3.5%	4.0%	4.2%
	Black Sea	1.3%	1.1%	1.1%	0.8%	0.8%	0.7%	0.8%	1.0%	0.8%

Source: Eurostat (SBS), DCF and Commission Services.

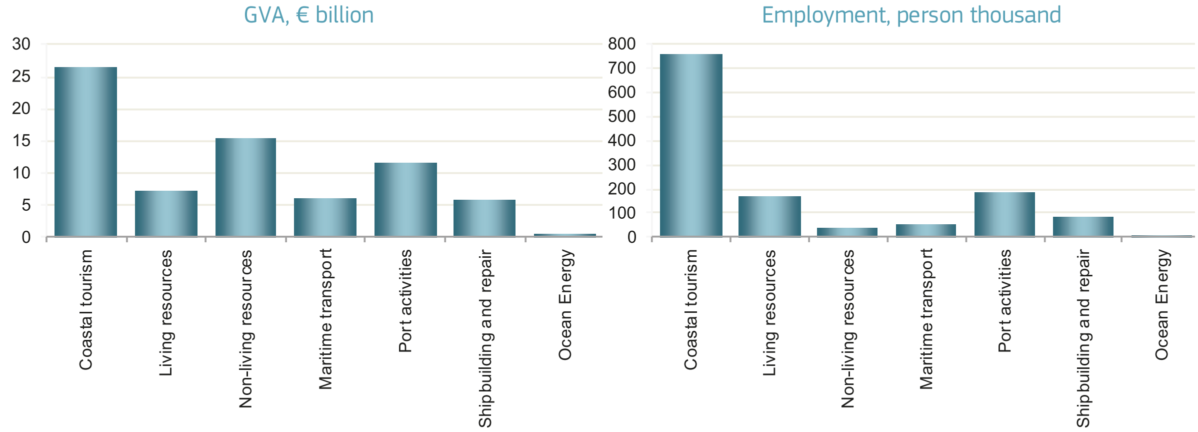
366 Additional breakdowns of the data are available at the Blue Economy Indicators webpage (https://blueindicators.ec.europa.eu/).

Table 8.3 The EU Blue Economy by sea basin, employment, person thousand

	Total Blue Economy	2009	2010	2011	2012	2013	2014	2015	2016	2017
	European Union	**4,953**	**4,673**	**4,330**	**3,991**	**4,085**	**4,072**	**4,006**	**4,294**	**4,476**
Nothern waters	Atlantic Ocean	26.1%	26.8%	28.1%	30.3%	30.6%	28.9%	28.7%	29.0%	28.7%
	North Sea	16.7%	17.8%	18.9%	20.1%	20.3%	19.9%	20.2%	20.0%	19.5%
	Baltic Sea	13.1%	14.2%	14.6%	15.9%	16.1%	16.1%	16.5%	15.7%	15.7%
Mediterranean	Mediterranean	43.0%	42.0%	39.1%	37.5%	37.2%	38.9%	38.0%	38.7%	39.7%
	West Mediterranean	28.2%	27.5%	27.2%	28.0%	27.8%	27.4%	28.2%	28.0%	28.5%
	Adriatic-Ionian Sea	21.9%	21.5%	18.6%	16.5%	16.5%	18.6%	17.3%	18.0%	19.0%
	East Mediterranean	12.4%	11.0%	9.2%	7.2%	8.1%	10.0%	8.9%	10.1%	10.7%
	Black Sea	7.5%	5.9%	6.5%	3.9%	3.6%	3.3%	3.4%	3.7%	3.1%

Source: Eurostat (SBS), DCF and Commission Services.

Figure 8.2 The **Atlantic Ocean Strategy** Blue Economy by sector, 2017



Source: Eurostat (SBS), DCF and Commission Services.

The Baltic Sea (17% of the EU Blue Economy GVA and 16% of the employment) and the Adriatic-Ionian Sea (11% of the GVA and 19% of the employment) have an intermediate size. The size of the Blue Economy in the East Mediterranean and the Black Sea is much smaller relative to the overall EU Blue Economy (Table 8.2 and Table 8.3).

In terms of evolution, the economy (for both GVA and employment) has been taking off in the Mediterranean Sea basins over the last three years, particularly in the East Mediterranean, driven by the expansion of *Coastal tourism*. On the other hand, the expansion in the Northern waters is more contained, particularly in terms of GVA; mainly due to the contraction of the *Marine Non-living resources* (see Section 5.2).

Northern waters

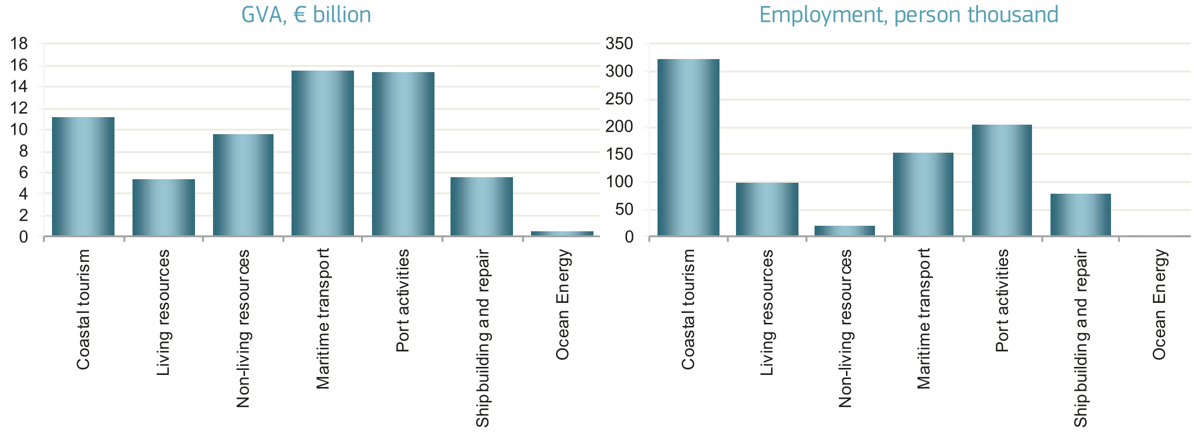
Given the size of the ports of Rotterdam, Antwerp and Hamburg and the importance of the extraction of crude oil by the UK, Denmark and the Netherlands, there is a certain degree of concentration in these sectors, in particular in terms of GVA, although *Coastal tourism* remains the main sector, at least in employment terms. This having been said, some particularities are observed in each sea basin of the Northern waters.

The Blue Economy in the **Atlantic Ocean** generated €73.4 billion of GVA and employed 1.29 million people in 2017. The GVA is generated mainly by *Coastal tourism* (€27 billion), followed by *Non-living resources* (€16 billion), *Port activities* (€12 billion) and *Living resources* (€7 billion). In terms of employment, *Coastal tourism* (0.76 million people) employs more than all the other sectors combined. *Port activities* (0.18 million people) and *Living resources* (0.17 million people) are also sectors offering significant employment opportunities (Figure 8.2).

In the **North Sea**, the importance of large ports make *Port activities* and *Maritime transport* the main sectors in terms of GVA (€15 billion in both cases) and the second and third ones in terms of employment (0.20 and 0.15 million people, respectively) behind *Coastal tourism* (0.32 million people). *Non-living resources* is also a relatively important in terms of GVA (€11 billion).

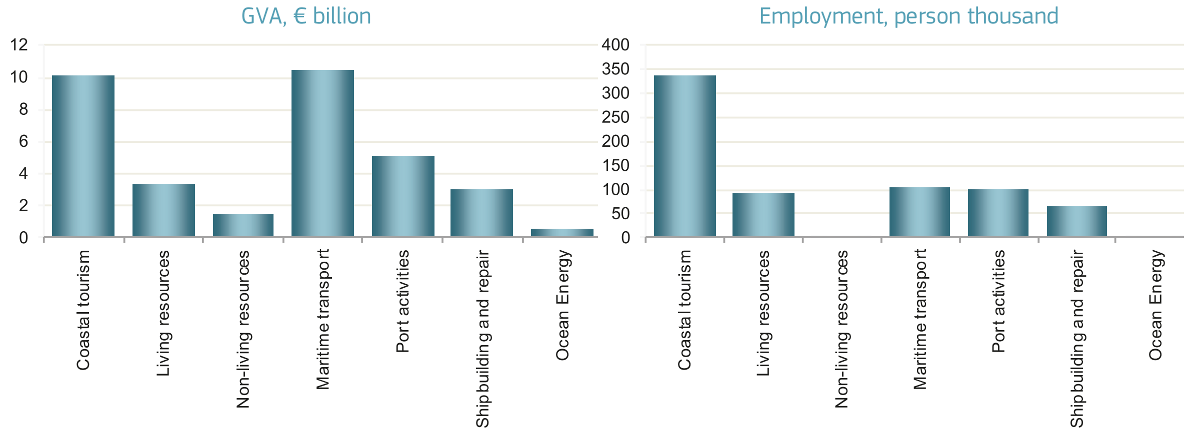
In the **Baltic Sea**, while *Coastal tourism* is also the main Blue Economy sector, a somewhat even distribution of activities can be observed. The relative importance of *Maritime transport* in terms of GVA should also be highlighted.

Figure 8.3 The **North Sea basin** Blue Economy by sector, 2017



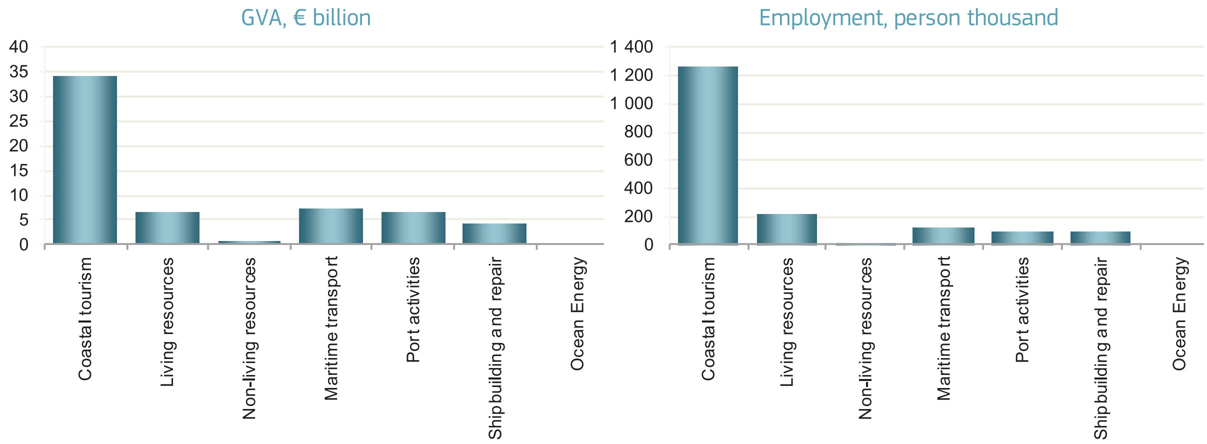
Source: Eurostat (SBS), DCF and Commission Services.

Figure 8.4 The **Baltic Sea Strategy** Blue Economy by sector, 2017



Source: Eurostat (SBS), DCF and Commission Services.

Figure 8.5 The **Mediterranean Sea basin** Blue Economy by sector, 2017



Source: Eurostat (SBS), DCF and Commission Services.

Mediterranean waters

In the **Mediterranean**, the Blue Economy generated €60 billion GVA in 2017 and 1.78 million jobs. The key sector is clearly *Coastal tourism* (€34 billion GVA and 1.26 million jobs) followed by *Maritime transport, Living resources* and *Port activities* (with €7 billion of GVA each). With small variations, this general structure is also observed across the different sub-basins.

In the **West Mediterranean**, the Blue Economy generated €48 billion GVA in 2017 and 1.28 million jobs, most of which in the *Coastal tourism* sector.

In the **Adriatic and Ionian** Region, the Blue Economy generated €23 billion GVA in 2017 and 0.85 million jobs, mainly in the *Coastal tourism* sector, followed by *Maritime transport* and *Living resources*.

In the **East Mediterranean** basin, the Blue Economy generated €9 billion GVA in 2017 and 0.48 million jobs, mainly in the *Coastal tourism* sector, followed by *Maritime transport*, *Living resources* and *Port activities*.

In the **Black Sea** basin, the Blue Economy generated €2 billion GVA in 2017 and 0.14 million jobs, mainly in the *Coastal tourism* sector, followed by *Shipbuilding and repair* and *Port activities*.

8.2. THE BLUE ECONOMY IN MAJOR COUNTRIES: THE US IN COMPARISON WITH THE EU

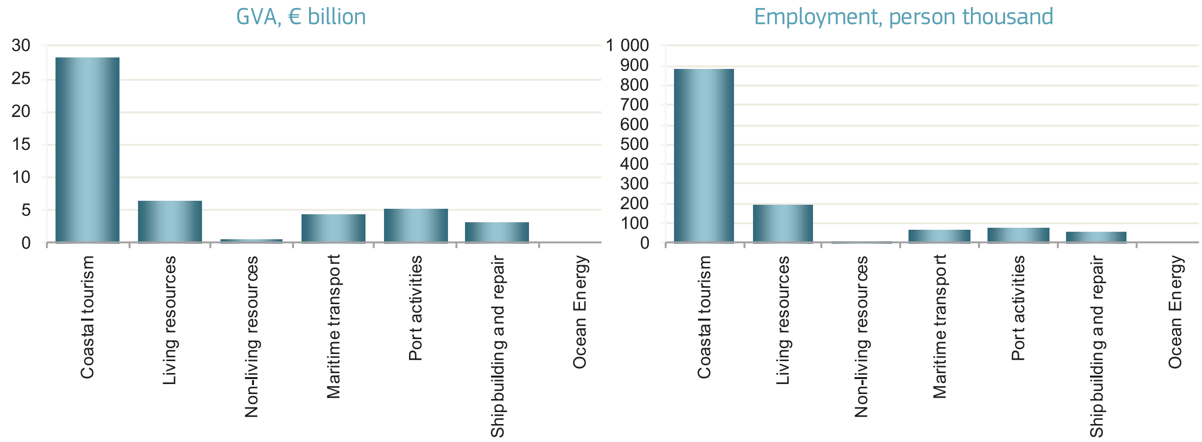
In 2019, the National Oceanic and Atmospheric Administration (NOAA) in the Unites States (US) published the "NOAA Report on the U.S. Ocean and Great Lakes Economy"[367], which comes with an additional report that breaks the data down by both sea basin and state level[368]. These reports could be somewhat seen as the equivalent to the EU Blue Economy report (BER), with the chapter on Member State Profiles and Regional Analysis one, corresponding to the additional NOAA report.

The US is likely the EU main counterpart, given that that the US is the main economy in the world and that its economic size is similar to that of the EU. It is hence worth comparing their blue economies. It is important to understand where the EU stands vis-à-vis the rest of the world but especially in contrast with major countries. Although, a comparison is a complex task when the conditions and specificities are unique to each continent, sector and activity, this analysis is meant to provide an overview of what the EU's main counterparts are doing and how the EU compares.

Scope: activities and classification

There are two key methodological differences between both reports. First, the BER only partially includes lakes, mainly because the extent (and therefore relevance) of these is minor in contrast with the US. Second, the US uses GDP at market prices as an indicator where the BER uses GVA (i.e. at factor costs). These differences can be seen as minor and do not jeopardise the comparison of the general magnitude and figures, especially since the sectors and activities presented in both reports are close to identical.

Figure 8.6 The **West Mediterranean Strategy** Blue Economy by sector, 2017

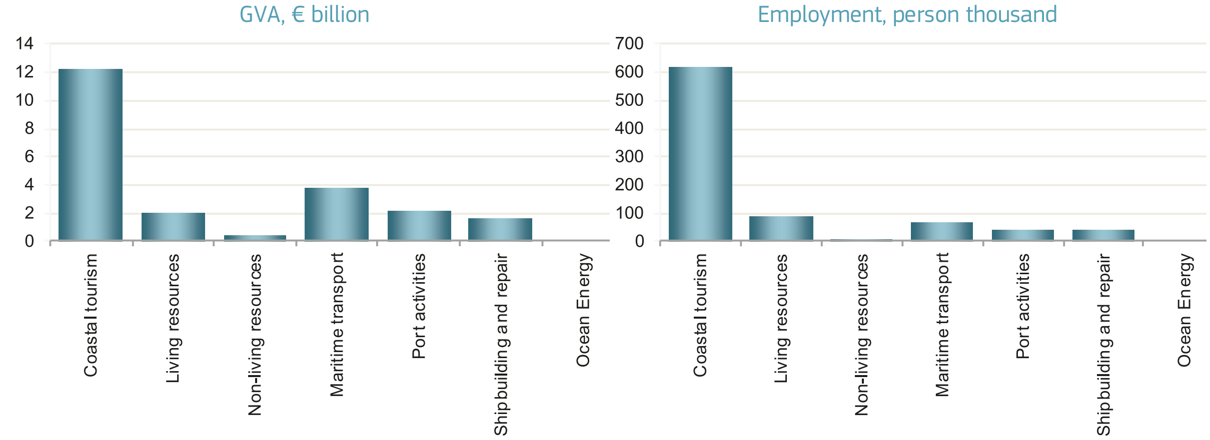


Source: Eurostat (SBS), DCF and Commission Services.

[367] National Oceanic and Atmospheric Administration (NOAA), Office of Coastal Management. 2019. "NOAA Report on the U.S. Ocean and Great Lakes Economy." Charleston, SC: NOAA Office for Coastal Management. Available at http://coast.noaa.gov/digitalcoast/training/econreport.html.

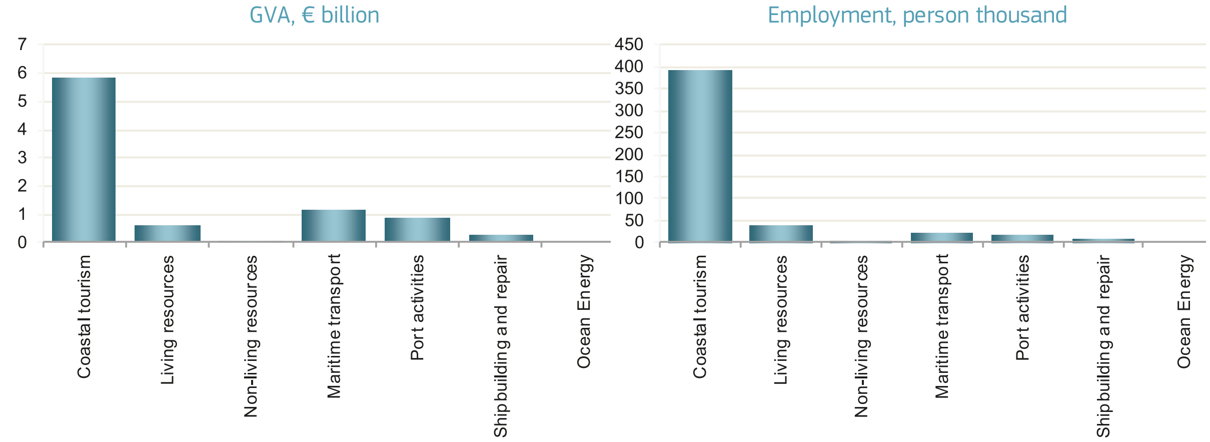
[368] National Oceanic and Atmospheric Administration (NOAA), Office of Coastal Management. 2019. "NOAA Report on the U.S. Ocean and Great Lakes Economy: Regional and State Profiles." Charleston, SC: Office for Coastal Management. Available at https://coast.noaa.gov/data/digitalcoast/pdf/econ-report-regional-state.pdf

Figure 8.7 The **Adriatic-Ionian Sea Strategy** Blue Economy by sector, 2017



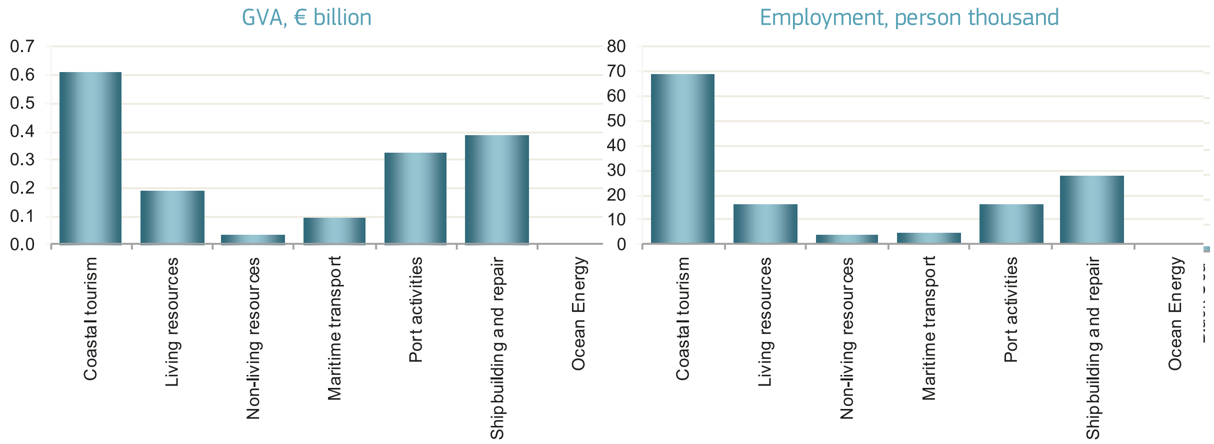
Source: Eurostat (SBS), DCF and Commission Services.

Figure 8.8 The **East Mediterranean sea basin** Blue Economy by sector, 2017



Source: Eurostat (SBS), DCF and Commission Services.

Figure 8.9 The **Black Sea basin** Blue Economy by sector, 2017



Source: Eurostat (SBS), DCF and Commission Services.

The data provided in the NOAA report are for 2016 (no time series are provided) and as such, it is compared against EU data for the same year[369].

NOAA is under the Department of Commerce hence, the publication may have a different audience and goal. Additionally, it may address sectors and activities from a distinct angle and may focus its analyses on some aspects as opposed to others. This may explain why the NOAA report provides data solely for what the BER classifies as established sectors, while the Blue Economy Report tries to analyse all sectors related to the ocean economy. The sectors included in the NOAA report, slightly differing in names to the BER, are as follows:

- Living resources.
- Ship and Boat Building machinery/equipment.
- Tourism and recreation (does not include transport as the BER does).
- Marine Transportation – (the US also includes machinery/equipment and warehousing, which are under Shipbuilding and Port activities respectively in the BER).
- Offshore mineral extraction (non-living resources).
- Marine construction[370] (This sector is not present as such in the BER; instead the activities included here are split into other sectors or not included at all).

The NOAA report does not have a sector named Port Activities (as the BER does) and activities under that sector are placed elsewhere (e.g. warehousing is included in Marine transport).

Economic performance

The indicators published in the NOAA report, aside of employment, include annual average wages, number of establishments (enterprises), and goods and services (GDP). The BER prefers to focus on Gross Value Added (GVA) and Gross Profit.

The Ocean economy in the US accounted for 1.6% of total GDP of the country, which equated to €274 billion. *Coastal tourism* is the most important figure representing 41% of all Blue Economy GDP, followed by *Non-living resources* with 26% and *Maritime transport* with 21%. *Shipbuilding and repair*, and *Living resources* contribute to the national GDP with 6% and 4% respectively.

Where the US total economy grew by 1.5% (compared to the previous year) the total Blue Economy decreased by 6.7%, with only two sectors showing a rise, i.e. *Living resources* (+42.2%) and *Coastal tourism* (+0.6%).

In contrast, the EU Blue Economy represented 1.3% of the GDP for the EU-28. The total EU economy saw a smaller increase compared to 2015 (0.7%) but the Blue Economy grew by approximately 1.6%. All sectors saw an increase of 9% or above except for the *Non-living resources* (falling by over 5%).

Table 8.4 GDP and GVA comparison between the EU and the US per established sector, 2016[371]

Sector	GDP (€ billion)	GVA (€ billion)
	US	EU
Living resources	10.2	21.0
Shipbuilding	15.8	15.3
Tourism	112.1	67.6
Maritime Transport	58.1	30.4
Non-living resources	72.3	15.6
EU Port activities	n/a	34.6
US Marine Construction	5.8	n/a
TOTAL	**274.3**	**184.6**

Source: NOAA report and Blue Economy Indicators, Commission Services.

Employment

In 2016, the Blue Economy in the US employed 3.3 million people, slightly below the 3.5 million people employed by the EU, of which over 72% work in the Coastal *tourism* sector (2.4 million), 69% in the EU (2.38 million). As with the figures for the EU, this comprises only direct activities (Table 8.5).

Table 8.5 Employment comparison between EU and US per established sector, 2016

Sector	Employment	
	US	EU
Living resources	87 869	565 320
Shipbuilding	157 913	319 440
Tourism	2.4 million	2.4 million
Maritime Transport	467 454	387 170
Non-living resources	132 008	55 320
Port activities	n/a	32 500
US Marine Construction	79 920	n/a
TOTAL	**3.3 million**	**3.5 million**

Note: the US Marine Construction sector and the EU ports activities sectors cannot be directly compared since they include different activities.
Source: NOAA report and Blue Economy Indicators, Commission Services.

Total employment in the Blue Economy is very similar in both regions, albeit slightly higher in the EU. However, when observing the breakdown by sector the figures show a different pattern. As mentioned previously, both the US and the EU see most of the Blue Economy employment in the *Coastal tourism* sector and similarities can also be observed for *Maritime transport*, where the US employs around 80000 more people.

Nevertheless, the clearest differences appear in the *Living* and *Non-living resources* sectors. The former employs over half a million people in the EU, whereas in the US it employs less than 90000, i.e. 15% of the EU figures. With the *Non-living resources* sector it is the other way around, the US employs over double the figures seen in the EU. This perhaps indicates where the different priorities and market needs and demands lie in the two regions. Another explanation is that as previously indicated, the same sectors in both regions may not include the same sub-sectors and

369 The UK is included in the data as was a full MS for the period of analyses.
370 Under the NOAA report, this sector includes heavy construction sub-sector/activities associated with: dredging navigation channels, beach re-nourishment and dock building.
371 US salaries have been converted into Euros using the average currency exchange rate (1.106) for the year of analysis (2016), as provided by European Central Bank (ECB): https://www.ecb.europa.eu/stats/policy_and_exchange_rates/euro_reference_exchange_rates/html/eurofxref-graph-usd.en.html

activities and therefore, the number of personnel move from one to the other. This is the case with warehousing, which NOAA places under *Maritime transport* and the BER under *Port activities*.

It is complex to compare wages between the US and the EU not only due to the currency exchange but because overall, salaries in the US tend to be higher as the cost of living is also higher. As with the EU, figures will vary from State to State and from one sector to another. However, the differences between the two are significant, for instance, the average salary for the *Living resources* in the US is €40 700 whereas in the EU it is slightly over half of that (€21 200)[372]. Likewise, the average salary for the *Shipbuilding* sector, in the US is €60 600, almost 40% above what it is in the EU (€37 000). What can be observed though is that the lowest salaries in both regions are found in the same sectors i.e. *Coastal tourism* (where the salaries for both are close) and *Living resources* and that the highest ones can be found in N*on-living resources* and *Maritime transport*.

Table 8.6 US-EU comparison for average yearly salaries in the BE established sectors[373], 2016

Sector	Average Annual wages in €	
	US	EU
Living resources	40 700	21 200
Shipbuilding	60 600	37 000
Coastal Tourism	22 600	18 100
Maritime Transport	63 300	43 300
Non-living resources	138 300	108 300

Source: NOAA report and Blue Economy Indicators, Commission Services.

Conclusions

The fact that NOAA is producing an Ocean economy report is in itself a clear sign of the increasing importance that is being given by policy-makers and stakeholders to having accurate and comparable data on the Blue Economy. As for the Blue Economy's contribution to the national economy the US and EU are not too far apart, even if slightly higher in the former. The growth observed by the Blue Economy sector however, was superior in the EU for that specific year.

Overall, employment created by the Blue Economy in both regions is almost the same and in both cases, *Coastal tourism* is the largest contributor. The difference in average Blue Economy wages is considerable, showing higher figures in the US. Nonetheless, these figures must be contextualised, as living costs are generally higher in the US than the EU with but a few exceptions.

Key differences for employment are clear in the *Living* and *Non-living resources*, where the EU employs over six times as many people in the former, but less than half the staff for the latter instead. This in turn might have an impact on the salaries, since the *Non-living resources* tends to pay greater wages, as these jobs usually require higher qualifications (in the form of engineering degrees or similar).

372 Blue Economy Indicators (BEI): https://blueindicators.ec.europa.eu/

373 US salaries have been converted into Euros using the average currency exchange rate (1.106) for the year of analysis (2016), as provided by European Central Bank (ECB): https://www.ecb.europa.eu/stats/policy_and_exchange_rates/euro_reference_exchange_rates/html/eurofxref-graph-usd.en.html

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