European Commission

THE EU BLUE ECONOMY REPORT 2024

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FOREWORD

Welcome to the seventh edition of the EU Blue Economy Report!

After the challenges from the 2022 significant spikes in energy prices, 2023 has marked a shift towards regaining pre-pandemic growth momentum. Despite the ongoing uncertainties from recent geopolitical events, such as the conflicts in the Middle East and the continued Russian invasion of Ukraine, the decline in energy prices in 2023 helped soften some of the negative effects from the previous year. This reduction in energy costs has contributed to a more positive outlook for the Blue Economy.

The year 2023 marked a significant milestone for the European Union in advancing its sustainability agenda. The European Commission made notable steps in its 'Fit for 55' policy package aimed at reducing the EU's carbon footprint, adopting key initiatives like the FuelEU Maritime Regulation and the extension of the EU Emissions Trading System (EU ETS) to the maritime sector as of January 2024. In 2023, the European Commission also adopted its Ocean and fisheries package, establishing the Energy Transition Partnership in EU fisheries and aquaculture.

In this year's edition, you will find a comprehensive overview of the latest trends in the EU's Blue Economy sectors, providing sector-specific, socio-economic knowledge to support informed decisions by policy-makers, Blue Economy operators and stakeholders. Moreover, the report remains the cornerstone of the Blue Economy activities in the EU by showing a picture of the challenges and opportunities faced by all sectors, as well as the main drivers to attain its potential, based on the most recent available data. The evidence contained in this report emphasises the need for a sustainable approach, adaptation to climate change, and integration of marine ecosystem services in the management of our marine resources, with a focus on nature-based solutions and sustainable blue growth.

A key sector highlighted in the report is ocean energy, which has experienced significant growth in recent years. I firmly believe that by adopting innovative technologies and harnessing the immense potential of ocean energy, we can create a future where the Blue Economy prospers while preserving the environment, and enabling other human activities at sea, such as fishing. The EU is a leader in developing energy from waves, tides, and offshore wind, with the goal of integrating these renewable sources into the broader energy landscape to meet its renewable energy targets and climate objectives.

The European Commission's latest communication, 'Delivering on the EU Offshore Renewable Energy Ambitions', outlines an ambitious plan to boost offshore wind capacity, nearly doubling the targets set in the 2020 Offshore Renewable Energy Strategy. These initiatives demonstrate the EU's strong commitment to advancing renewable energy and reducing its reliance on fossil fuels.

As the EU moves forward on its path toward a sustainable future, I believe this report will be an essential guide, illustrating the EU's commitment to fostering a resilient Blue Economy, while addressing global environmental and climate challenges.

I encourage you to plunge into the findings and recommendations presented in this report and to work with us as we champion a sustainable and thriving Blue Economy in the European Union.

Enjoy diving into the dynamic world of the EU Blue Economy!

Virginijus Sinkevičius,
EU Commissioner for Environment, Oceans and Fisheries

FOREWORD

The year 2023 was turbulent, with various global shocks impacting the European Union (EU). These events have also had, and will continue to have, impact on the Blue Economy – a sustainable use of ocean and sea to benefit our economies and societies. The 2024 edition of the EU Blue Economy Report, which I am pleased to present, maps these developments.

Under this flagship initiative the European Commission monitors coastal, marine, and ocean-related economic activities. The initiative harnesses and processes available knowledge to promote a sustainable Blue Economy, which is important to our prosperity and competitiveness. In this report, we explore the dynamics of the close interconnectedness between geopolitical, environmental and socio-economic systems.

Past editions of the report have made this collaborative effort a key resource for policymakers and stakeholders. The report supports the sustainable development of oceans and coastal resources, and the implementation of policies and initiatives under the European Green Deal. And this despite the challenge posed by the persistent lack of detailed and comparable data for all sectors at EU level.

The 2024 edition of the EU Blue Economy Report analyses the socio-economic evolution, trends and drivers of both established and emerging sectors of the Blue Economy. It examines the progress the EU has made in its energy transition. It also investigates the potential impacts of coastal floods on ecosystem services and assesses economic resilience along the EU's coastline.

Complementing this report is the EU Blue Economy Observatory, our online knowledge gateway that provides regular updates on the performance of the Blue Economy by sector, activity and country. The Observatory offers a detailed overview of all Blue Economy sectors, highlighting their potential for economic growth, job creation and the transition to sustainability.

The EU Blue Economy Report and Observatory demonstrate the Commission's dedication to fostering a sustainable, competitive, fair and thriving ocean economy. These resources are the result of a significant effort and commitment of our teams. I am confident that the 2024 edition of the report will serve as a source of inspiration for policymakers, stakeholders and investors.

Iliana Ivanova,
EU Commissioner for Innovation, Research, Culture, Education and Youth

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EXECUTIVE SUMMARY

The **seventh edition of the EU Blue Economy Report**, presented in a fresh format, persists in thoroughly examining the scale and breadth of the Blue Economy within the European Union (EU). Its primary aim remains to offer guidance to policymakers and stakeholders in fostering the sustainable advancement of oceans and coastal resources, aligning closely with the principles of the European Green Deal (EGD). By providing economic insights, the Report also aims to inspire potential investors.

This seventh edition of the Report focuses on a summarised data analysis, trends and drivers of the **Blue Economy sectors**. The analysis of the sectors *Marine living and non-living resources*, *Marine renewable energy* (offshore wind), *Port activities*, *Shipbuilding and repair*, *Maritime transport* and *Coastal tourism* is based on data collected by the European Commission from EU Member States and the European Statistical System. Specifically, fisheries and aquaculture data were collected under the EU Data Collection Framework (DCF); data for the other sectors are taken from Eurostat Structural Business Statistics (SBS), PRODCOM, National Accounts and tourism statistics. Along with these sectors, the reader can find relevant information on innovative Blue Economy sectors, namely *Desalination* and *Blue biotechnology*. These sectors offer significant potential for economic growth, sustainability transition, as well as employment creation. Comparable data are not yet fully available in the public domain, and therefore data presented in the Report for these sectors come from various sources.

This year's Report also includes special sections on **Energy Transition and Climate Change** in the EU Maritime transport sector, on the EU fishing fleet and the partnership in fisheries and aquaculture, as well as a section on **Coastal flood impacts** due to climate change along the EU27 coastline, with a particular reference to the EU Outermost Regions.

This edition will continue taking advantage of the **EU Blue Economy Observatory** platform, which provides more timely and regular updates of the Blue Economy data per sector, EU-27 Member State and sea basin. Further analysis will be published throughout the year, as the most recent data become available, and sectors or topics gain more relevance. Analyses are given for the EU-27 as a whole and by sector and industry for each Member State. An initial regional analysis is also envisaged, to be completed within the EU Blue Economy Observatory.

The detailed methodology followed in this report is explained in the EU Blue Economy Observatory website[1].

According to the most recent figures, the established sectors of the EU Blue Economy directly employed close to 3.59 million people and generated around €623.6 billion in turnover and €171.1 billion in gross value added (Table 1).

Table 1 EU Blue Economy established sectors, main indicators, 2021

Indicator	EU Blue Economy 2021
Turnover	€623.6 billion
Gross value added	€171.1 billion
Gross profit	€76.4 billion
Employment	3.59 million
Net investment in tangible goods	€6.75 billion
Net investment ratio	8.8%
Average annual salary	€26 400

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 Gross Value Added.

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

These figures offer an **underestimated** picture of the full socio-economic value of the EU Blue Economy, as they refer to seven sectors for which accurate and comparable data are available at EU level, namely: *Marine living resources*, *Marine non-living resources*, *Marine renewable energy*, *Port activities*, *Shipbuilding and repair*, *Maritime transport* and *Coastal tourism*. Besides these sectors, the Blue Economy encompasses other marine-based and marine-related activities, including emerging and innovative sectors, for which a comprehensive analysis is more challenging due to the paucity of data. The inclusion of all economic activities with a maritime component, together with indirect and induced effects alongside the various supply chains, would significantly increase the above-mentioned figures.

Among the various sectors, two are particularly noteworthy. With gross profits valued at €9.7 billion in 2021, ***Marine living resources***, saw a 24%-rise compared to 2020. On the other hand, ***Marine renewable energy*** – mainly offshore wind – also experienced significant growth, resulting in a 45%-increase compared to 2020, with gross profits estimated at €2.4 billion and Gross Value Added (GVA) at €3.3 billion in 2021. Despite a substantial rebound, overall the EU Blue Economy in 2021 still lagged behind its pre-pandemic value, primarily due to the incomplete recovery of Coastal tourism, with travel restrictions still being in place in several EU Member States.

Within the EU-27, **five Member States** account for 70% of the entire EU Blue Economy's GVA: Germany, France, Spain, Italy, and the Netherlands, in that sequence. In terms of employment, the top 5 Member States are respectively Spain, Germany, Greece, France, and Italy, representing a combined contribution of 67% of total jobs in the EU-27 Blue Economy. The Blue Economy's contribution to national economies varies significantly across EU countries, ranging from 6% in Croatia to 0.1% in Luxembourg.

The transition towards a sustainable Blue Economy, called for by the EGD, is generating new business opportunities, for example in the development of clean technologies and fuels, which can contribute to meeting the ambitious EU decarbonisation targets. The ongoing **energy transition** has already produced important results in terms of fuel intensity and efficiency, both in *Maritime transport* and in *Fisheries and aquaculture*. For example, fuel

[1] https://blue-economy-observatory.ec.europa.eu/methodology-estimation-established-sectors-data_en

consumption and CO_2 emissions of the EU fishing fleet decreased by 25% between 2009 and 2021. However, in the last few years fuel efficiency has worsened, due to rising fuel prices. According to the Scientific, Technical and Economic Committee for Fisheries (STECF) , the small-scale coastal fleet is generally more resilient to high-fuel prices, than the large-scale fleet.

Fisheries and coastal communities are also particularly vulnerable to climate change. Economic **damages from coastal flooding** in the EU-27, which currently amount to €1 billion annually, are projected to rise sharply in the coming years due to global warming. Without an increase in current levels of coastal protection, annual damages are projected to escalate to between €137 billion and €814 billion by 2100, depending on the emissions and mitigation scenarios pursued.

CHAPTER 1

GENERAL OVERVIEW AND ECONOMIC CONTEXT

This chapter describes the general context and the relevant background information in which economic data presented in this Report should be interpreted, as well as a high-level overview of the established sectors.

1.1. GENERAL ECONOMIC CONTEXT

Unlike the strong rebound experienced in 2021 and 2022 following the recession triggered by the COVID-19 outbreak, in 2023 the Gross Domestic Product (GDP) of the EU-27 expanded by just 0.5%[2]. Nevertheless, employment rates reached record levels in the first half of 2023, with unemployment remaining close to its record low. The severity of labour shortages is gradually easing but is still significant.

The conflicts in the Middle East and the Russian invasion of Ukraine have had an impact on the EU economy and the Blue Economy sectors, affecting energy prices, altering shipping routes due to trade restrictions, and causing bottlenecks in the supply chain. The escalation in energy prices since late 2021, compounded by the Russian invasion of Ukraine in 2022, resulted in marine diesel prices doubling from 2021 to 2022. These effects – and in particular the high prices of marine diesel – have severely impacted fisheries, resulting in an overall loss for the sector in 2022.

The sharp fall in energy prices in 2023 has alleviated these impacts, leading to a faster-than-expected moderation of price pressures. Despite mild upward pressure from higher shipping costs, inflation – which, according to Eurostat, has decelerated from 6.9% in March 2023 to 2.4% in March 2024 – continues on a steady downward trend. As inflation decelerates, real wage growth and resilient employment support a rebound in households' purchasing power and consumption. Combined with a higher level of investment, this conjunction has resulted in an EU growth outlook of 0.9% in 2024 and 1.7% in 2025. Employment growth in the EU is set to ease from 1.0% in 2023 to 0.4% in both 2024 and 2025[3]. The unemployment rate is expected to remain broadly stable over the forecast horizon.

In this economic context, the EU Blue Economy sectors, and particularly *Marine living resources*, *Coastal tourism* and *Maritime transport* initiated a gradual recovery in 2023 which continues in 2024.

In conclusion, the economic forecast for the EU-27 in 2024 and 2025 presents a mixed outlook. While the annual growth projections have been revised downward, the pace of growth is expected to stabilise broadly in line with potential as of the second half of 2024 and into 2025. However, geopolitical tensions and trade disruptions pose risks to the economic outlook, particularly in energy prices, shipping, and supply chains. Despite these challenges, the forecast also highlights the potential for economic stabilisation and recovery, supported by resilient employment and declining inflation.

1.2. THE EU BLUE ECONOMY

There are many different views and definitions of what the Blue Economy is. Deciding what sectors it should include exactly is a challenge in itself, given the difficulty of delineating the extent of coastal, marine and ocean-related activities, and their direct and indirect socio-economic benefits and environmental impacts. These challenges are exacerbated by the paucity of data for certain maritime sectors and the lack of comparability between Member States' data. To address this latter challenge, we use the latest SBS data published by Eurostat, which at the time of writing this Report cover the period 2009 - 2021.

A delineation of the Blue Economy largely depends on the sectors included, and the extent to which indirect upstream and downstream effects can be identified and measured. Hence, deciding what sectors and activities to include when analysing the current state and size of the Blue Economy is an important first step.

For the purposes of this Report, and with a view to being consistent with its previous editions published since 2018, the term Blue Economy includes economic activities that are:

(a) marine-based, including those undertaken in the ocean, sea and coastal areas, such as capture fisheries and aquaculture, offshore oil and gas, offshore wind energy, ocean energy, desalination, shipping and maritime transport, and marine and coastal tourism; and

(b) marine-related activities which use products and/or produce products and services for the ocean and marine-based activities; for example, seafood processing, marine biotechnology, shipbuilding and repair, port activities, maritime communication, maritime equipment, maritime insurance and maritime surveillance.

Yet, the Blue Economy also includes those parts of the public sector with direct coastal and ocean responsibilities (national defence, the coast guard, marine environmental protection, etc.), as well as marine education and research. The ocean also has economic value that is not easy to quantify, in terms of habitats for marine life, carbon sequestration, coastal protection, waste recycling and storing, and processes that influence climate and biodiversity. New, emerging and innovative activities are also developing rapidly, such as blue biotechnology. These activities also need to be included and measured to comprehensively assess the Blue Economy. This work is being undertaken in the context of the EU Blue Economy Observatory[4], launched in May 2022. More detailed analysis per sector will be added there, keeping this publication as a succinct Report.

1.3. OVERVIEW OF THE EU BLUE ECONOMY SECTORS

Out of all economic sectors related to the Blue Economy, seven sectors can be considered 'established' in accordance with the terminology used in previous editions of this report. These sectors – for which more complete, accurate and comparable data are usually available than for other Blue Economy sectors – are defined in this report as: *Marine living resources*, *Marine non-living resources*, *Marine renewable energy*, *Port activities*, *Shipbuilding and repair*, *Maritime transport* and *Coastal tourism*. Each of these sectors is further divided into sub-sectors as summarised in Table 2. These sub-sectors, in turn, consist of several economic activities.

[2] https://economy-finance.ec.europa.eu/document/download/2b7b7fae-0844-4dd1-bedd-619c3544aaed_en?filename=ip268_en_0.pdf
[3] *Ibid.*
[4] https://blue-economy-observatory.ec.europa.eu/index_en

Table 2 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
	Support activities
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

The analyses contained in this Report are based on Eurostat's SBS data for all the above-mentioned sectors, with the exception of the primary sector[5] activities within *Marine living resources*, which are based on data originating from the DCF[6]. In addition, data from the Tourism Expenditure Survey and from the EU Tourism Satellite Accounts were used for the *Coastal tourism* sector.

In addition to these established sectors, the 2024 Blue Economy Report also analyses *Marine renewable energy* – which also includes other ocean energy sources besides offshore wind – *Desalination* and *Blue biotechnology* – which includes algae production and processing, otherwise not included under *Marine living resources*. For these three sectors, fewer comprehensive and comparable data are available, partly because they are not fully captured by the statistical classification of economic activities due to their emerging character.

The Report provides indicators of the socio-economic performance of the EU Blue Economy sectors and their contribution to the EU economy as a whole in terms of turnover, value added, operating surplus, and employment (Figure 2 and Figure 3). Although only the direct contribution of the Blue Economy sectors is considered here, all activities may have indirect and induced effects on the rest of the economy. For example, in *Shipbuilding and repair* a significant proportion of the sector's value added is generated by activities upstream and downstream the industry supply chain. This implies that, besides its direct contribution to the economy reflected in this Report, the Blue Economy may have important multiplier effects on income and jobs in many other strands of the economy.

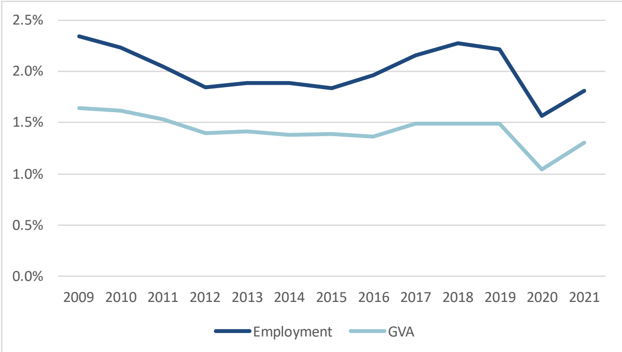
The direct GVA of the Blue Economy established sectors was **€171.1 billion** in **2021**, contributing **1.3%** to the EU-27 economy – a 35%-increase from **€126.6 billion** (**1.0%** of the EU-27 economy) in **2020**. Despite this significant post-pandemic recovery, the 2021 GVA did not yet match its 2019 value of **€186.8 billion**.

Turnover in the EU Blue Economy increased 21% from **€513.2 billion in 2020** to **€623.6 billion in 2021**.

Gross operating surplus (profit) at **€76.4 billion in 2021** was **73%** higher compared to **2020**.

Employment increased 17% from **3.07 million persons in 2020** to **3.59 million in 2021**; **1.8%** in terms of contribution to the EU-27 economy (Figure 1)[7].

Figure 1 Contribution to the Blue Economy to the overall EU economy in terms of GVA and employment

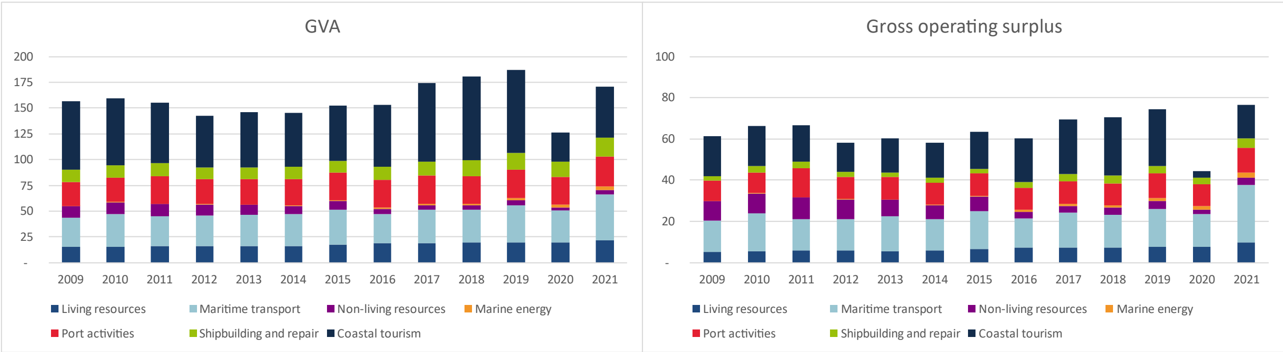


It is interesting to note that the growth of *Marine renewable energy*, *Shipbuilding and repair* and *Marine living resources* sectors has been greater than the average Blue Economy.

The 2021 figures, the latest available in Eurostat, show the impact generated by the COVID-19 pandemic in 2020 and the recovery the EU Blue Economy had in 2021. In particular, *Coastal tourism* was still the most impacted sector with a 64%-decrease in GVA and a 48%-decrease in employment in 2020. In 2021, the sector had not yet fully recovered, despite GVA and employment increased respectively by 74% and 33%. Similarly, *Marine non-living resources* had not yet reached its pre-pandemic level, but it should be noted that the sector has been suffering an important disinvestment in recent years, in line with the EGD policies towards a carbon neutral and sustainable EU economy. *Marine non-living resources* and *Maritime transport* had caught up with 2019 in terms of employment, but not in terms of GVA.

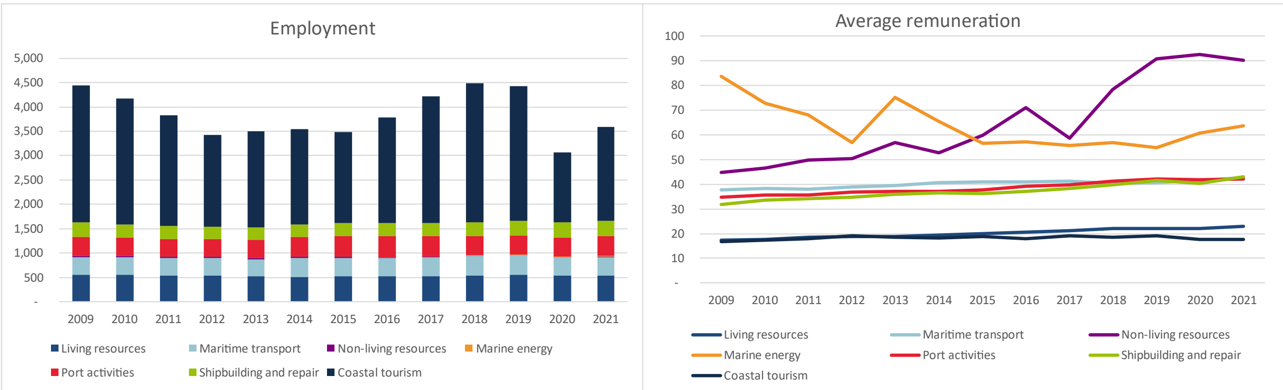
[5] Capture fisheries and aquaculture.
[6] https://stecf.jrc.ec.europa.eu/reports/dcf-dcr.
[7] Data on the Blue Economy extracted from the Blue Economy Indicators (In-depth Analytical Tool). All economic magnitudes are expressed in nominal prices.

Figure 2 GVA and gross operating surplus (€ billion) in the EU Blue Economy



Source: Own calculations based on Eurostat (SBS) and DCF data

Figure 3 Employment (thousand people) and gross remuneration per employee (€ thousand) in the EU Blue Economy



Source: Own calculations based on Eurostat (SBS) and DCF data

Despite the decrease compared with 2019, ***Coastal tourism* keeps generating the largest share of employment and GVA in the EU Blue Economy**, with 54% and 29%, respectively, followed by *Maritime transport* with 11% and 26%, *Port activities* with 11% and 17%, *Marine living resources* with 15% and 13% and *Shipbuilding and repair* with 9% and 11%. *Marine renewable energy* generated 0.4% of employment and 2% of GVA, while *Marine non-living resources* contributed 0.2% and 2% respectively (Table 3).

It should be noted that ***Marine renewable energy*** is the fastest-growing sector in relative terms, and probably one of the fastest-growing in the EU economy as a whole. The turnover of this sector grew from €91 million of turnover in 2009 to €3.4 billion in 2021 in nominal terms.

Gross remuneration per employee for the EU Blue Economy established sectors has increased steadily since 2009. Average gross remuneration per employee is lowest in *Coastal tourism* and *Marine living resources*, whereas it is highest in *Marine non-living resources* and *Marine renewable energy*.

Marine non-living resources and *Marine renewable energy* have diverging **employment trends**, with *Marine renewable energy* being a relatively new sector characterised by high growth, and *Marine non-living resource* , notably the oil and gas sub-sector, experiencing decline, particularly due to the EU's efforts to mitigate carbon emissions.

Table 3 Overview of the EU Blue Economy by sector

Persons employed (thousands)	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Marine living resources	556.5	555.1	536.1	536.7	520.7	518.5	521.7	529.6	525.2	539.9	550.8	539.4	543.1
Marine non-living resources	34.4	31.6	29.8	30.4	27.7	28.1	27.5	17.9	12.5	11.1	10.1	9.4	8.8
Marine renewable energy	0.4	0.6	0.9	1	1.2	1.7	4	5.1	7	8.3	10.6	12.3	14.3
Port activities	383.5	374.4	361.4	369.4	365.6	405.3	415.9	420.1	417.7	387.2	384.7	387.7	409.7
Shipbuilding and repair	306.8	274.7	263.4	255.5	256.6	258.8	264.1	269.2	274.8	292.8	299.1	305.5	311.8
Maritime transport	358	355	363.7	356.8	356.9	376.4	383.7	368.1	385.2	398.7	403.7	372.1	379.3
Coastal tourism	2 804.7	2 584.8	2 275.4	1 880.1	1 970.4	1 956.6	1 867.4	2 167.0	2 595.2	2 855.5	2 763.7	1 447.4	1 922.6
Blue Economy GVA	4 444.3	4 176.3	3 830.9	3 429.9	3 499.2	3 545.5	3 484.2	3 777.3	4 217.6	4 493.5	4 422.5	3 073.7	3 589.7
National employment	189 682	186 911	186 928	186 213	185 475	187 671	189 703	192 579	195 571	197 687	199 678	196 599	198 039
Blue Economy contribution (%)	2.3%	2.2%	2.0%	1.8%	1.9%	1.9%	1.8%	2.0%	2.2%	2.3%	2.2%	1.6%	1.8%

GVA (€ million)	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Marine living resources	15 080	15 602	16 168	16 221	15 772	16 220	17 218	18 521	18 566	19 510	19 560	19 512	21 959
Marine non-living resources	11 190	11 325	11 935	11 237	9 684	8 215	8 431	4 723	3 940	4 291	4 704	2 839	4 161
Marine renewable energy	91	167	220	254	358	443	784	1 122	1 486	1 592	2 104	2 406	3 339
Port activities	23 262	23 442	26 936	24 018	24 313	25 553	26 492	27 271	27 490	26 638	27 996	27 000	29 485
Shipbuilding and repair	11 674	12 217	12 153	11 349	11 464	12 016	11 670	12 790	13 938	15 149	16 050	14 869	18 017
Maritime transport	28 684	31 775	28 879	29 190	30 820	30 556	34 247	28 859	32 803	31 894	36 015	31 285	44 282
Coastal tourism	66 365	64 696	58 858	50 288	53 280	52 539	53 360	59 812	75 793	81 564	80 377	28 646	49 824
Blue Economy GVA	156 346	159 225	155 150	142 558	145 692	145 542	152 202	153 098	174 015	180 639	186 807	126 557	171 068
National employment	9 536 725	9 853 561	10 150 676	10 211 496	10 319 572	10 555 777	10 939 171	11 227 692	11 689 958	12 096 090	12 535 780	12 106 022	13 098 801
Blue Economy contribution (%)	1.6%	1.6%	1.5%	1.4%	1.4%	1.4%	1.4%	1.4%	1.5%	1.5%	1.5%	1.0%	1.3%

Source: Own calculations based on Eurostat (SBS) and DCF data

1.4. THE BLUE ECONOMY SECTORS ACROSS MEMBER STATES

Generally speaking, the four largest Member States, namely Germany, Spain, Italy and France, also happen to be the largest contributors to the EU Blue Economy established sectors, accounting together for 61% of GVA and 55% of employment. However, Greece ranks third in terms of employment, contributing 12% of the EU's Blue Economy jobs, after Spain and Germany, though it only generates 4% of the EU's Blue Economy GVA.

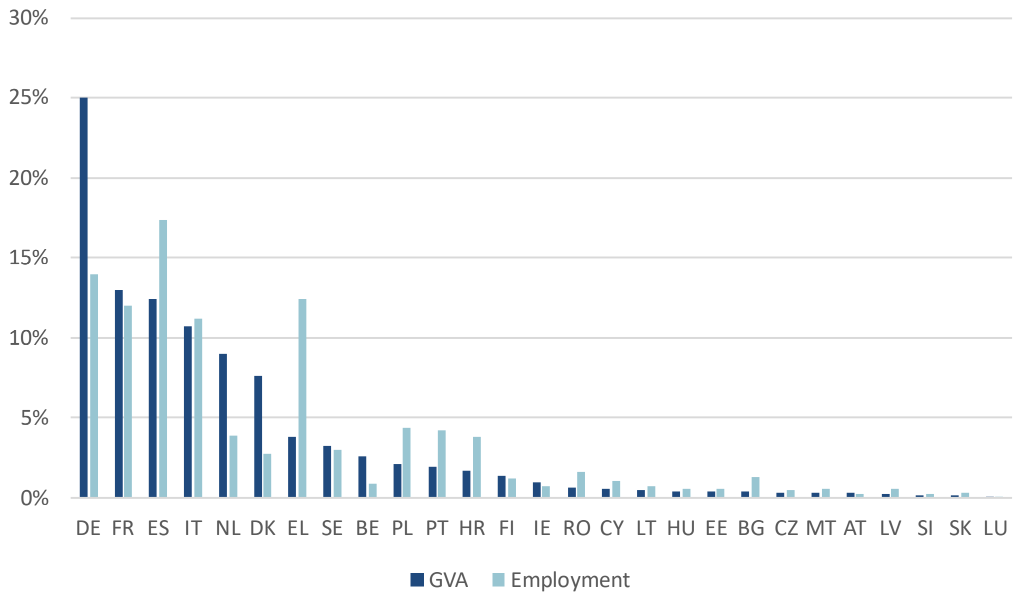
In 2021, the Blue Economy established sectors contributed 1.8% in terms of employment and 1.3% in terms of GVA to the overall EU economy, a decrease compared with 2019, when the same sectors contributed 2.2% of employment and 1.5% of GVA. The downward trend can be attributed to the harsh impact of the COVID-19 pandemic on *Coastal tourism,* which stands as the largest sector within the EU Blue Economy. This sector has a tendency to grow more rapidly than other sectors during periods of economic expansion, but also experiences sharper contractions during crises. Consequently, its performance has had a significant impact on the overall trajectory of the Blue Economy, leading to faster growth and contraction compared to the EU economy as a whole.

At the same time, it should be noted that the proportion of the Blue Economy within the entire EU economy would be higher when including in the analysis all the other emerging or innovative sectors, for which comparable data for all EU countries is, however, scarce.

The contribution of the Blue Economy to national economies varies widely across Member States (Figure 4). In terms of employment, shares range from 1% in Greece to 0.2% in Austria. When it comes to GVA, the range extends from 6% in Croatia to 0.1% in Luxembourg (Figure 5).

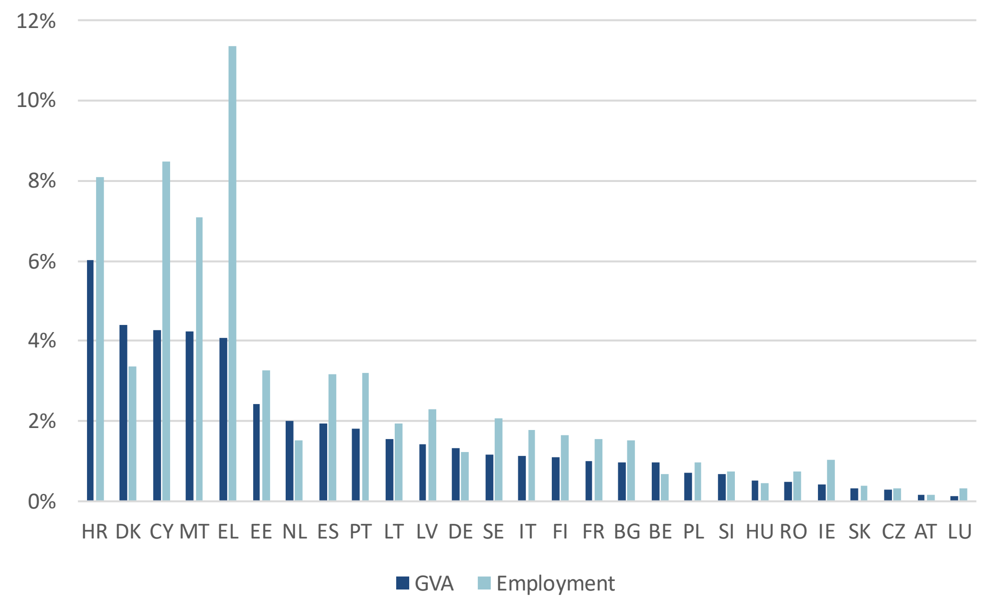
In general, the Blue Economy is a more significant contributor to the national GVA and employment in the insular Member States or those with archipelagos: Croatia, Denmark, Cyprus, Malta, Greece, and Portugal.

Figure 4 National contribution to the EU Blue Economy, percentage (EU27 = 100%) in terms of employment and GVA, 2021



Source: Own calculations based on Eurostat (SBS) and DCF data

Figure 5 Relative size of the Blue Economy, as share (percentage) of blue jobs and GVA in the national economy, 2021



Source: Own calculations based on Eurostat (SBS) and DCF data

1.5. OUTLOOK

The EU Blue Economy is poised for growth over the coming years, driven by the transition to a sustainable and circular economy, the ambitious net zero climate targets, and a focus on innovation and research.

As consumers become more conscious of the environmental impact of their choices, there is a growing emphasis on sustainable practices in all Blue Economy sectors, particularly *Marine living resources*, *Maritime transport* and *Port activities*. There is also an increasing focus on pursuing and deploying renewable energy sources, such as offshore wind, and marine biotechnology.

The ongoing energy transition is attracting public and private investments in the development and scaling up of new technologies to harness the potential of the oceans for clean energy production. The EU's focus on blue innovation, research and entrepreneurship through numerous funding and policy instruments is expected to continue to spearhead growth in the Blue Economy, leading to the creation of new jobs and economic opportunities.

The economic outlook will show variations across different Blue Economy sectors, depending on their diverse specificities, such as maturity, resource dependency and global competitiveness. ***Blue biotechnology*** and ***Desalination***, for instance, show comparatively higher growth rates.

The socio-economic performance of the Blue Economy sectors will also depend on their different reaction to endogenous and exogenous shocks. One of the main concerns is the impact of climate change and environmental degradation on the **health of marine ecosystems**. Rising sea temperatures, ocean acidification, and pollution can have detrimental effects on fisheries, aquaculture, and marine biodiversity, ultimately affecting the economic viability of these sectors. Overfishing and unsustainable fishing practices continue to pose a threat to marine resources, potentially leading to stock depletion and ecosystem damage.

Socio-economic damages from coastal flooding in the EU-27 are projected to rise sharply in the coming years due to global warming, calling for substantial investments in coastal protection, adaptation of infrastructures and nature-based solutions.

Moreover, **geopolitical tensions** could create uncertainty, hinder investment, create upward pressures on fuel and energy prices, disrupt trade and shipping routes, thereby affecting the prospects of growth of the Blue Economy. Lastly, economic downturns and global pandemics can also have a negative impact on the overall demand for Blue Economy products and services.

The EU Blue Economy grows faster than the EU overall economy in periods of economic growth, but also shrinks faster during crisis. This is explained by the fact that ***Coastal tourism***, which accounts for 54% of employment and 29% of GVA of the EU Blue Economy, is particularly vulnerable to demand-side shocks, as was the case during the COVID-19 pandemic.

Addressing these challenges will be crucial to maintaining a positive trajectory and ensuring the sustainability transition of the EU Blue Economy in the coming years. This will entail, among others, further strengthening the regulatory framework and implementing effective conservation measures. Against this backdrop, *Marine renewable energy* will continue to be key to the EU ambitions of the Offshore Renewable Energy Strategy[8] as well as to the goals of the Renewables Energy Directive[9].

More detailed information on the analysis per EU-27 Member State can be found in the EU Blue Economy Observatory.

[8] COM(2020) 741.
[9] PE/36/2023/REV/2.

CHAPTER 2

BLUE ECONOMY SECTORS

THE EU27 BLUE ECONOMY

ESTABLISHED SECTORS

2021

Source: own elaboration based on Eurostat and DCF data

Employment	GVA	Gross Operating Surplus	Turnover
3.6 million people	€171 billion	€76 billion	€624 billion

Sector	Persons employed (change)	Persons employed	GVA	GVA (change)
Living Resources	+4%	543,000 people	22 billion	+27%
Maritime Transport	-1%	379,000 people	44 billion	+29%
Non-living Resources	-68%	9,000 people	4 billion	-51%
Offshore Wind	+258%	14,000 people	3 billion	+326%
Port Activities	-1%	410,000 people	29 billion	+11%
Shipbuilding and Repair	+18%	312,000 people	18 billion	+54%
Coastal Tourism	+3%	1.9 M people	50 billion	-7%

AQUACULTURE
Production volume
1.12M TONNES

MARITIME TRANSPORT
% of waterborne transport over total transport
68% (freight)

COASTAL TOURISM
% of nights spent in coastal areas over total nights spent
48%

Percentage values refer to the **2015-21** period

EMERGING SECTORS

CUMULATIVE RENEWABLE ENERGY CAPACITY IN EUROPEAN SEA BASINS (2023)

The levelized cost of electricity (LCOE) represents the price at which the generated electricity should be sold for the system to break even at the end of its lifetime. The load factor is the percentage of power output an intermittent renewable energy source actually produces compared to its nominal capacity (i.e. the max output)

	WAVE	TIDAL	FLOATING WIND	BOTTOM-FIXED WIND
Capacity	13.3 MW	30.5 MW	207 MW	32.6 GW
LCOE	160-750 €/MWh	110-480 €/MWh	145-350 €/MWh	60-232 €/MWh

LOAD FACTOR

Source: 4COffshore, BNEF, IRENA, Ocean Energy Europe

DESALINATION ACTIVE CAPACITY (2024)

3.4 BILLION M³/YEAR

Seawater and brackish water 72%

other sources 28%

SPAIN	ITALY	GERMANY	NETHERLANDS	CYPRUS	REST OF THE EU
65%	7%	4%	4%	4%	16%
914 plants	342 plants	184 plants	79 plants	30 plants	817 plants

Source: own elaboration based on DesalData

2.1. MARINE LIVING RESOURCES

The exploitation of marine biological resources is analysed in this report in this section, as well as in *Blue biotechnology* (section 2.8).

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. While the *Blue biotechnology* sector considers the non-traditionally commercially exploited groups of marine organisms and their biomass applications.

The EU is the eighth largest producer of fishery and aquaculture products, behind China, Indonesia, India, Vietnam, Peru, the Russian Federation and the United States of America, covering around 2% of global production[10]. Overall EU production has been rather stable in the last few decades. The EU has slightly more than 54 200 active vessels landing about 3.6 million tonnes of seafood worth €6 billion in 2021[11]; while the EU aquaculture production represents about 25% of the total EU seafood production with about 1.2 million tonnes worth €4.3 billion.

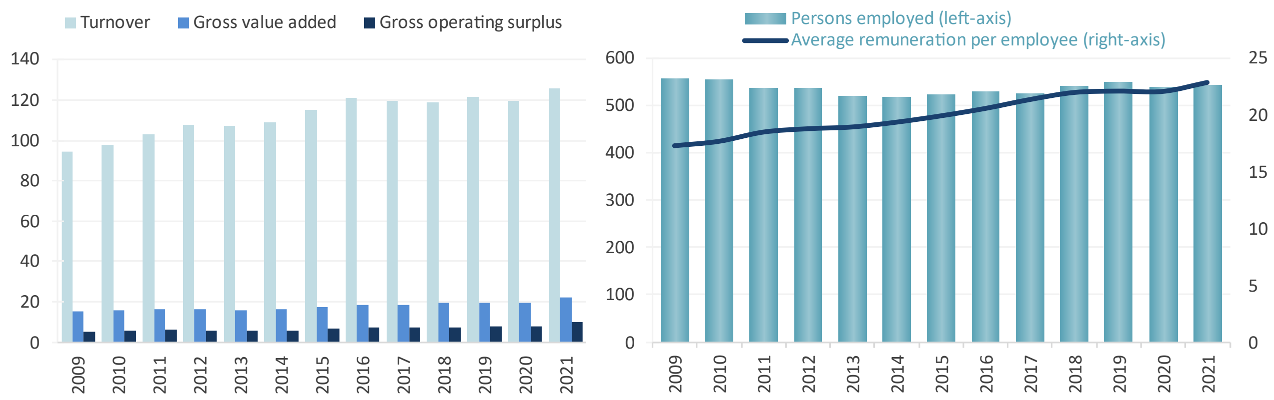
The EU *Marine living resources* sector has been heavily impacted by external factors in recent years. The Trade and Cooperation Agreement (TCA) following Brexit gradually reduces the share of EU fishing opportunities in UK waters stocks from 2021 to 2025. The COVID-19 pandemic and public health interventions depressed demand and disrupted supply chains for many fishing businesses in 2020[12]. The military invasion of Ukraine by Russia in February 2022 resulted in an increase in energy and fuel prices, as well as in general inflation, until the end of 2022[13]. Fuel prices went consistently below €1 per litre only after November 2022, allowing the primary sector to recover its economic performance from 2023. The impacts on the processing and distribution sectors have been milder as they have relied on imports to fill the gap in domestic production.

Size of the EU Marine living resources sector in 2021

The sector generated more than €22.0 billion in GVA in 2021, a 13%-increase compared to 2020. While gross profits increased by 24%, reaching €9.7 billion, the reported turnover was about €126 billion.

The sector directly employed more than 543 000 persons, a 1%-increase from 2020. The annual average wage is estimated at €22 800, a 4%-increase from 2020 (Figure 6).

Figure 6 Size of the EU *Marine living resources* sector, 2009-2021. Turnover, GVA and gross operating surplus in € billion, persons employed (thousand), and average wage (€ thousand)



Source: DCF and own calculation

Results by sub-sector and Member State

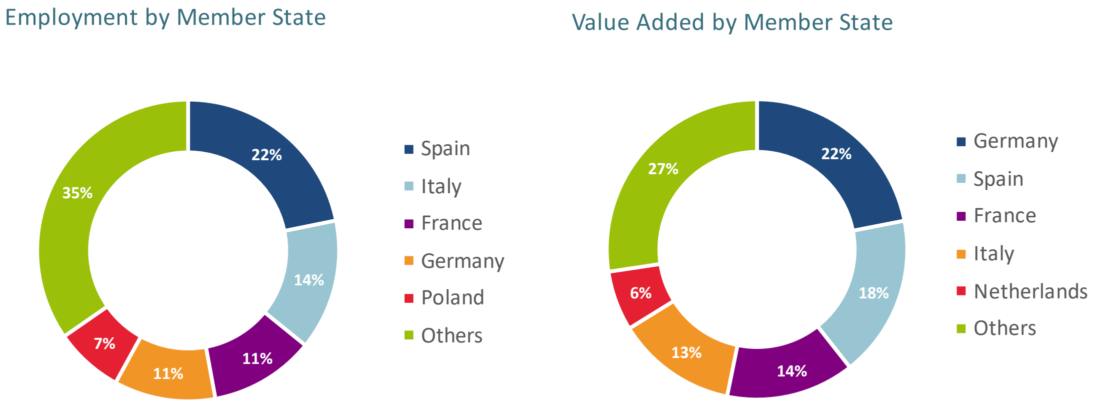
Spain leads the employment in the sector with 22% of jobs, followed by Italy with 14%, and France and Germany with 11% each. Germany generates 22% of GVA, tailed by Spain with 18%, France with 14% and Italy with 13% (Figure 7).

Employment: Distribution of fish products employed about than 211 300 persons, accounting for 39% of jobs, while Primary production employed slightly more than 200 200 persons (37%) and Processing of fish products about 131 500 persons (24%).

Gross value added: In 2021, Distribution of fish products generated €11.7 billion GVA, about 53% of the entire sector, followed by Processing of fish products with €5.8 billion (26%) and Primary production with €4.5 billion (20%).

[10] EUMOFA. 2023. The EU fish market, 2023 edition. Luxembourg: Publications Office of the European Union. doi: 10.2771/38507.
[11] STECF. 2023. The 2023 Annual Economic Report on the EU Fishing Fleet. Publications Office of the European Union, Luxembourg.
[12] Carpenter, G., Carvalho, N., Guillen, J., Prellezo, R., Villasante, S., Andersen, J. L., ... & Zhelev, K. (2023). The economic performance of the EU fishing fleet during the COVID-19 pandemic. Aquatic Living Resources, 36(2).
[13] Guillen, J., Carvalho, N., Carpenter, G., Borriello, A., & Calvo Santos, A. (2023). Economic Impact of High Fuel Prices on the EU Fishing Fleet. Sustainability, 15(18), 13660.

Figure 7 Share of employment and GVA in EU *Marine living resources* sector, 2021



Source: DCF and own calculations

Trends and drivers

Overall economic indicators in 2021 displayed an improvement compared to 2020, reaching the historical maximum. Estimates suggest that the performance of the sector will be slightly worse in 2022, due to the increase in fuel prices and inflation.

The economic performance of wild-capture fisheries and aquaculture is line with the one in 2020 and worse than in 2019. However, for fish processing, and especially distribution, performance reached its maximum in 2021, partly thanks to the increasing imports of seafood products.

In 2022, household expenditure on fishery and aquaculture products in the EU reached €62.9 billion, marking an 11%-increase from 2021. The average consumption per capita is estimated at 23.71 kg (measured in live weight equivalent) of fishery and aquaculture products in 2021, which represented a 2%-increase from 2020 [14]. Wild products, and in particular imported ones, accounted for about 70% of the EU consumption of fishery and aquaculture products consisted of wild products.

The EU's self-sufficiency is estimated to have reached its lowest level with 38.2% in 2021[15]. Self-sufficiency is the capacity of EU Member States to meet their citizens' demand for seafood from their own production. Hence, the EU is able to maintain its consumption of fishery and aquaculture products by importing them from other regions of the world.

In the EU, the fish processing industry strongly relies on imports from third countries: salmon and cod from Norway and the UK, Alaska pollock from China, shrimp from South and Central America and South-East Asia, sardine from Morocco, squid, tropical tuna, etc.

In 2022, a substantial growth of the value of extra-EU imports was reported. It could not be solely attributed to the consequences of the COVID-19 pandemic recovery, which led to sudden spikes in demand and increases in prices; it was also a consequence of lower supply contributing to an increase in prices, which was due to the effect of lower quotas for a number of species and tightened competition on raw materials. Moreover, the Russian military invasion of Ukraine heavily contributed to the rise in value, affecting energy costs, and in turn production costs. It has been estimated that every 10 cents increase in the fuel price per litre would lead to a profitability loss of around €185 million in the EU fishing fleet[16].

The Russian aggression also had a significant impact on exchange rates, which played a role in the increase in prices and overall values, affecting trade between countries on a global scale. In 2023, however, inflation was lower, whereas imports kept on tightening, resulting in more stable prices and values..

High energy prices have affected the sector. Prices of raw materials such as soy, fishmeal and oil have also been impacted by the conflict, driving up overall prices in *Marine living resources*' related industries, such as aquaculture[17].

In 2023, the Commission presented a fisheries and oceans package[18] which includes four initiatives. The main objectives of the measures are to promote the use of cleaner energy sources and reduce dependency on fossil fuels, as well as reduce the sector's impact on marine ecosystems. This package includes the Communication on the Energy Transition of the EU Fisheries and Aquaculture sector (See Section 3.2 on energy transition) with measures to improve its sustainability and resilience.

In the framework of the Communication on the Energy Transition, the Commission has released a dashboard on the EU Blue Economy Observatory[19], aimed at measuring the incremental impact of fuel prices on the economic performance of the EU fishing sector. Another key action in this area was the set-up of the Energy Transition Partnership, which was launched in 2023 and supported by a number of thematic workshops. These workshops will feed into the development of a common roadmap for the energy transition in EU fisheries and aquaculture.

Another important policy development has been the entry into force of the new EU Fisheries Control Regulation [20] . This revised EU fisheries control regulation updates most of the rules for fishing vessels to modern technology and promotes sustainability. The key

[14] EUMOFA. 2023. The EU fish market, 2023 edition. Luxembourg: Publications Office of the European Union. doi: 10.2771/38507.
[15] *Ibid.*
[16] Guillen, J., Carvalho, N., Carpenter, G., Borriello, A., & Calvo Santos, A. (2023). Economic Impact of High Fuel Prices on the EU Fishing Fleet. Sustainability, 15(18), 13660.
[17] STECF. 2023. Economic Report on the EU aquaculture (STECF-22-17). Publications Office of the European Union, Luxembourg, doi:10.2760/51391.
[18] Fisheries, aquaculture and marine ecosystems: transition to clean energy and ecosystem protection for more sustainability and resilience. Available at: https://ec.europa.eu/commission/presscorner/detail/en/IP_23_828.
[19] https://blue-economy-observatory.ec.europa.eu/fishing-fleet-fuel-analysis_en.
[20] Regulation (EU) 2023/2842 of the European Parliament and of the Council of 22 November 2023 amending Council Regulation (EC) No 1224/2009, and amending Council Regulations (EC) No 1967/2006 and (EC) No 1005/2008 and Regulations (EU) 2016/1139, (EU) 2017/2403 and (EU) 2019/473 of the European Parliament and of the Council as regards fisheries control.

changes involve enhanced monitoring of fishing activities, better traceability of catches and harmonised sanctions for rule violations. These revised rules modernise the way fishing activities are controlled for EU vessels and for non-EU vessels fishing in EU waters. They aim to prevent overfishing, create a more efficient and unified fisheries control system, and promote fairness among different sea basins and fleets.

For more information, please visit the section on *Marine Living Resources*[21] within the EU Blue Economy Observatory.

2.2. MARINE NON-LIVING RESOURCES

Marine non-living resources have been a significant sector of the EU Blue Economy for many years. Over the past decade, the mature offshore oil and gas sector has experienced a decline, following the ambitious EU decarbonisation goals and net-zero emission targets. However, there is potential for the sector to transition towards more sustainable practices, such as exploring and exploiting renewable energy sources, as well as contributing to the development and deployment of low-carbon technologies. Additionally, there is an increasing focus on oceanographic research and the extraction of raw materials from Europe's seas and oceans, which could play a crucial role in the transition to a sustainable Blue Economy. Therefore, while the traditional oil and gas sector may face challenges, there are opportunities for the industry to contribute to a more sustainable and environmentally-friendly approach to extractive activities in EU waters.

For the purpose of this report, the *Marine non-living resources* sector comprises two main subsectors:

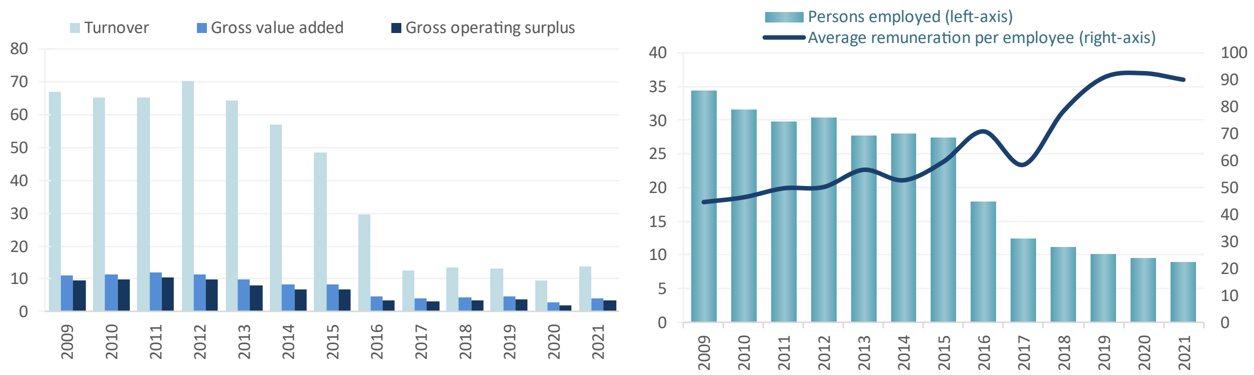
1. ***Oil and gas***: Extraction of crude petroleum, Extraction of natural gas, Support activities;
2. ***Other minerals***: Operation of gravel and sand pits; mining of clays and kaolin; it also includes extraction of salt.

Size of the EU Marine non-living resources sector in 2021

In 2021, the GVA generated by the sector amounted to €4.1 billion, up from €2.8 billion of the year before. This 46.5%-increase, boosted by a similar year-on-year increase in turnover (+44.4%) – totalling €13.6 billion in 2021 – is a clear effect of the sharp increase in fuel prices following the COVID-19 pandemic. The good performance of the sector in 2021 is further testified by a 49.2%-increase in profits, which reached €3.5 billion, up from €1.9 billion in 2020.

Nevertheless, the oil and gas extractive sector has kept shrinking, as testified by the continuous decrease in employment, which followed on the downward trend registered since 2009. In 2021, the *Marine non-living resources* sector employed more than 8 800 persons, i.e. nearly 600 less than in 2020 (slightly more than 9 400). The average annual remuneration per employee also decreased from €92 500 to €90 100 (-2.6%) (Figure 8).

Figure 8 Size of the EU *Marine non-living resources* sector, 2009-2021. Turnover, GVA ad gross operating surplus in € million, persons employed (thousand), and average wage (€ thousand)



Source: Eurostat (SBS) and own calculations.

Notwithstanding the 2021 rebound, as can be seen in the graph above, the sector's turnover fell sharply between 2012 and 2017, and then stabilised between €10 and €13 billion, mainly because of fuel price dynamics. The sector's workforce has been steadily declining since 2009, with only minor exceptions in 2012 and 2014. In 2021, the *Marine non-living resources* sector accounted for 9% of jobs, 4% of GVA and 3% of profits of the entire EU Blue Economy.

Results by sub-sector and Member State

Denmark, Netherlands, Romania and Italy (in this order) lead the *Marine non-living resources* sector, employing 84% of the workforce. However, the Netherlands and Denmark together produce by far the largest share of the sector's GVA (80%), followed by Italy (15%) (Figure 9).

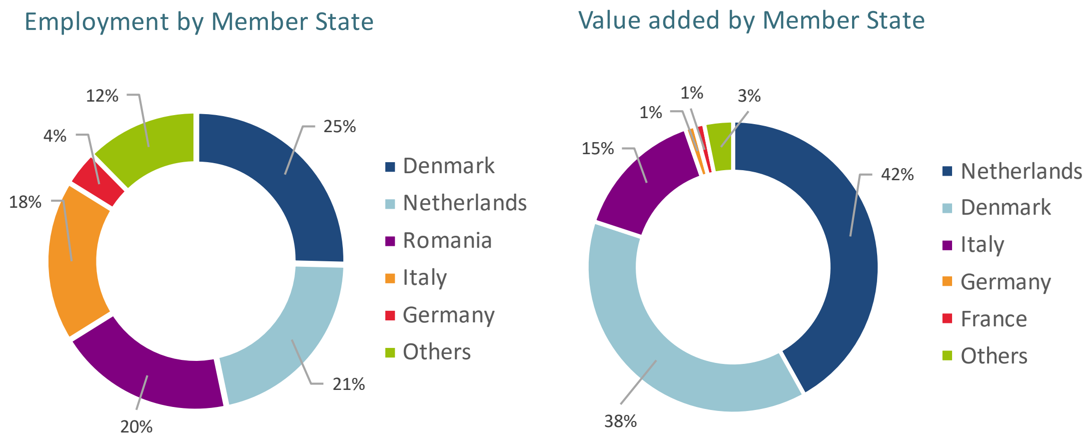
Employment: The EU *Marine non-living resources* sector employed less than 9 000 Full Time Equivalent (FTE) in 2021, compared to 34 300 in 2009. The industry is among the most affected by the transition to sustainability in the energy sector, hence the strong decline in workforce in line with global trends[22]. Despite its steady contraction, the oil & gas sub-sector still employed 84% of the total

[21] https://blue-economy-observatory.ec.europa.eu/eu-blue-economy-sectors/marine-living-resources_en
[22] ILO 2022. The future of work in the oil and gas industry.

workforce, whereas the remaining 16% was employed in extraction of other minerals.

Gross value added: In 2021, the EU *Marine non-living resources* sector generated €4.1 billion GVA, marking a 46.5%-increase from 2020, mainly driven by rising fuel prices. The largest increase was registered in the oil & gas sub-sector – 99% of the year-on-year increase.

Figure 9 Share of employment and GVA in the EU *Marine non-living resources* sector, 2021



Source: Eurostat (SBS) and own calculations.

Trends and drivers

The ongoing declining trend in EU oil and gas production persists, as highlighted in previous Blue Economy Reports[23]. This decline can be attributed to various factors[24]:

Production costs are rising due to the more expensive exploitation of deeper offshore fields and the use of non-conventional exploitation techniques – like fracking or tar sands. This is partly due to installations reaching their optimal design life of 25 years, which could be extended, but with rising operational costs[25]. It is estimated that over 200 platforms and 2 500 wells will be in decommission phase by 2025 in the North Sea, the EU's main oil and gas production area[26]. While costs are increasing, final prices are restrained to levels that ensure access to consumers and enterprises, limiting the adaptability of the industry and the need for alternative fuel sources[27].

On the demand side, **consumption** is being reduced due to the implementation of the 'EU Fit for 55' package[28], which prioritises the adoption of cleaner energy sources, as well as the REPowerEU measures, aimed at reducing energy dependence on Russia[29]. Also, the transport industry, on which this sector heavily relies, is shifting towards greener solutions, which will further reduce demand over the coming years, in alignment with the International Maritime Organisation (IMO) strategy to reduce maritime transport emissions to net-zero by around 2050[30].

On the supply side, there is **intra-sectorial competition** as oil-based fuels are being substituted partly by liquefied natural gas (LNG), which has reduced greenhouse gas emissions. The process involves liquefying natural gas at temperatures of -169ºC in dedicated facilities within the exporting nation. Subsequently, it is transported via tanker vessels, and later stored, degasified for integration into the gas network, or utilised as a fuel source. Additionally traditional fuels are gradually replaced by newer, greener alternatives like e-methanol, e-ammonia, or biofuels[25]. Furthermore, the sector is reliant on transport routes plagued by instability, like Russian pipelines or the Red Sea[31].

The prevailing trends in the sector are influenced by the repercussions of the Russian aggression against Ukraine and the subsequent sanctions imposed by the EU in response. The Russian decision to curtail or halt gas supply to European nations resulted in gas prices surging to unprecedented levels during the winter of 2022 (see Figure 10).

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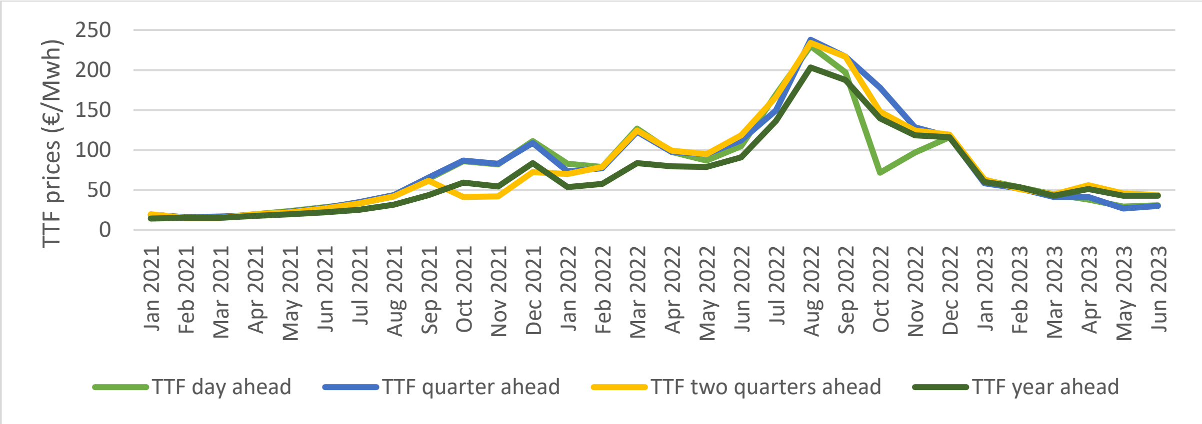
[23] EU Blue Economy Report 2023.
[24] Marine Investment for the Blue Economy (MARIBE), WP 4: Socio-economic trends and EU policy in offshore Economy, https://maritime-spatial-planning.ec.europa.eu/media/12257.
[25] https://maritime-spatial-planning.ec.europa.eu/sector-information/oil-and-gas#1.
[26] RAE 2013, Decommissioning in the North Sea, https://raeng.org.uk/media/b0ebnlfo/raeng_offshore_decommissioning_report.pdf.
[27] Marine Investment for the Blue Economy (MARIBE), WP 4: Socio-economic trends and EU policy in offshore Economy, https://maritime-spatial-planning.ec.europa.eu/media/12257.
[28] https://www.consilium.europa.eu/en/policies/green-deal/fit-for-55-the-eu-plan-for-a-green-transition/.
[29] https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/european-green-deal/repowereu-affordable-secure-and-sustainable-energy-europe_es.
[30] IMO, https://www.imo.org/en/MediaCentre/HotTopics/Pages/Cutting-GHG-emissions.aspx.
[31] S&P Global 2024, https://www.spglobal.com/commodityinsights/en/market-insights/latest-news/oil/011724-european-oil-product-imports-fall-20-in-jan-on-red-sea-turmoil-cas.

Figure 10 Gas prices in the EU, TTF (Title Transfer Facility) index day-ahead (spot) prices compared to TTF quarter-ahead, two quarters-ahead and year-ahead prices



Source: European Commission, Market Observatory for Energy, DG Energy, own elaboration[32].

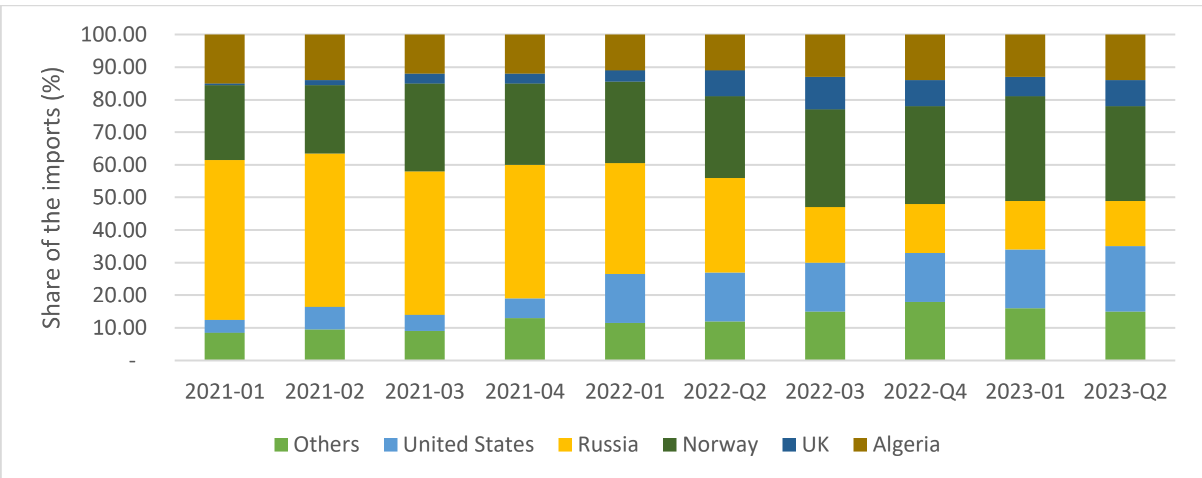
In response to the energy crisis, the EU has implemented measures focused on diminishing consumption, diversifying energy sources and reducing dependency on imports from specific countries[33]. In this process, LNG emerged as a main solution facilitating the import of natural gas from countries lacking a direct pipeline connection. Notably, between 2021 and 2023, LNG imports within the EU experienced a noteworthy surge, escalating from 20% to 40% of total gas imports[34]. This strategic shift has significant maritime implications, as the substitution of Russian pipeline gas is facilitated by the transport of LNG via ships and the use of maritime pipelines connecting with Norway and North African countries – the Mediterranean Hub. In addition to Norway and Algeria, other sources of increasing gas imports in the EU since 2021 are the US and the UK (Figure 11).

Particularly significant has been the rise in imports from the US, increasing from 7% to 20% of the overall gas imports and reaching 50% of the EU's total LNG imports[35, 36]. This presents both challenges and opportunities for the EU gas production industry. While introducing a greater volume of gas and new competitors without direct pipeline, it fosters greater diversification of EU gas supply.

Other important trends to be highlighted in the sectors include the rising trend of oil prices in the beginning of 2024, coming from the relative stability during the second semester of 2023. This results from halts in exports from OPEC countries, like the instability in the Red Sea – forcing tankers to avoid the Suez Canal in favour of the longer Cape of Good Hope – and an extreme Artic winter freeze in oil-producing North American regions[37]

For more information visit the section on *Marine non-living resources* within the EU Blue Economy Observatory.

Figure 11 Quarterly share of gas imports in the EU, combining both pipeline and LNG imports



Source: European Commission, Market Observatory for Energy, DG Energy, based on Quarterly Reports on European Gas Markets Q1 2022 to Q2 2023, own elaboration[38]

[32] Quarterly Reports on European Gas Markets Q1 2022 to Q2 2023, Market Observatory for Energy, DG Energy, https://energy.ec.europa.eu/data-and-analysis/market-analysis_en#gas-market---recent-developments.
[33] https://energy.ec.europa.eu/topics/energy-security/diversification-gas-supply-sources-and-routes_en.
[34] https://energy.ec.europa.eu/data-and-analysis/market-analysis_en#gas-market---recent-developments
[35] *Ibid.*
[36] https://www.consilium.europa.eu/en/infographics/eu-gas-supply/.
[37] ": IEA Oil Market Report - February 2024 https://www.iea.org/reports/oil-market-report-february-2024.
[38] https://energy.ec.europa.eu/data-and-analysis/market-analysis_en#gas-mar

2.3. MARINE RENEWABLE ENERGY

Marine renewable energy includes both **offshore wind energy** and **ocean energy**, two green energy resources that are key to the EU's ambitions to decarbonise its energy sector.
The most established marine energy sector is the **offshore wind** industry, where bottom-fixed offshore technology still represents the majority of projects, but there is a trend towards floating offshore technologies. **Ocean energy** is a promising sector, where the EU has shown a leading role in technology development.

Offshore wind energy

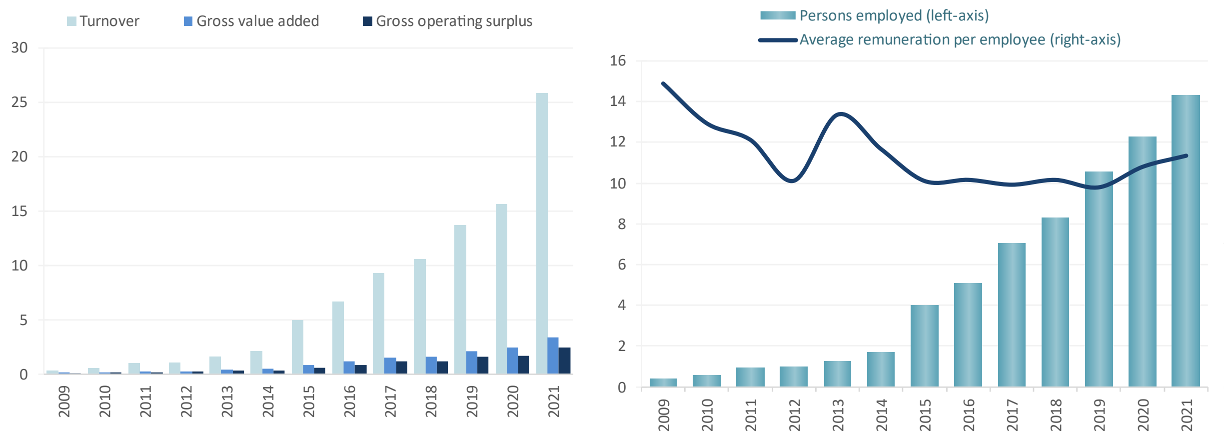
Offshore wind energy is currently the only commercial deployed marine renewable energy with wide-scale adoption. From only a small number of demonstration plants[39] in the early 1990s, the EU now hosts a cumulative capacity of 17.8 GW of offshore wind, spread across 11 Member States[40]. In late 2023, 993 MW of new capacity were added to the grid (provisional data). In addition, several projects of common/mutual energy infrastructure interest highlight investment on offshore wind capacity in various Member States[41].

By 2050, all of the 22 non-land locked Member States are projected to have varying levels of offshore wind capacity, with offshore wind representing over 30% of total wind capacity in 11 Member States (Malta (88%), Netherlands (59%), Finland (55%), Denmark (48%), Poland (48%), Germany (44%), Ireland (36%), Latvia (34%), Belgium (34%), Sweden (33%) and Estonia (33%), according to PRIMES's model reference scenario projections[42].

Based on Eurostat data on (exclusively) production and transmission, the sector generated more than €3.3 billion in GVA in 2021, a 39%-increase compared to 2020. Gross profits accounted for €2.4 billion, up 45% from 2020; and the reported turnover was about €25.9 billion, up 65% from 2020.

The sector directly employed 14 300 persons, up from less than 400 persons in 2009. Personnel costs totalled €912 million. The average annual wage, estimated at €63 800, is almost 24% lower compared to 2009 (€83 800) (Figure 12).

Figure 12 Size of the EU offshore wind sector, 2009-2021: Turnover, GVA ad gross operating surplus in € million (left) and persons employed (thousand), and average wage in € thousand (right)



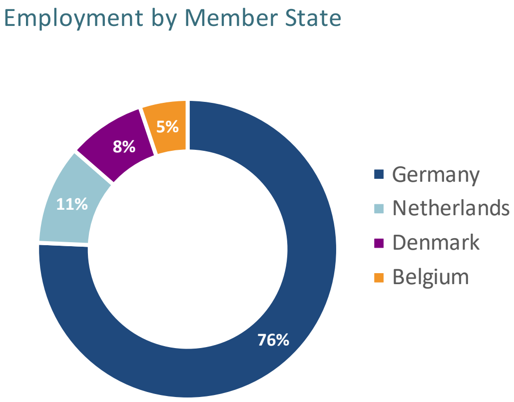
Source: Eurostat (SBS) and own calculations

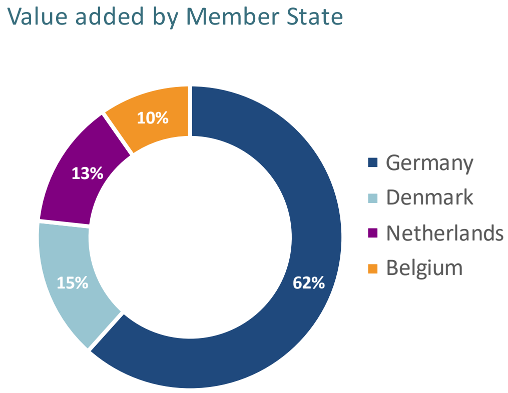
Results by sub-sector and Member State

Germany currently leads in offshore wind energy with 76% of jobs and 62% of GVA, followed by the Netherlands and Denmark. The sector is undergoing major expansion (Figure 13).

[39] The first offshore wind farm (Vindeby) was installed in Denmark in 1991 and decommissioned in 2017, after 25 years of useful life.
[40] JRC analysis based on GWEC (2023) and 4C OFFSHORE (2023) WIND FARMS DATABASE.
[41] See Commission Delegated Regulation (EU) 2024/1041 of 28 November 2023 https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=OJ:L_202401041#d1e173-1-1
[42] European Commissionc, Directorate-General for Climate Action, Directorate-General for Energy, Directorate-General for Mobility and Transport, De Vita A, Capros P, Paroussos L, Fragkiadakis K, Karkatsoulis P, HöglundIsaksson L et al. EU reference scenario 2020 : energy, transport and GHG emissions : trends to 2050. Publications Office; 2021, doi: 10.2833/35750

Figure 13 Share of employment (left) and GVA in EU offshore wind sector (right) in 2021





Source: Eurostat (SBS) and own calculation

WindEurope has calculated direct jobs in the European (EU and UK) offshore wind sector[43]. These numbers incorporate different activities along the supply chain – as opposed to those presented by Eurostat, which only include production and transmission – such as developers, turbine and substructure manufacturers, and service providers, for the years 2011 to 2019[44] (Figure 16).

Figure 14 Size of the EU offshore wind sector, 2011-2019: Persons directly employed in the EU offshore wind energy sector (thousand)

Source: Own elaboration based on WindEurope (2020)[45]

Trends and drivers

Over the past 15 years, offshore wind energy has surged with advancements in turbine technology, expanded site availability, and reduced costs. Europe's offshore wind sector has drawn from onshore wind experiences, addressing grid issues and employing competitive tendering. It is integral to Europe's carbon-neutrality goals, with plans to deploy 60 GW by 2030 and 300 GW by 2050, as outlined in the European Commission's Offshore Renewable Energy Strategy. The revised Renewables Energy Directive aims for 42.5% renewables by 2030, accelerating permit procedures. Regional offshore wind roadmaps aim for 111 GW by 2030, increasing to 317 GW by 2050. The EU has developed into a global leader in offshore wind, exporting equipment and expertise worldwide. By the end of 2023, the cumulative installed capacity reached 17.8 GW for offshore wind in the EU, with an increase of 993 MW in the last year. After a peak in deployments in 2020, the relative slow-down in EU waters since 2021 is partly due to the delays faced by offshore wind companies, due to, amongst others, supply chain disruptions and permitting delays.

[43] It is assumed that the EU to UK share of employment are determined by the ratio of offshore wind installed capacity. Due to the assumption, this calculation may still underestimate EU employment.
[44] WindEurope, 'Wind energy and economic recovery in Europe – How wind energy will put communities at the heart of the green recovery', 2020.
[45] *Ibid.*

The Levelised Cost of Electricity (LCOE) of bottom-fixed offshore wind energy has decreased with larger offshore wind energy deployment. For 2023, BNEF reports LCOEs for offshore wind of 60-110 €/MWh in Denmark, 62-132 €/MWh in Germany, 66-125 €/MWh in the Netherlands, 82-160 €/MWh in Poland and 155-232 €/MWh in France[46].

Floating wind energy, an emerging sector within offshore wind, is steadily advancing toward commercial viability, offering deployment in deeper waters compared to fixed-bottom turbines. This is particularly attractive for Member States with deep-water seas (>50m) that have limited conventional offshore wind development. Various floating structure technologies are in use, including semi-submersible and spar-buoy (Technology Readiness Level TRL 8-9), concrete barge (TRL 7-8) and tension-leg platform (TRL 6). Current floating wind energy projects in the EU account for 29 MW of installed capacity[47]. National ambitions to further develop the floating wind sector are evident, with multiple auctions planned in France, Spain, Italy, Portugal and Greece, and installed capacity is expected to grow towards 3 GW by 2030 and 11 GW by 2035-2040.

The LCOE of floating wind is currently higher than that of bottom-fixed wind, and with multiple floating technologies still in development, the LCOE is also more project-dependent. For the years 2020-2023, a global range of LCOE was identified between 145 €/MWh (Hywind Tampen project in Norway) and 350 €/MWh (Fuyao project in China), with WindFloat Atlantic in Portugal at an intermediate LCOE of 240 €/MWh[48].

Ocean energy

In addition to the offshore wind industry, **ocean energy** technologies offer a complementary option for developing marine energy production. Ocean energy projects utilise a range of technologies that harness tidal, wave, ocean thermal energy conversion, and salinity gradient from the oceans. These projects attract both public and private investments, with some of the more advanced projects reaching high TRL and LCOE slowly approaching those of more established offshore energy sectors – even though commercial exploitation remains a challenge. The 2020 EU strategy on offshore renewable aims to increase the contribution of ocean energy to the offshore EU goals, from 1 GW in 2030 to 40 GW in 2050[49].

Tidal energy is the first of the ocean energy technologies to have been implemented at a large scale, with barrages in France (1966), China (1975, 1985) and South Korea (2011). These barrages make use of tidal range technology, which captures the potential energy stored between a basin and the external sea. While tidal range projects are commercially viable – thanks to their similarity with the hydropower sector – the deployment of such facilities has been limited by the availability of suitable locations and by the significant local environmental impacts. New technologies have emerged as an alternative, exploiting tidal stream rather than tidal range. These tidal stream technologies include horizontal axis turbine (TRL 9), tidal kite (TRL 8), enclosed tips (TRL 7), vertical axis turbine (TRL 7), undulating membrane (TRL 7) and oscillating hydrofoil (TRL 6).

Harnessing the surface motion of ocean waves, **wave energy** technologies include oscillating water column (TRL 9), point absorber (TRL 9), attenuator (TRL 8), overtopping (TRL 8), oscillating wave surge converter (TRL 7) and rotating mass (TRL 7). Some of these technologies have been installed and operated in Spain and Italy (oscillating water columns) and in Portugal and Sweden (point absorbers). Others are being tested in the UK (point absorber and attenuator system), France and Italy (oscillating surge converters).

Ocean thermal energy conversion (OTEC) exploits the temperature difference between deep cold water (at 800 to 1 000 m depth) and surface warm water. The technology has been tested by developers in Japan and the US (TRL 8), and at a smaller scale in China and India[50].

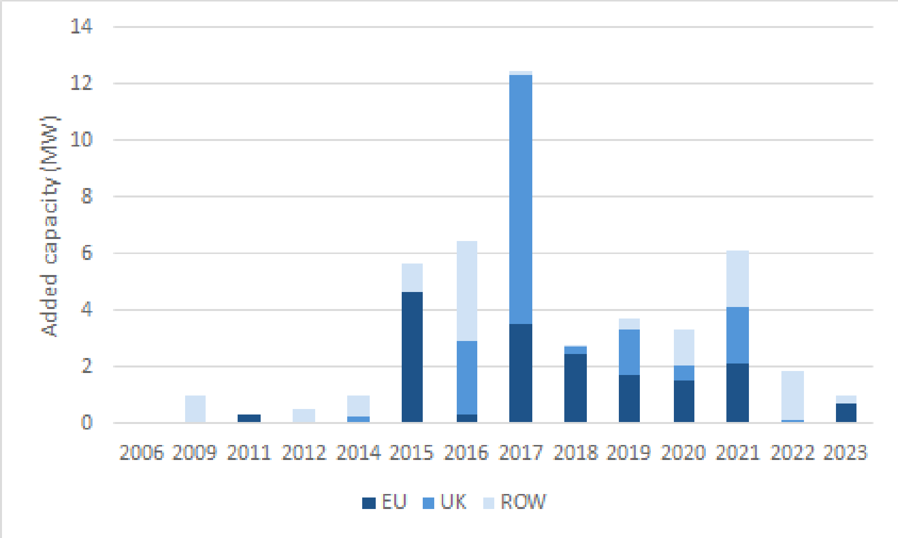
Salinity gradient power (or osmotic power) uses salt content differences between freshwater and saltwater. This technology has mainly been tested in European sea basins, for example the demonstration plant in the Netherlands using Reverse Electrodialysis technology (RED, TRL 7).

Operating and cumulative energy production capacities

At the end of 2023, emerging operational EU ocean energy capacities (i.e. ocean energy capacities excluding the already-established tidal range technology projects) account for 2.18 MW, including 1.16 MW for tidal energy (9% of global production), 0.97 MW for wave energy (50% of global production) and 50 kW for salinity gradient (100% of global production)[51]. In 2023, 715 kW of emerging ocean energy capacities were installed in the EU, a significant increase compared to the 150 kW additions in 2022 (see Figure 15). There is currently no operating capacity in the EU or in Europe for OTEC technologies.

46 Analysis derived from BNEF 2023.
47 4C OFFSHORE (2023) WIND FARMS DATABASE.
48 4C OFFSHORE 'Floating wind: Industry focus' (2023).
49 COM(2020) 741.
50 https://www.ocean-energy-systems.org/publications/oes-annual-reports/document/oes-annual-report-2023/
51 *Ibid.*

Figure 15 Annual capacity installation of tidal stream and wave energy plants in the EU, UK and rest of the world



Source: JRC database, 2024

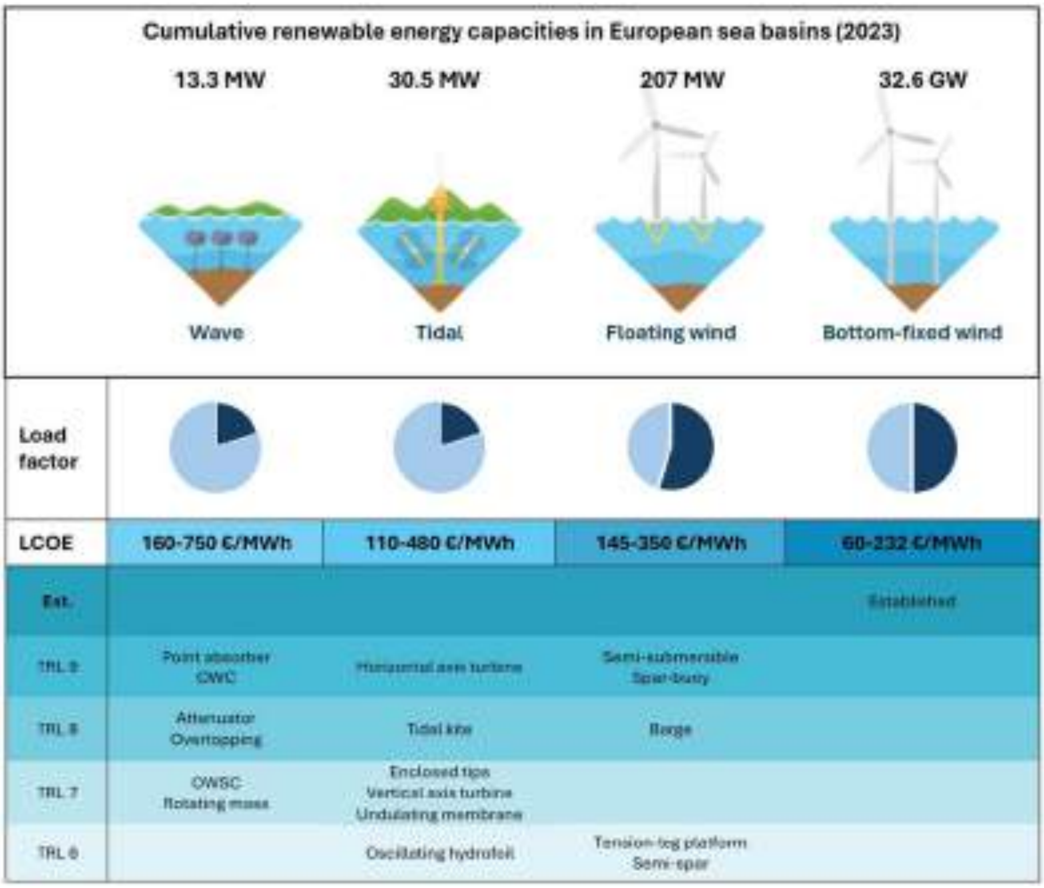
The only established ocean energy capacity in Europe, the La Rance tidal barrage (240 MW), has experienced capacity losses over the past decades due to the aging installation[52]. This led the whole ocean energy capacity in the EU27 (emerging and established capacities that are operational) to remain relatively stable over the past 10 years (2014-2023), despite new additions in emerging ocean projects. The barrage should recover part of its initial capacity after the current phase of renovation (2021-2026)[53]. Since 2011, no new project using tidal range technology has been developed. In 2023, according to the IRENA, the whole operational ocean energy capacity – both emerging and established – reached 527 MW globally[54]. Europe has historically been at the forefront of the ocean energy sector, with almost two thirds of the total capacity (43.8 MW out of the 67.8 MW) located within EU sea basins.

Emerging ocean energy technologies are not established enough to be commercially viable through their revenue from energy production. The main **economic indicators** available for the sector are the LCOE and investments, both public and private. According to the latest estimate from IRENA (2019)[55], LCOEs range from 110 to 480 €/MWh for tidal energy, and from 160 to 750 €/MWh for wave energy (Figure 16). Most ocean energy projects in the EU and the UK benefit from EU funding. 64 projects were funded under Horizon 2020 through 2014-2020, totalling €185 million for ocean energy projects, including €92 million for tidal energy and €86 million for wave energy. Overall, the share of the EU contribution in total public funding of these projects still decreased from 51% to 37% for tidal energy projects and from 79% to 72% for wave energy projects. This is due to the take-off of private investments, in particular for tidal energy.

The ocean energy sector already provides economic benefits by directing public and private investment towards job creations. The nature of these jobs depends on the readiness level of technologies. At the early stages of development, ocean energy projects tend to finance jobs in Research & Development. In a second stage, when an innovation is promising, the creation of specialised SMEs brings additional jobs dedicated to management, administrative tasks and communication. Scaling-up of projects and the energy device deployment on sea mobilise further work in financing, civil engineering and maintenance. Overall, ocean energy projects are estimated to mobilise at least 415 FTE in the EU (532 FTE, including the UK) within specialised ocean energy companies (energy device providers)[56].

52 https://www.cairn.info/revue-l-information-geographique-2017-4-page-103.htm.
53 https://www.edf.fr/rance-i-communique-un-chantier-titanesque-sous-la-mer-en-cours.
54 https://mc-cd8320d4-36a1-40ac-83cc-3389-cdn-endpoint.azureedge.net//media/Files/IRENA/Agency/Publication/2023/Jul/IRENA_Renewable_energy_statistics_2023.pdf?rev=7b2f44c294b84cad9a27fc24949d2134
55 https://www.irena.org/publications/2021/Jul/Offshore-Renewables-An-Action-Agenda-for-Deployment.
56 This estimate represents only part of the workforce within the ocean energy sector, for which data was available (employees of ocean energy device provider companies). It does not include jobs within either civil engineering companies or larger energy companies (for example in the offshore fossil industry).

Figure 16 Offshore renewable energy technologies overview



Sources: ***Cumulative capacities*** *tidal and wave from OEE[57], floating and bottom-fixed wind from 4C Offshore[58];* ***LCOE tidal and wave*** *from IRENA[59], floating wind from 4C Offshore[60], bottom-fixed wind from BNEF[61].*

For more information, visit the section on Marine renewable energy within the EU Blue Economy Observatory.

[57] OEE, 2024.
[58] 4C OFFSHORE (2023) WIND FARMS DATABASE.
[59] IRENA 2019.
[60] 4C OFFSHORE 'Floating wind: Industry focus' (2023).
[61] Analysis derived from BNEF 2023.

2.4. PORT ACTIVITIES

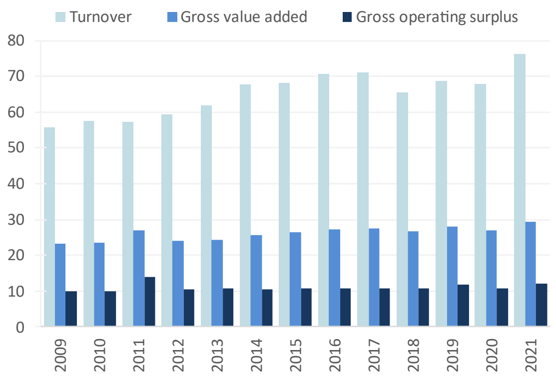
The *Port activities* sector plays a crucial role in the EU economy. Ports are vital infrastructures with significant commercial and strategic importance, and they support the free movement of goods and people across Europe. In addition to traditional port activities such as cargo handling, logistics, and services for the shipping industry, ports also facilitate the clustering of energy and industrial companies in their vicinity, contributing to economic and trade development. Furthermore, ports support a diverse range of industries, including shipbuilding, chemical, food, construction, petroleum, electrical power, steel, fish processing, and automotive industries. These industries are engaged in ambitious pathways towards decarbonisation and transition to clean energy. The EU recognises the importance of ports in driving economic growth and is committed to supporting their efforts to modernise and improve their competitiveness in the evolving global context. This includes making EU ports more sustainable and promoting the use of innovative infrastructures in port activities.

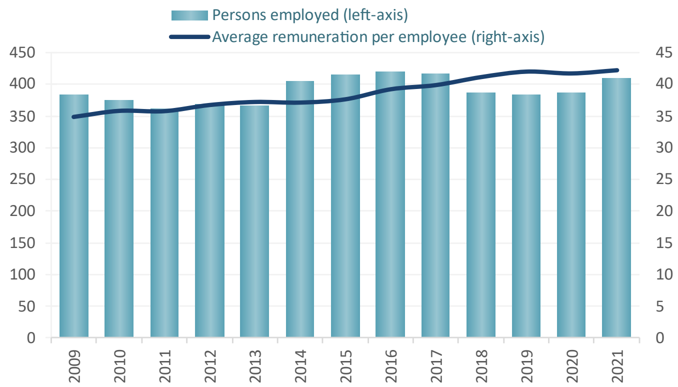
Size of the EU Port activities sector in 2021

In 2021, the GVA generated by the sector amounted to €29.5 billion, representing a 9.2%-increase from 2020 and a 27%-increase from 2009 (€23.2 billion). Reported turnover, at €76.0 billion in 2021, marked the sharpest year-on-year increase since 2009 (+€8.1 billion). This led to a considerable increase in gross profits, which reached the highest value since 2011 (€12.1 billion).

Overall, the sector's turnover has been growing steadily since 2011, except for 2018 and 2020, when the sector was affected by the COVID-19 pandemic. (Figure 17). The significant rebound registered in 2021 shows that the sector has recovered ever since. In 2021, the *Port activities* sector accounted for 11.4% of jobs, 17.2% of GVA and 15.9% of profits of the entire EU Blue Economy.

Figure 17 Size of the EU *Port activities* sector, 2009-2021. Turnover, GVA ad gross operating surplus in € billion, persons employed (thousand), and average wage (€ thousand)





Source: Eurostat (SBS) and own calculation

Results by sub-sector and Member State

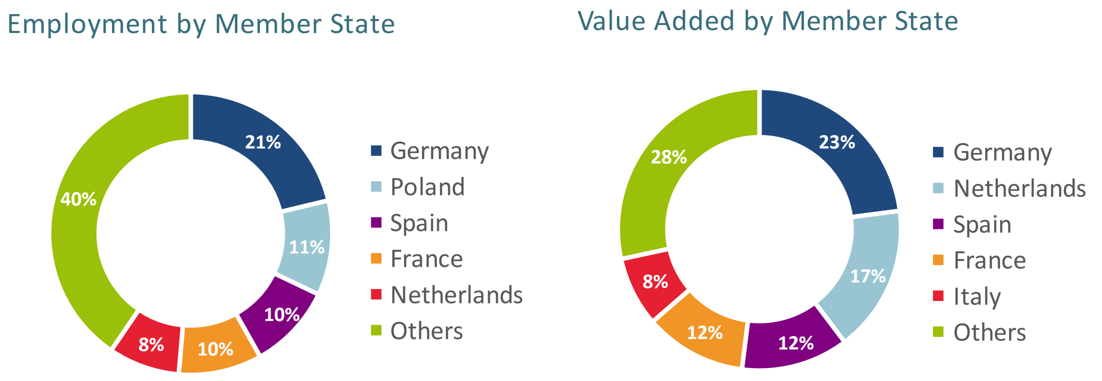
Germany leads the *Port activities* sector, producing nearly one fourth of GVA (23%) and employing 21% of the workforce, followed by the Netherlands (17% of GVA); Spain and France (12% each) and Italy (8%). Poland has the second-largest workforce employed in the sector, representing 12% of the sector's jobs in the EU (Figure 18).

Employment: The *Port activities* sector directly employed nearly 410 000 persons in 2021. It is estimated that the total number of people employed in EU ports under different contracts, including seasonal or part-time, is approximately 1.5 million. This includes both direct and indirect employment in various port-related activities across the 22 coastal Member States [62]. Cargo and warehousing activities made up nearly 60% of total employment in the sector in 2021. The remaining 40% of the workforce was employed in the port and water projects sector. Within these two sub-sectors, between 2020 and 2021 employment increased particularly in warehousing and storage activities (+18%) and construction of water projects (+4%).

Gross value added: In 2021, the *Port activities* sector generated the largest GVA on record since 2009, amounting to approximately €29.5 billion, thanks to a sharp 9.2%-increase from 2020. In 2021, the two sub-sectors (port and water projects, and cargo and warehousing) continued to generate an almost equal share of the sector's GVA at approximately €15 billion each, with the largest year-on-year increase registered in warehousing and storage activities (+16%).

[62] European Commission Directorate-General for Mobility and Transport. https://transport.ec.europa.eu/transport-modes/maritime/ports_en.

Figure 18 Share of employment and GVA in the EU *Port activities* sector, 2021



Source: Eurostat (SBS) and own calculation

Trends and drivers

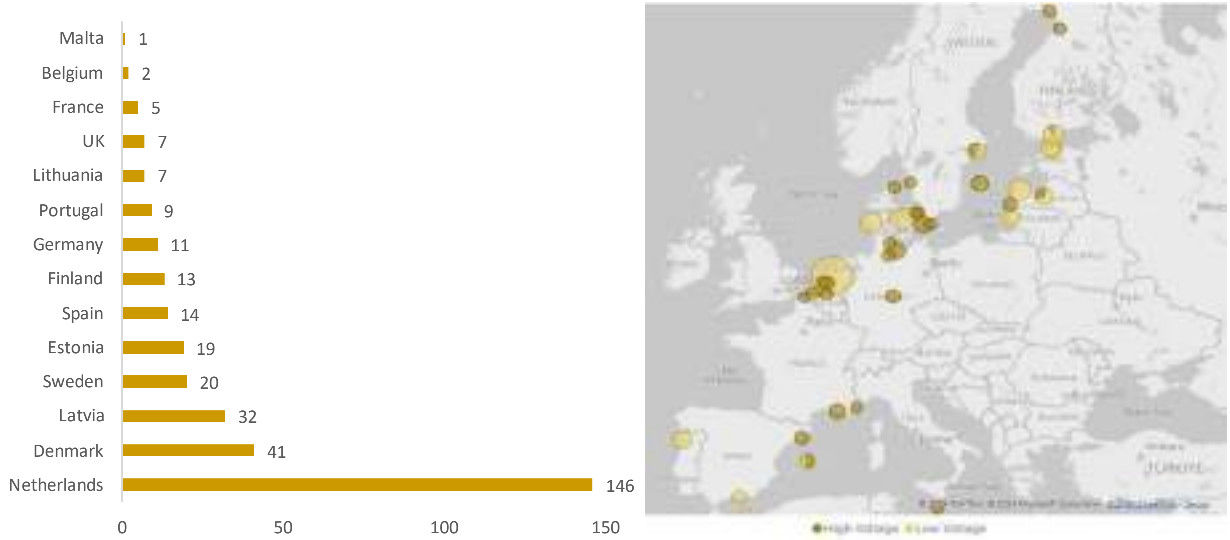
Over the past few years, several significant developments have taken place in the *Port activities* sector in the EU in response to technological advancements, environmental challenges, and evolving trade dynamics. Some of the most relevant developments include:

Geopolitical developments: Since mid-November 2023, the Iran-backed Houthi militia, which controls large parts of Yemen, has attacked numerous Western commercial ships near the Bab el-Mandeb Strait in the Red Sea. In response, major shipping companies have temporarily suspended Suez transits and diverted their trade. Geopolitical developments such as the Red Sea crisis have had a significant impact on the socio-economic performance of the *Port activities* sector in the EU. The crisis has led to disruptions in trade routes and global supply chains, affecting the flow of goods and services through European ports[63].

Digitalisation and automation: Ports across the EU have been increasingly investing in digitalisation and automation technologies to improve efficiency, reduce emissions, and enhance overall operations. This includes the implementation of smart port solutions, such as blockchain-based platforms for supply chain management, automated cargo handling systems, and the use of data analytics for optimising port processes. The adoption of technologies such as blockchain and the Internet of Things (IoT) in port logistics, for instance, is transforming the management and tracking of cargo by expediting the transit of goods, lowering operational costs, and streamlining the processes of loading, unloading, stowing, and storage. Additionally, these advancements can alleviate administrative costs and simplify compliance procedures. ***Sustainability transition***: The port sector is undergoing significant transformation towards more sustainable practices and reducing carbon emissions, aligning with global strategies to address environmental challenges. Initiatives such as the REPowerEU [64] strategy, the Alternative Fuels Infrastructure Regulation (AFIR)[65], the EU Emissions Trading Scheme (ETS)[66], the Innovation Fund[67], and FuelEU Maritime[68] are instrumental in driving this transition. Specifically, AFIR envisages the deployment of alternative fuel infrastructure across the EU, with mandatory national targets set for the rollout of this infrastructure. In addition, the FuelEU Maritime Regulation aims to reduce the greenhouse gas intensity of fuels used in the maritime sector, encouraging the use of renewable and low-carbon fuels. This regulatory framework aims to progressively decrease these emissions by up to 80% by 2050 compared to 2025 levels, thus promoting the adoption of new technologies and alternative fuels in maritime transport. Both regulations represent significant steps towards the decarbonisation of transport and highlight the crucial role of ports in achieving long-term environmental goals. In this connection, many European ports have launched initiatives to reduce their carbon footprint, such as investing in onshore power facilities to enable vessels to connect to renewable energy sources while at berth, as well as adopting alternative fuels and technologies to minimise emissions from port activities. ***Onshore Power Supply (OPS)*** allows ships docked in port to connect to electrical power derived from renewable sources. The number of ports in the EU equipped with OPS facilities in 2020 was 21[69]. According to the European Alternative Fuels Observatory, this number has now increased to 40 ports (Figure 19). These installations include 320 supply points, with 84% operating at low voltage.

[63] European Parliamentary Research Service (EPRS). Recent threats in the Red Sea Economic impact on the region and on the EU. March 2024. https://www.europarl.europa.eu/thinktank/it/document/EPRS_BRI(2024)760390
[64] https://ec.europa.eu/commission/presscorner/detail/es/ip_22_3131
[65] https://www.consilium.europa.eu/en/press/press-releases/2023/07/25/alternative-fuels-infrastructure-council-adopts-new-law-for-more-recharging-and-refuelling-stations-across -europe/
[66] https://climate.ec.europa.eu/eu-action/eu-emissions-trading-system-eu-ets_en.
[67] https://climate.ec.europa.eu/eu-action/eu-funding-climate-action/innovation-fund_en.
[68] https://ec.europa.eu/info/law/better-regulation/have-your-say/initiatives/12312-CO2-emissions-from-shipping-encouraging-the-use-of-low-carbon-fuels_en
[69] EEA. (2021). Number of ports and OPS facilities in the EU (updated to December 2020). Retrieved from: https://www.eea.europa.eu/data-and-maps/figures/number-of-ports-and-ops.

Figure 19 Onshore Power Supply infrastructure in Europe



Source: Cero2050[70]

The above-mentioned transformations are marking a widespread transition toward ***green ports***, which combine technological innovation, environmental management and community engagement. EU ports have positioned themselves at the forefront of these efforts. This transition is reflected in the evolution of the Environmental Management Index, which increased from 7.8 in 2020 to 8.08 in 2023[71]. EU ports are among the busiest and most efficient in the world, serving as major hubs for container shipping, bulk cargo transport, and passenger traffic. The port of Rotterdam, for example, is one of the leaders in sustainable port development.

Infrastructure investment: Significant investments have been made in upgrading and expanding port infrastructure to accommodate larger vessels and handle increased cargo volumes. This includes the construction of new terminals, the deepening and widening of navigation channels, and the enhancement of intermodal connectivity to facilitate the efficient movement of goods. The deployment of green technology facilities, such as large-scale electricity storage and the above-mentioned OPS, also requires considerable investments from both port authorities and shipowners. A similar trend is also applying to LNG[72], which is experiencing a significant growth in Europe. The expansion of LNG as a transition fuel to meet the ambitious EU decarbonisation goals requires a parallel improvement of associated infrastructure, including the expansion of terminals, supply stations, and bunkering and trans-shipment services. Currently, there are 56 ports in Europe offering LNG bunkering services, with an additional 40 ports currently planning to do so. Thanks to recent investments – with co-financing from the RePower EU initiative and the Connecting Europe Facility – the EU's LNG import capacity grew by 40 billion cubic meters (bcm) in 2023, and an additional 30 bcm is expected to become available in 2024. The EU is the largest LNG importer in the world. In 2023, the EU imported over 120 bcm. The largest LNG importers in the EU are France, Spain, Netherlands, Belgium and Italy[73].

The importance of these developments for the competitiveness of EU ports and their role in the energy transition are also highlighted in the non-legislative Resolution on Building a comprehensive ***European port strategy***[74] adopted by the European Parliament in January 2024.

For more information visit the section on *Port Activities* within the EU Blue Economy Observatory.

[70] https://cero2050.es/es/datos/onshore-power-supply

[71] The Environmental Management Index is a composite indicator developed by the European Sea Port Organisation (ESPO) and used to monitor the environmental performance of European ports. Puig, M., Raptis, S., Wooldridge, C., & Darbra, R. M. (2020). Performance trends of environmental management in European ports. Marine pollution bulletin, 160, 111686.

[72] Traditional LNG: This is natural gas that has been cooled to about -162 °C (-260 °F) until it liquefies. This process reduces its volume by approximately 600 times, making it easier to store and transport. LNG mainly consists of methane and is used as an energy source for heating, electricity generation, and as fuel for vehicles and ships. It is considered cleaner than other fossil fuels like coal or oil, but it is still a source of CO2 emissions when burned (source: https://energy.ec.europa.eu/topics/oil-gas-and-coal/liquefied-natural-gas_en).

Bio-LNG: Similar to traditional LNG in terms of usage and physical properties, but it is produced from biomass or organic waste materials. Inputs such as agricultural waste, municipal solid waste, or sewage sludge are broken down in the absence of oxygen (a process known as anaerobic digestion) to produce biogas, which is then purified and liquefied into Bio-LNG. This process makes Bio-LNG a renewable energy source and can significantly reduce greenhouse gas emissions compared to traditional LNG and other fossil fuels (source: European Biogas Association. (2020). BioLNG in Transport: Making Climate Neutrality a Reality. European Biogas Association, Belgium).

Renewable Synthetic LNG: Also known as e-LNG, it is produced by combining renewable hydrogen with CO_2 captured from industrial sources or directly from the air (direct air capture). The hydrogen is produced through the electrolysis of water using electricity generated from renewable sources such as wind, solar, or hydro. The hydrogen is then combined with CO_2 in a process called methanation to produce methane, which is liquefied to form LNG. This process results in a fuel that is carbon-neutral or even carbon-negative if the CO_2 is captured directly from the air, making it part of the solutions to combat climate change (source: Comer, B., O'Malley, J., Osipova, L., & Pavlenko, N. (2022). Comparing the future demand for, supply of, and life-cycle emissions from bio, synthetic, and fossil LNG marine fuels in the European Union).

[73] European Council. https://www.consilium.europa.eu/en/infographics/lng-infrastructure-in-the-eu/

[74] European Parliament resolution of 17 January 2024 on building a comprehensive European port strategy (2023/2059(INI))

2.5. SHIPBUILDING AND REPAIR

The EU *Shipbuilding and repair* sector encompasses overall around 300 shipyards[75]. Roughly half of them are large shipyards, where a variety of vessels, both civilian and naval, along with platforms and other maritime equipment, are constructed. About 40 shipyards are active in the global market for large seagoing commercial vessels[76]. According to the European Maritime Safety Agency[77], in 2022 approximately one out of eleven ships was built in an EU shipyard, with a majority of fishing vessels, passenger ships and tug/dredgers.

In 2023, Europe received 7% of global orders, ranking far behind China (55%) and South Korea (26%)[78]. In spite of the know-how to build any commercial ship type, Europe registered very few orders for cargo ships but maintained its leadership position in the construction of complex vessels, especially cruise ships. European shipbuilders also hold a strong position for ship maintenance, repair, conversion and retrofitting due to their expertise, as well as for building fixed and floating platforms.

It should be noted that, although the European market size is marginal compared to the Asian one, in 2021 and 2022 there was an increasing trend in the merchant ships[79] built in terms of gross tonnage (GT) in the European continent, rebounding after Covid-19. Specifically, European shipbuilders built roughly 6% more GT in 2022 than in 2019[80].

Growth in Europe's shipyards is expected due to their capability for future technology adaptation[81]. Naval shipbuilding over the next 20 years is expected to be about €145 billion for the top five nations in Europe (UK, France, Germany, Italy, and Turkey)[82].

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

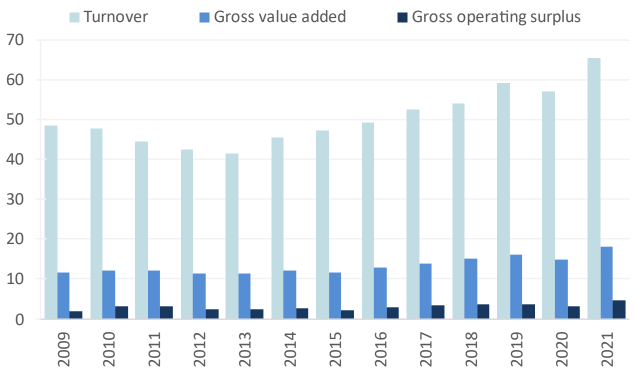
1. **Shipbuilding**: building of ships and floating structures; building of pleasure and sporting boats; repair and maintenance of ships and boats.
2. **Equipment and machinery**: manufacture of cordage, rope, twine and netting; manufacture of textiles other than apparel; manufacture of sport goods; manufacture of engines and turbines (except aircraft), and manufacture of instruments for measuring, testing and navigation.

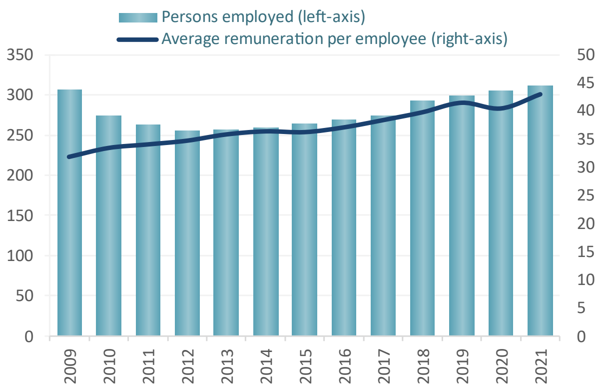
Size of the EU Shipbuilding and repair sector in 2021

The sector generated a GVA of €18 billion in 2021, a 21%-increase compared to 2020, and a 12%-increase compared to the 2019 peak. Gross profit, at €4.6 billion increased by 52% on the previous year. The turnover reported for 2021 was €65.4 billion, recording a 15%-increase on the previous year.

In 2021, about 312 000 persons were directly employed in the sector (2%-increase on 2020), and the annual average wage was estimated at €43 000, up 6% compared to 2020 (Figure 20)..

Figure 20 Size of the EU *Shipbuilding and repair* sector, 2009-2021. Turnover, GVA ad gross operating surplus in € billion. Persons employed (thousand), and average wage (€ thousand)





Source: Eurostat (SBS) and own calculations

Results by sub-sector and Member State

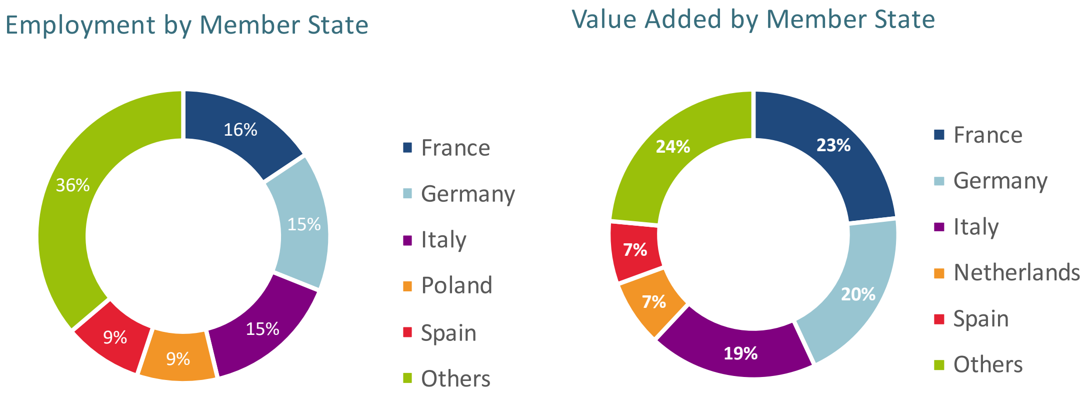
France leads employment within the sector (Figure 21), contributing with 16% of jobs, followed by Germany (15%) and Italy (15%). In terms of GVA, France records 23% of the Members States' GVA, followed by Germany (20%) and Italy (19%).

Employment: in 2021, *Shipbuilding and repair* employed roughly 262 000 people (84% of the sector) whilst Equipment and machinery employed 50 000 people (16%).

Gross value added: *Shipbuilding and repair* generated €14.3 billion in GVA, about 79% of the sector's GVA, whilst Equipment and machinery produced €3.7 billion (21%).

[75] https://www.seaeurope.eu/images/content/INFO_PACT_FOR_SKILLS_Shipbuilding_and_Maritime_Tech_Summary.pdf
[76] https://single-market-economy.ec.europa.eu/sectors/maritime-industries/shipbuilding-sector_en.
[77] https://emsa.europa.eu/eumaritimeprofile/section-2-the-eu-maritime-cluster.html#shipbuilding.
[78] SEA Europe - 2023 Shipbuilding Market Analysis.
[79] The figures cover seagoing propelled merchant ships of 100 gross tons (GT) and above, excluding inland waterway vessels, fishing vessels, military vessels, yachts, and offshore fixed and mobile platforms and barges.
[80] https://unctadstat.unctad.org/datacentre/dataviewer/US.ShipBuilding.
[81] https://www.seaeurope.eu/smrc/smrc-industry-at-a-glance.
[82] EMI report: https://euro-sd.com/2023/06/articles/32104/european-naval-shipbuilding-and-market-outlook.

Figure 21 Share of employment and GVA in EU *Shipbuilding and repair* sector, 2021



Source: Eurostat (SBS) and own calculations

Trends and drivers

There are some factors that currently influence the *Shipbuilding and repair* sector and are expected to continue to do so in the near future. The **unprovoked invasion of Ukraine by Russia** has already impacted shipbuilding, with uncertainties over shipping routes in the region causing some shipping companies to delay long-term investment decisions. One direct impact has been increased demand for LNG vessels globally, as Russia exporting more fuel oil to Asia has resulted in Europe importing more gas via LNG carriers, instead of via Russia[83]. The increased use of the Danube as an alternative route for Ukrainian exports may increase smaller river vessel construction. By contrast, the Gaza conflict and Houthi attacks on Red Sea shipping may continue to disrupt shipping, leading to changes in vessel demand due to longer sea journeys. Certain ship repair sectors are also being affected by the Russian invasion of Ukraine, as sanctions on Russia-owned assets include impounding super yachts.

The **superyachts market** influences the overall sector. Almost 50% of the global superyacht fleet lies within a range between 24 metres and 30 metres, while the average length of the superyacht fleet is increasing. Very large vessel (more than 70 metres) new builds have increased market share from 3% between 2000 to 2009 to 7.5% between 2010 and 2019[84]. The number of superyachts over 30 metres increased from 4 136 in 2010 to 5 559 December 2019. The number of superyachts is predicted to increase from 5 718 superyachts in 2020 to about 7 189 to 7 701 superyachts by 2030[85]. Sales are relatively immune to recessions, being reliant on a growing global population of high-net-worth individuals. EU companies dominate both construction and refit with Italy, the Netherlands, the UK, Germany, Denmark and France being the top Member States involved in the industry. Construction (new and refit) has the largest contribution to the economy (2021 saw €13.6 billion in revenue[86]), but yacht services also provide a significant economic contribution (just over €1 billion in commission revenue in 2021[87]) through general yacht management, brokerage services – for chartering as well as for sale and purchase – and other ancillary services. Despite its focus on luxury, the superyacht sector is not exempt from international regulations such as the IMO's SulphurCap 2020, and the sector is increasingly focused on green technology in new builds and refitting.

Very recently, smart shipping has started to use digitalisation to realise optimisation and to leverage value from data. **Autonomous ships** sit at the more advanced end of the smart ship spectrum and are defined by the IMO as 'a ship which, to a varying degree, can operate independent of human interaction'. Estimates of the global autonomous shipping market size vary from $4-10 billion for 2022-2023, with predicted compound annual growth rates of about 10% and values of $8-12 billion by the end of the decade. Europe is seen as a major player in this market, investing in sustainable maritime operations and R&D. In the EU, research and development funding is driving innovation and sustainability in the autonomous ship market, with several major EU projects, some funded under Horizon 2020, either completed or currently in delivery. Projects have progressed from concept/feasibility studies (e.g. €2.9 million project MUNIN completed in 2016) to on-water demonstration project (e.g. AUTOSHIP, EUROGARD, SEAMLESS).

Finally, the focus on sustainability and circularity stresses the importance of **ship recycling**. This activity registered a peak in 2017 in the EU, with 40 ships recycled, equalling a total of 21 000 light displacement tonnes (LDT); however, that amount reduced to 4 500 LDT in 2019. A total of 211 ships were recycled in EU facilities between 2014 and 2019, mainly in Denmark and Belgium, but this represents less than 1% of the EU-controlled fleet. However, outside the EU, many large ships are still dismantled in ship recycling facilities which operate under poor environmental standards and safety conditions[88].

The IMO's Hong Kong Convention, adopted in 2009 and ratified in 2023, ensures safe and environmentally sound ship recycling practices. It will enter into force on 26 June 2025[89]. The EU was an early signatory[90], and the EU's Ship Recycling Regulation (SRR), in force since 2020, expedites the Convention's ratification within the EU and adds safety and environmental measures[91]. Ship recycling

[83] OECD, 2023. Impacts of Russia's war of aggression against Ukraine on the shipping and shipbuilding markets https://www.oecd-ilibrary.org/docserver/4f925e43-en.pdf?expires=1710433811&id=id&accname=guest&checksum=FBC0B66374F05368B8286A61E9E25B34.
[84] https://www.myba-association.com/files/index.cfm?id=482&crypt=5656.
[85] The Superyacht New Build Report, The Superyacht Report, Issue 206, 02/2021, London. https://www.superyachtnews.com/reports/thesuperyachtreport.
[86] https://www.myba-association.com/files/index.cfm?id=482&crypt=5656.
[87] *Ibid.*
[88] https://www.emsa.europa.eu/sustainable-shipping/ship-recycling.html.
[89] https://www.ilo.org/safework/info/publications/WCMS_154921/lang--en/index.htm.
[90] Recognising the Convention within REGULATION (EU) No 1257/2013: https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX%3A32013R1257&from=NL.
[91] https://www.shipownersclub.com/latest-updates/publications/interactive-guide-eu-ship-recycling-regulation/#:~:text=The%20European%20Union%20(EU)%20Ship,and%20the%20health%20of%20workers.

rates globally remain low due to cost and facility limitations[92]. The SRR provides a list of approved facilities for EU-flagged vessels, primarily within the EU (44), and a few in Turkey, the UK, and India[93].

For more information, please visit the section on *Shipbuilding and repair* within the EU Blue Economy Observatory.

2.6. MARITIME TRANSPORT

Globally, approximately 12 billion tonnes of traded goods were transported by sea in 2022, accounting for roughly 49% of total trade, nearly double the proportion transported by air (26%)[94]. Port calls from liquid bulk carriers (e.g. oil) forerun container ships and dry bulk carriers (e.g. grain). Europe loaded and discharged 1.6 and 1.7 billion tonnes[95] of goods, respectively. The most-connected European economies, as measured by the Liner Shipping Connectivity Index (LSCI), were Spain, the Netherlands and Belgium[96], whilst the most connected EU ports were Rotterdam (NL), Antwerp (BE) and Hamburg (DE)[97].

In 2021, short sea shipping (SSS) made up 60.9% of the total sea transport of goods to and from the main EU ports (almost 1.8 billion tonnes). Italy, the Netherlands and Spain accounted for almost 41% of EU SSS in 2021. Liquid bulk (40%) was the dominant type of cargo in EU SSS, followed by dry bulk (21%), containers (17%) and Ro-Ro (15%)[98].

In 2022, 348.6 million passengers were recorded in EU ports, a 16.7%-decrease compared to pre-Covid (2019)[99]. Greece (20%), Italy (15%) and Denmark (12%) accounted for the almost half the total number of passengers embarked and disembarked in EU ports. The minimal variance between the count of passengers disembarking and embarking underscores the predominant reliance on national or intra-EU ferry services.

EU ports recorded 32% less cruise passengers (roughly 10 million) than pre-Covid-19 (2019). Almost three quarters of these passengers passed through Italian, Spanish and German ports in 2022[100].

For the purpose of this report, *Maritime transport* includes the following sub-sectors:

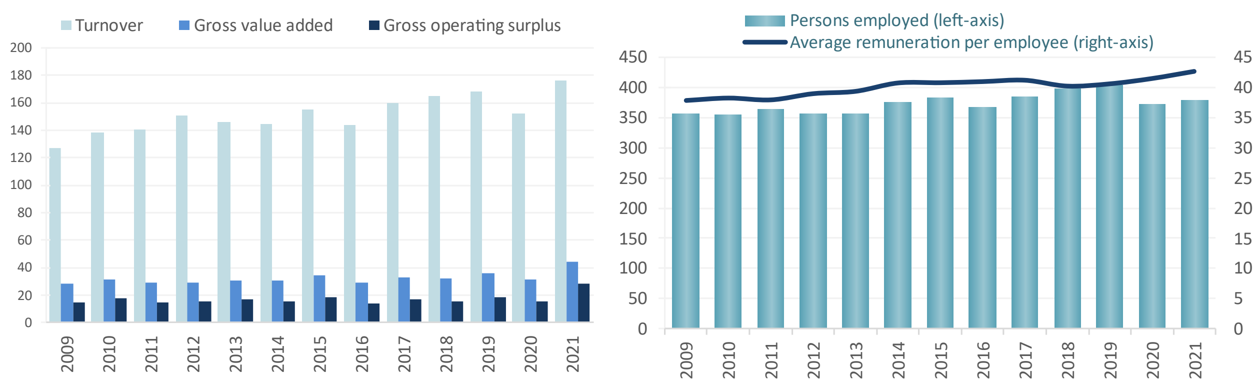
1. **Passenger transport**: sea and coastal passenger water transport and inland passenger water transport;
2. **Freight transport**: sea and coastal freight water transport and inland freight water transport;
3. **Services for transport**: renting and leasing of water transport equipment.

Size of the EU Maritime transport sector in 2021

The sector generated a GVA of €44.3 billion in 2021, a 42%-increase compared to 2020, and a 23%-increased compared to the 2019 peak. Gross profit, at €28.1 billion, increased by 77% on the previous year. The turnover reported for 2021 was €176.7 billion, a 16%-increase on the previous year.

In 2021, almost 380 000 persons were directly employed in the sector, 2% more than in 2020. The annual average wage was estimated at €43 000, up 3% compared to 2020 (Figure 22).

Figure 22 Size of the EU *Maritime transport* sector, 2009-2021. Turnover, GVA ad gross operating surplus in € billion, persons employed (thousand), and average wage (€ thousand)



Source: Eurostat (SBS) and own calculation

Results by sub-sector and Member State

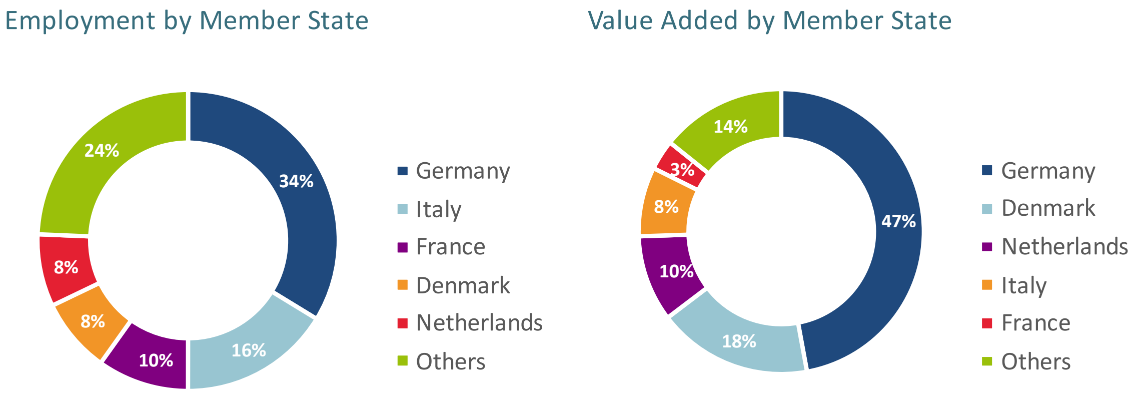
Germany leads employment within *Maritime transport* (Figure 23), contributing with 34% of the jobs, followed by Italy (16%) and France (10%). In terms of GVA, Germany generates 47% of the Members States' GVA, followed by Denmark (18%) and the Netherlands (10%).

[92] https://unctad.org/system/files/official-document/rmt2023_en.pdf
[93] https://environment.ec.europa.eu/topics/waste-and-recycling/ships/site-inspection-reports_en
[94] World Trade Organisation - World Trade Statistical Review 2023.
[95] UNCTAD - Handbook of Statistics 2023.
[96] UNCTAD - Review of maritime transport 2023.
[97] UNCTAD - Handbook of Statistics 2023.
[98] EUROSTAT - Maritime transport statistics. https://ec.europa.eu/eurostat/web/transport/data/database.
[99] *Ibid.*
[100] *Ibid.*

Employment: in 2021, Services for transport employed about 50% of the jobs, while Passenger transport and Freight transport both employed 25% in 2021.

Gross value added: Freight transport generated about 58% of the sector's GVA (€25.5 billion), followed by Services 33% (€14.8 billion) and then Passenger transport with 9% (€4 billion).

Figure 23 Share of employment and GVA in EU *Maritime transport* sector, 2021



Source: Eurostat (SBS) and own calculation

Trends and drivers

The **COVID-19 pandemic** had major consequences for economies, including the *Maritime transport* sector. While the impact on cargo tonnage was relatively limited, the effects of COVID-19 on logistics and costs were profound. Container shipping prices raised up to $11 108 in September 2021 from $1 389 in December 2019, and port congestion resulted in average port waiting days from 3.12 days to 9.78 days in developed economies, due to higher demand of goods and limitations in port operations. This situation persisted until mid-2022, eventually stabilising and returning to pre-pandemic levels in 2023.

As a consequence of the unprovoked Russian invasion of Ukraine, **change in trade routes** is observed. The EU, the UK and the US have implemented a series of restrictive economic measures targeting the trade of Russian crude oil, refined petroleum products, and gas. These measures include import bans, pipeline transport restrictions, and a cap on the price of crude oil barrels. Consequently, European countries sought alternative sources of energy, leading to increased imports of crude oil from Libya, Iraq, Norway, and Egypt, as well as LNQ and crude oil from the US East Coast. On an annual basis, SSS tonnage to and from major EU ports experienced a substantial decrease of 8.7%, while deep-sea shipping increased by 1.0% compared to the previous period[101]. In terms of total gross weight of goods, the US continued to be the primary *Maritime transport* partner of the EU in the second quarter of 2023 (59 million tonnes), maintaining this position for five consecutive quarters. The UK (52 million tonnes) ranked as the second-largest maritime transportation partner of the EU during that period, followed by Norway (31), China (29), Turkey (29), Brazil (23), and Egypt (21). Russia (18) experienced a continuous decline in its position, falling to the eighth place[102].

In the long run, PRIMES projects EU-27 trends for water transport of passengers (maritime cruises and ro-pax and inland, Gpkm) and freight (short- and deep-sea and inland, Gtkm) to grow 50% by 2050 relative to pre-Covid-19 activities[103].

Disruptions in key maritime routes, like the Suez and Panama Canals due to crises and environmental challenges, have led to increased freight costs and insurance premiums, prompting the search for alternative routes that may escalate fuel consumption and CO_2 emissions. In this context, **maritime security** has gained prominence, particularly in strategic areas like the Red Sea and the Black Sea, where conflicts have reshaped global oil and cereal trade[104].

Maritime transport, central to international trade, faces significant challenges on its path to **digitalisation**. Despite its importance, only a small percentage of cross-border transactions in the EU are executed fully digitally (1%)[105], compared to aviation (40%) and rail (5%). Legal and technical barriers (e.g., the need for handwritten signatures on transport documents), as well as the absence of uniform standards and a consolidated digital infrastructure complicate interoperability between the different systems used in the sector. In response to these challenges, the EC has promoted initiatives such as the Digital Transport and Logistics Forum, seeking to bridge the digital divide in this area. The introduction of Regulation (EU) 2020/1056 on electronic freight transport information (eFTI) marks a step forward, establishing a legal framework that facilitates the exchange of information electronically in maritime transport, which represents a crucial advance towards the modernisation and efficiency of the sector[106].

[101] https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Maritime_transport_of_goods_-_quarterly_data#Gross_weight_of_goods_handled_in_the_main_EU_ports_decreased_by_5.9_.25_in_the_second_quarter_of_2023_compared_with_the_same_quarter_of_2022.
[102] EUROSTAT - Maritime transport statistics. https://ec.europa.eu/eurostat/web/transport/data/database.
[103] European Commissionc, Directorate-General for Climate Action, Directorate-General for Energy, Directorate-General for Mobility and Transport, De Vita A, Capros P, Paroussos L, Fragkiadakis K, Karkatsoulis P, HöglundIsaksson L et al. EU reference scenario 2020: energy, transport and GHG emissions : trends to 2050. Publications Office; 2021, doi: 10.2833/35750.
[104] UNCTAD. (n.d.). Red Sea, Black Sea and Panama Canal: UNCTAD raises alarm about disruptions to global trade. Retrieved from https://unctad.org/es/news/mar-rojo-mar-negro-y-canal-de-panama-la-unctad-alza-la-voz-de-alarma-sobre-las-perturbaciones.
[105] EEA - Transport and environment report 2022 Digitalization in the mobility system: challenges and opportunities. Retrieved from https://www.eea.europa.eu/publications/transport-and-environment-report-2022.
[106] *Ibid.*

In 2019, the International Hydrographic Organisation released the S-100 Universal Hydrographic Data Model, which supports the development of interoperable marine data, including navigational charts, bathymetric data, seabed features, and other relevant information used for maritime navigation, safety, and management[107], enhancing navigation, research, and all other maritime activities.

A major digitalisation trend is the coming of the **Maritime Autonomous Surface Ships (MASS)**. These vessels can range from steering and navigational assistance to full automation of navigation. While there are not currently ships in the third degree, conditional automation – the fifth degree being full automation – this trend is seen as a way to reduce operational costs, improve working conditions, save fuel by optimising routes, and reduce human errors and accidents. The European Maritime Safety Agency (EMSA) is providing support through the SafeMASS project by identifying risks and regulatory gaps, and Horizon 2020 projects are also tackling the topic, like the Autoship project (building and operating two autonomous inland vessels), the AEGIS project (autonomous navigation and cargo handling), and MOSES project (autonomous vessel manoeuvring and docking scheme)[108].

Insurance is a key activity for all *Maritime transport*, due to the relevance of cargos. More than 80% of maritime insurance premiums are in the category of Transport/Cargo (57.3%) and Global hull (23.4%)[109]. The seaborne transport leadership of (continental) Europe can also be appreciated on its leadership in maritime insurance premiums (47.7%), followed by Asia/Pacific (28.4%) and Latin America (10.3%)[110]. The sector was, in economic broad terms, not affected by the COVID-19 pandemic, nevertheless it is challenged by the increase in extreme weather conditions, fires on-board vessels, increasing value and risk accumulation on single vessels/ports, and increasing geopolitical tensions[111].

For more information, please visit the section on *Maritime transport* within the EU Blue Economy Observatory.

2.7. COASTAL TOURISM

Coastal tourism is the largest sector of the EU Blue Economy in terms of GVA and employment, with EU coastal areas being highly sought-after destinations for both European and international travellers. Over half of EU bed capacity is located in regions with a sea border[112].

Tourism plays a significant role in the economies of many non-landlocked EU Member States, particularly in Southern Europe, where it contributes a substantial portion of their total national revenue[113].

At the same time, coastal regions are those with the highest seasonality, i.e., with tourism demand concentrated in a limited number of months, usually July and August[114].

For the purpose of this report, the *Coastal tourism* sector comprises recreational activities taking place in proximity of the sea (e.g. beach-based tourism, coastal walks, wildlife watching) as well as those taking place in the maritime area, including nautical sports (e.g. sailing, scuba diving, cruising, etc.). The socio-economic statistics presented in this section originate from three typologies of activities typically undertaken by tourists as reported by EU Member States, attributed to coastal areas on the basis of a specific computation methodology:

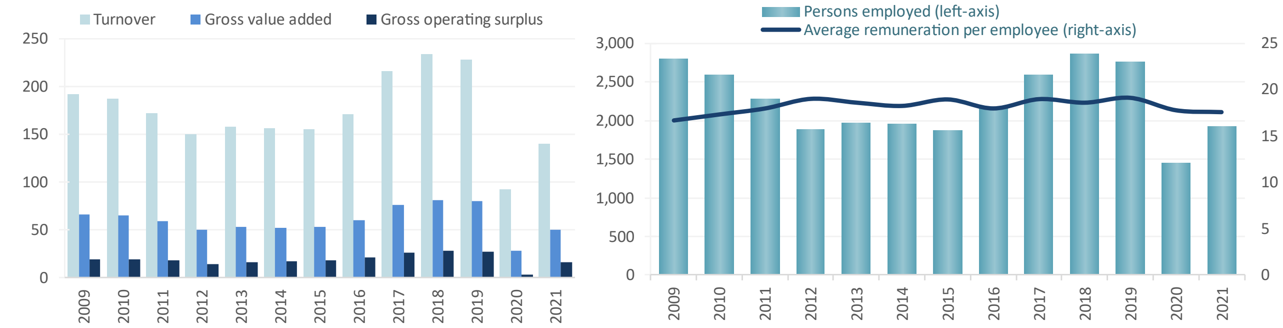
1. **Accommodation**, i.e. nights spent at tourist accommodation establishments in coastal areas;
2. **Transport**, reflecting the maritime proportion of sea-borne, road, rail and air passenger travel;
3. **Other expenditures**, covering specific tourist expenditures in coastal areas (e.g., food & beverage services, cultural and recreational goods, purchase of water-sport equipment and clothing, etc.).

Size of the EU Coastal tourism sector in 2021

The sector was hit hard by the COVID-19 pandemic in 2020. In 2021, the *Coastal tourism* sector recovered, but still did not reach the pre-crisis level. The GVA generated by the sector amounted to €49.9 billion, up from €28.6 billion registered in 2020, i.e., a year-on-year 74%-increase, but still a 38%-contraction compared to 2019. Gross profits, at €16.1 billion, increased 4.2 times compared to 2020. Nonetheless, the sector's turnover resulting from the aggregation of the above-mentioned sub-sectors amounted to €140.0 billion (Figure 24).

[107] https://iho.int/en/s100-project
[108] EEA - Transport and environment report 2022 Digitalization in the mobility system: challenges and opportunities. Retrieved from https://www.eea.europa.eu/publications/transport-and-environment-report-2022.
[109] Global Marine Insurance Trends, IUMI 2023, https://iumi.com/statistics/public-statistics.
[110] Global Marine Insurance Trends, IUMI 2023, https://iumi.com/statistics/public-statistics.
[111] Global Marine Insurance Trends, IUMI 2023, https://iumi.com/statistics/public-statistics.
[112] European Commission. Coastal and maritime tourism. https://ec.europa.eu/growth/sectors/tourism/offer/maritime-coastal_en.
[113] Eurostat. 2023. Tourism Satellite Accounts in Europe – 2023 edition: Available at: https://ec.europa.eu/eurostat/web/products-statistical-reports/w/ks-ft-22-011. European Commission. Tourism Dashboard. Available at: https://tourism-dashboard.ec.europa.eu/map-view?lng=en&ctx=tourism&is=TOURISM&ts=TOURISM&pil=indicator-level&tl=0&i=344&clc=socio-economic-vulnerability&db=1289&it=ranking-chart&cwt=bar-chart.
[114] Eurostat (2022). Tourism statistics - seasonality at regional level. https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Tourism_statistics_-_seasonality_at_regional_level#The_regions_with_the_highest_seasonality_are_coastal_regions.
Batista e Silva, F., Barranco, R., Proietti, P., Pigaiani, C., & Lavalle, C. (2021). A new European regional tourism typology based on hotel location patterns and geographical criteria. Annals of Tourism research, 89, 103077. https://doi.org/10.1016/j.annals.2020.103077.

Figure 24 Size of the EU *Coastal Tourism* sector, 2009-2021. Turnover, GVA ad gross operating surplus in € billion, persons employed (thousand), and average wage (€ thousand)



Source: Eurostat (SBS) and own calculations

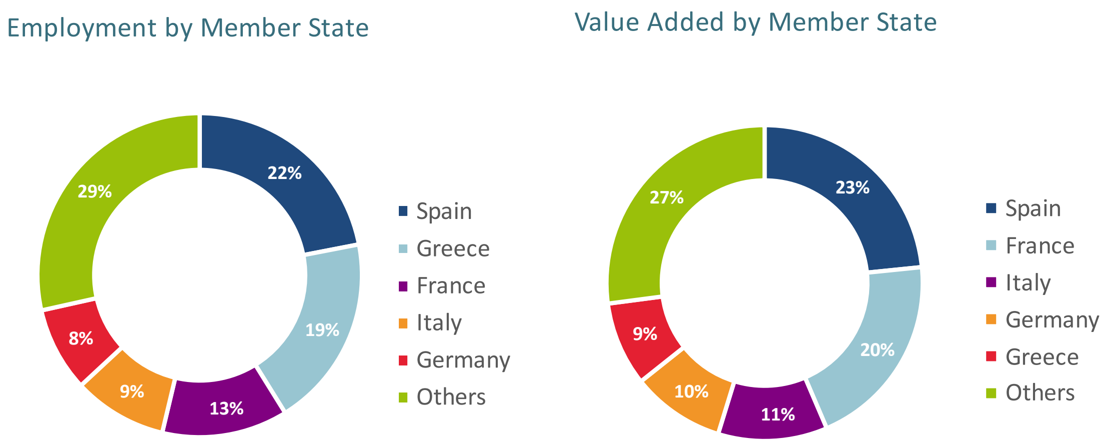
Results by sub-sector and Member State

Spain leads the *Coastal tourism* sector in terms of employment contributing with 22% of jobs, followed by Greece with 19%, France with 13% and Italy with 9%. In terms of GVA, Spain leads with 23%, followed by France with 20%, and Italy with 11% (Figure 25).

Employment: the sub-sector Accommodation employed almost 848 000 persons, accounting for about 44% of jobs; while about 812 000 persons (42%) were employed in Other services (e.g. restaurants), and about 263 000 persons (14%) were employed in Transport.

Gross value added: In 2021, the sub-sector Accommodation generated €24 billion GVA, about 48% of the sector's GVA, while Other services generated €16.7 million (33%) and Transport €9.1 million (18%).

Figure 25 Share of employment and GVA in the EU *Coastal Tourism* sector, 2021



Source: Eurostat (SBS) and own calculation.

Trends and drivers

Tourism was hit hard by the COVID-19 pandemic and is taking longer than other blue economy sectors to recover, even though *Coastal tourism* was the least affected typology. Controlling for restrictions, the loss in guest nights in 2020 compared to 2019 was relatively higher in urban and rural destinations, indicating higher preferences from tourists for coastal destinations[115].

The first priority area of the 'Coastal and Maritime Strategy' of 2014 highlights 'opportunities for cruise tourism' in a sustainable manner.

According to the industry representatives, the cruise sector represented 1.2 million jobs and contributes $150 billion to the global economy before the COVID-19 pandemic. In 2022, it was close to $44 billion[116]. With around sixty ports suitable for cruise ships, Europe ranks second behind the American continent.

Throughout the 2010s, the cruise tourism industry experienced rapid growth from 12 to 17 million passengers disembarking in EU ports, offering an expanding array of itineraries, varying lengths of stay, and diverse ports of call. Italy and Spain emerged as the top two EU Member States hosting the highest number of cruise passengers. Together they represented half of all EU cruise passengers in 2019, i.e., over 8 million people. However, the onset

[115] Curtale, R., Batista e Silva, F., Proietti, P., & Barranco, R. (2023). Impact of COVID-19 on tourism demand in European regions-An analysis of the factors affecting loss in number of guest nights. Annals of Tourism Research Empirical Insights, 4(2), 100112. https://doi.org/10.1016/j.annale.2023.100112.
[116] Source: https://cruising.org/-/media/clia-media/research/2023/2023-clia-state-of-the-cruise-industry-report_low-res.ashx.

of the COVID-19 pandemic halted cruise operations for over 4 months, with a slow recovery due to strict restrictions. There has therefore been an exceptional 16-fold reduction in stopover passengers between 2019 and 2020. During this period, the sector utilised the pause to rebuild and construct ships with greater environmental sustainability and increased capacity. Since then, the industry has largely resumed its operations, returning progressively to pre-pandemic levels.

Eurostat also provides a breakdown of cruise passengers by port, allowing to group them by sea basin. Certain countries, such as Italy and Spain, have ports hosting cruise ships on two sea basins. In 2022, the most important sea basin in the EU-27 in terms of number of cruise passengers was the Western Mediterranean – almost half of the EU total with Barcelona, Palma de Mallorca and Civitavecchia as main ports – followed by Northern Europe – with Antwerp-Bruges and Hamburg being the main ports – and Scandinavia/Baltic – Kiel being the main port.

The estimated sum of cruise passengers' expenditure in the EU ranges between €274 and €644 million in 2022. These estimates are much lower than the estimates of the Cruise Lines International Association that considers a €44 billion economic contribution and 315 000 jobs provided by the industry in Europe in 2021[117]. This highlights that cruise passengers' onshore expenditures may only represent a limited share of the economic contribution of the sector.

Overall, cruise tourism can be a significant driver of economic growth and development for host countries, particularly those with attractive port destinations and supportive infrastructure. Measuring the exact economic impact of this type of tourism on the local economy can be challenging due to the lack of overnight stays, which sets it apart from other forms of tourism. Tourists typically visit for the day, participating in activities such as shopping and dining. To accommodate the arrival of hundreds or even thousands of tourists, host cities need to have robust infrastructure, logistics, transportation, and services in place.

Despite the economic benefits that cruise tourism offers, it is also subject to evidence-based criticism regarding the sustainability of the sector and various challenges. Some of the main criticisms and challenges associated with the cruise industry include air and water pollution, waste management, overcrowding in port cities, regulatory challenges, etc. resulting in local population discontent[118].

For more information, please visit the section on [Coastal tourism](#) within the EU Blue Economy Observatory.

2.8. BLUE BIOTECHNOLOGY

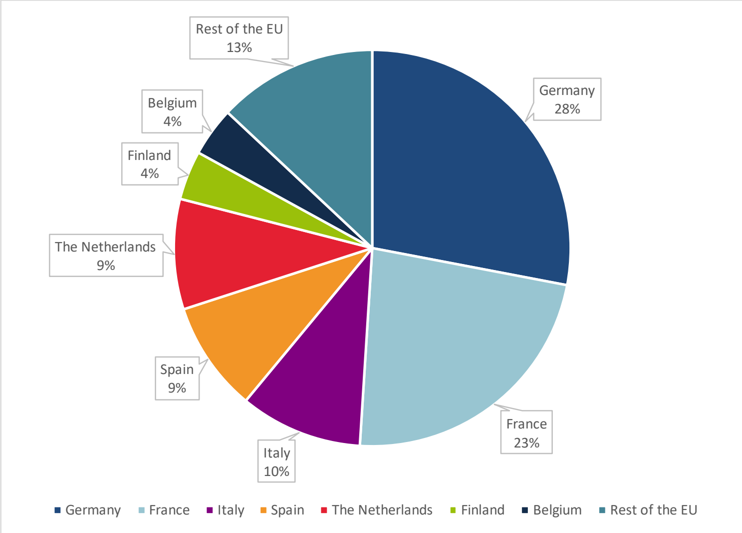
Blue biotechnology is defined as the 'application of science and technology to living organisms from marine resources, as well as parts, products and models thereof, to alter living or non-living materials for the production of knowledge, goods and services'[119]. This sector encompasses a wide set of activities and applications, which can serve different markets and uses.

Whilst *Blue biotechnology* offers significant growth potential in Europe and globally due to rich marine biodiversity, rising demand for sustainable resources, technological advancements, and economic opportunities for coastal communities, the quantification of its economic value is a complex task. The current statistical classification of economic activities in the European Union (NACE) does not have a specific code for *Blue biotechnology*, which means there are no official data on the turnover, value added, and employment of the sector[120]. Estimates on the current size and growth prospects of the sector are only available in a number of reports from research organisations, international organisations, and private companies alike. However, each of these reports may use different definitions of blue biotechnology and employ different methodologies for calculations, ultimately making estimates fraught with uncertainties and virtually impossible to compare. Nevertheless, estimates of the global market value (turnover) of *Blue biotechnology* range between €2.5 and €3.9 billion. For example, Maximize Market Research estimated a market value of €2.51 billion in 2021 and forecast a Compound Annual Growth Rate (CAGR) of 7.11% from 2022 to 2029, with the market reaching €4.34 billion[121]. Cognitive Market Research projects *Blue biotechnology* growth from €2.83 billion in 2022 to €4.92 billion in 2030 at a CAGR of 8.24%[122]. While Market Research Future (MRFR) estimates a market value of €3.9 billion, reaching €8.9 billion in 2032, at a CAGR of 7.15%[123].

As specifically regards the EU, the total market is valued at €868 million in 2021 and is projected to grow to €1 786 million in 2032 at a CAGR of 6.8%, according to MRFR. Germany (28%) and France (23%) alone make slightly more than half of the EU market value and are also projected to grow faster than the other EU Member States (Figure 26).

[117] State of the Cruise Industry 2023 – Cruise lines international association.
[118] The return of the cruise – How luxury cruises are polluting Europe's cities. TE- Transport Environment.
[119] OECD (2017), 'Marine biotechnology: Definitions, infrastructures and directions for innovation', *OECD Science, Technology and Industry Policy Papers*, No. 43, OECD Publishing, Paris, https://doi.org/10.1787/9d0e6611-en .
[120] The NACE classification does indeed have a code that groups enterprises working 'Research and experimental development on biotechnology' (M 72.11), but this does not allow to discriminate between blue and non-blue.
[121] Maximize Market Research, Blue Biotechnology Market- Global Industry Analysis and Forecast (2022-2029), 2023. https://www.maximizemarketresearch.com/market-report/blue-biotechnology-market/14327/
[122] Cognitive Market Research, Blue Biotechnology Market Report 2024 (Global Edition), 2023. https://www.cognitivemarketresearch.com/blue-biotechnology-market-report.
[123] Market Research Future (MRFR). (2024). Global blue biotechnology market research report: Forecast to 2032.

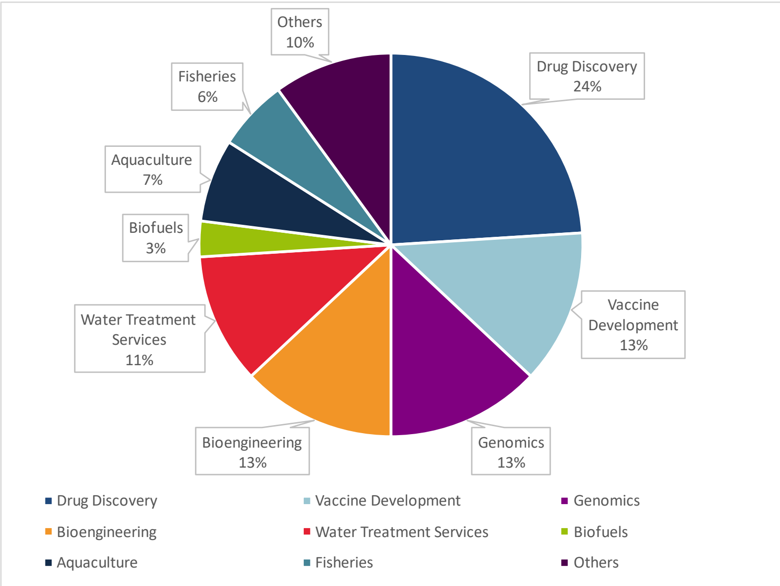
Figure 26 *Blue biotechnology* market value by EU Member State, 2021



Source: own elaboration based on data from Market Research Future

In terms of applications, the medical and pharmaceutical sectors are at the forefront of *Blue biotechnology* development both in the EU and worldwide. As of 2021, it was estimated that 'drug discovery' made up 24% of Blue biotechnology market value in EU, with vaccine development, genomics and bioengineering each contributing 13% (Figure 27). Vaccine development and genomics are also believed to contribute the most to the future growth of the sector, with a CAGR of respectively 10.2% and 9.06% until 2032, according to MRFR. These trends are common to all EU Member States and reflect the increasing interest of consumers towards products based on marine compounds, together with the fact that pharmaceuticals and medical applications tend to have high added value.

Figure 27 *Blue biotechnology* market value by application, 2021



Source: own elaboration based on data from Market Research Future

An insightful analysis of the blue economy sector's recent developments can be also gleaned from Hub Azul[124], a platform launched by Fórum Oceano, Portugal's Blue Economy Cluster. Hub Azul serves as a networking tool connecting blue economy businesses with potential investors. While the data provided is not comprehensive [125] due to voluntary participation, it still offers valuable insights into emerging industry trends. As of March 2024, there are 163 European start-ups and scale-ups from *Blue biotechnology* that are registered on Hub Azul, with an overall **economic value** in 2023 of about €1.1 billion.

In terms of **employment**, Hub Azul reports 3 957 workers in the sector in 2023. Employment remains concentrated in smaller companies and startups. Large enterprises currently employ a relatively small portion of the overall *Blue biotechnology* workforce in Europe. This is usually a typical sign of a nascent and vibrant industry, where most of the business takes place in relatively new and small companies, which have not yet had enough time to grow

[124] https://hubazul.pt/en/landing-page-en.

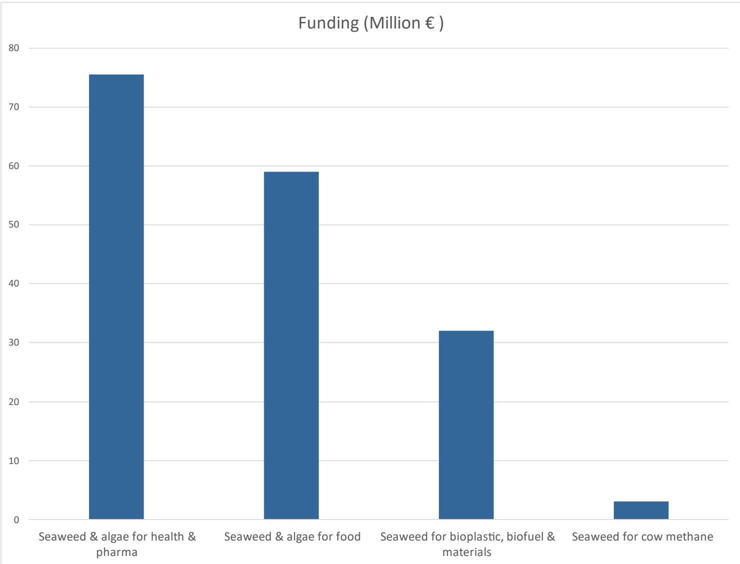
[125] It should also be noted that, as subscription is voluntary, there might also be self-selection and survivorship biases, meaning that the companies that are actually on Hub Azul might also happen to be the most proactive and successful ones, and so they are not representative of the whole population.

large. At the same time, the distribution of employment and the predominance of small companies is also a sign of inherent fragility, though it is expected that, as the EU *Blue biotechnology* ecosystem continues maturing, employment at larger companies may increase over time.

One of the difficulties that small companies face in their growth towards commercial maturity is the strain in accessing credit on the private market. This is because innovative companies are inherently risky. High-risk investments – which ultimately are investments with higher probability to fail – are usually associated with high returns on investments, typically from venture capitalists and equity investors, who are accustomed to taking high risks, if the prospects are good. However, *Blue biotechnology* companies are often too capital-intensive – due to the high costs of research & development – for venture capitalists and too risky for equity financing. In this sense, initiatives such as BlueInvest[126] and European Investment Bank loans[127] are of special significance, as they contribute to lower the risk profile of innovative companies.

Nonetheless, the EU *Blue biotechnology* sector is comparatively rather vital and seems to be attracting the interest of venture capital. From the sample of companies and investors covered by Hub Azul, **private funding** in *Blue biotechnology* tallied €184 million in 2023[128]. The overwhelming majority, approximately 95%, of investments in this segment have been directed towards startups focusing on seaweed and algae, with a wide range of applications including pharmaceuticals, food, feed supplements for reducing cow methane emissions, biomaterials, and biofuels (Figure 28).

Figure 28 *Blue biotechnology* funding by segment (€ million)



Source: Hub Azul, own elaboration.

Opportunities for growth in *Blue biotechnology* underscore the sector's potential to address global challenges related to human health, food security, energy sustainability, and environmental protection. By leveraging marine biodiversity, technological innovation, and interdisciplinary collaboration, stakeholders can unlock the full economic and societal benefits of *Blue biotechnology* while safeguarding marine ecosystems for future generations. Some promising applications of blue biotechnology include:

Development of novel therapeutics: marine organisms produce a wide range of bioactive compounds with potential pharmaceutical applications, including antimicrobial agents, anticancer drugs, and anti-inflammatory compounds. Exploiting these natural resources can lead to the discovery of new drugs and therapies[129].

Nutraceuticals and functional foods: marine-derived ingredients can be incorporated into functional foods and nutraceuticals, offering health benefits such as omega-3 fatty acids, antioxidants, and vitamins. The growing demand for natural and functional ingredients presents opportunities for the development of marine-based food and dietary supplement[130].

Bioenergy[131] and ***bioremediation***[132]: marine microorganisms and algae can be used for the production of biofuels, such as biodiesel and bioethanol, as well as for bioremediation purposes to clean up marine pollution. These applications contribute to the development of sustainable energy sources and environmental conservation efforts.

Bioprospecting *and* ***biodiversity conservation***: exploring marine biodiversity for biotechnological purposes can lead to the discovery of new species and genetic resources with potential commercial value. By promoting biodiversity conservation and sustainable use of marine resources, *Blue biotechnology* contributes to the preservation of marine ecosystems.

For more information, please visit the section on [Blue biotechnology] within the EU Blue Economy Observatory.

[126] https://maritime-forum.ec.europa.eu/theme/investments/blueinvest_en.
[127] https://www.eib.org/en/projects/topics/energy-natural-resources/preserving-our-oceans/index.htm.
[128] Note that data from the past 12 months are not yet consolidated, and thus are most certainly underestimated.
[129] Mayer AM, Rodríguez AD, Berlinck RG, Hamann MT. Marine pharmacology in 2005-6: Marine compounds with anthelmintic, antibacterial, anticoagulant, antifungal, anti-inflammatory, antimalarial, antiprotozoal, antituberculosis, and antiviral activities; affecting the cardiovascular, immune and nervous systems, and other miscellaneous mechanisms of action. Biochim Biophys Acta. 2009 May;1790(5):283-308. doi: 10.1016/j.bbagen.2009.03.011.
[130] Calder, P.C., Marine omega-3 fatty acids and inflammatory processes: Effects, mechanisms and clinical relevance, Biochimica et Biophysica Acta (BBA) - Molecular and Cell Biology of Lipids, Volume 1851, Issue 4, 2015, Pages 469-484, ISSN 1388-1981, https://doi.org/10.1016/j.bbalip.2014.08.010.
[131] Borowitzka, M.A., Moheimani, N.R. Sustainable biofuels from algae. Mitig Adapt Strateg Glob Change 18, 13–25 (2013). https://doi.org/10.1007/s11027-010-9271-9.
[132] Aliko, V.; Multisanti, C.R.; Turani, B.; Faggio, C. Get Rid of Marine Pollution: Bioremediation an Innovative, Attractive, and Successful Cleaning Strategy. Sustainability 2022, 14, 11784. https://doi.org/10.3390/su141811784.

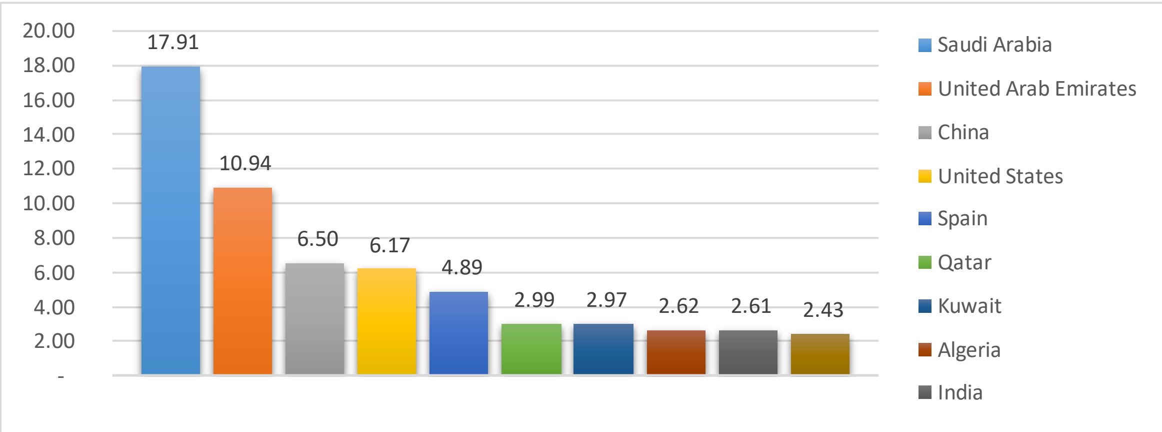
2.9. DESALINATION

Desalination addresses global water scarcity. It is predicted that many regions in the EU – especially, southern European Member States – will face severe water scarcity by 2050, when water demand is expected to increase by up to 30%[133] with the progress of global warming. According to the PESETA IV project[134], the population currently exposed to severe water scarcity may rise from about 50 million at present, up to 65 million people under an increase of 3°C in global average temperature[135]. Using different technologies – ranging from thermal processes such as multistage flash distillation (MSF) and thermal vapour compression (TVC) to membrane processes such as reverse osmosis (RO) – *Desalination* allows the removal of dissolved inorganic substances (salts and other minerals) mainly from seawater, but also from brackish water or wastewater.

The global Desalination capacity

Global installed capacity for the production of desalinated water has increased significantly in recent years. In 2018, there were nearly 16 000 *Desalination* plants worldwide[136], with a total global operating capacity of roughly 95.37 million m^3/day (million cubic litres/day)[137]. More recent studies estimate that there were more than 21 000 seawater *Desalination* plants in 2022, with a daily global production of 99 million m^3/day of desalinated water, but also more than 150 million m^3/day of brine byproduct[138]. Currently, *Desalination* is largely used in the Middle East and North Africa (MENA region) – accounting for 70% of global capacity – in the US, and only to a limited extent in Europe (about 10% of global capacity)[139] (Figure 29).

Figure 29 Top 10 countries by installed capacity, 2024 (Million m3/day)



Source: Desaldata, own elaboration.

The industry comprises a wide range of companies operating at all levels of the ***Desalination* value chain**, from plant construction to water distribution. This includes providers of raw material, equipment manufacturing companies, maintenance and service providers, plant operation companies, water supply infrastructure/services, as well as financial intermediaries. Upstream activities include product and service development, procurement, supply, and manufacturing.

Current ***Desalination* technologies** include[140]:

Membrane technologies: RO is the most frequently used technique. It consists of filtering water through membranes under high pressure that retain salt. Electrical Dialysis Reversal (EDR) is another membrane process where the salts are separated from the water by applying an electric potential difference.

Thermally-driven technologies: these use heat to evaporate water and subsequently condense it again. Thermally driven technologies include MSF, TVC, multi-effect distillation (MED), and mechanical vapour compression (MVC). Membrane distillation (MD) is an emerging hybrid thermal process making also use of membranes.

MSF and RO currently dominate the global *Desalination* market, with the latter being by far the most widely used technology in the EU, accounting for 88.5% of total capacity. On the other hand, thermal processes are still employed to a considerable extent in the MENA region (MSF: 31%, MED: 9%), especially due to low-cost fuels and co-location with large power plants[141].

Desalination plants can be classified by operational capacity as small (less than 1 000 m^3/day), medium (1 000-10 000 m^3/day), large (10 000-50 000 m^3/day), or extra-large (over 50 000 m^3/day). Plants can be installed on land, on offshore platforms, or mobile.

[133] World Resources Institute. https://www.wri.org/freshwater
[134] https://joint-research-centre.ec.europa.eu/peseta-projects/jrc-peseta-iv/water-resources_en.
[135] Bisselink B., Bernhard J., Gelati E., Adamovic M., Guenther S., Mentaschi L., Feyen L., and de Roo, A, Climate change and Europe's water resources, EUR 29951 EN, Publications Office of the European Union, Luxembourg, 2020, ISBN 978-92-76-10398-1, doi:10.2760/15553, JRC118586.
[136] Of these, 11,724 are currently operating, representing 85% of the total number of facilities and accounting for 92% of the global capacity.
[137] Jones, E., Qadir, M., van Vliet, M. T., Smakhtin, V., & Kang, S. M. (2019). The state of desalination and brine production: A global outlook. Science of the Total Environment, 657, 1343-1356.
[138] Eyl-Mazzega M.A. and É. Cassignol, (2022). The Geopolitics of Seawater Desalination, Études de l'Ifri, IFPRI, September 2022.
Sirota, R., Winters, G., Levy, O., Marques, J., Paytan, A., Silverman, J., ... & Bar-Zeev, E. (2023). Impacts of Desalination Brine Discharge on Benthic Ecosystems. Environmental Science & Technology.
[139] The European Climate Adaptation Platform Climate (ADAPT). https://climate-adapt.eea.europa.eu/en/metadata/adaptation-options/desalinisation.
[140] *Ibid.*
[141] DesalData.

Land-based *Desalination* plants provide most of the world's *Desalination* capacity (approximately 95%), while offshore-based plants represent less than 3% of installed capacity[142].

The EU Desalination sector today

Desalination is a rapidly emerging sector with a large potential. In the EU, only a relatively small fraction of freshwater is obtained through seawater desalination. *Desalination* in the EU has developed almost exclusively in response to territorial water shortages in the early 1990s, with small plants supplying drinking water to hotels and resorts. Given that climate change will exacerbate the natural fluctuations in seasonal water availability, it is expected that the EU *Desalination* market will expand in the coming years[143].

To-date, EU facilities can supply up to 3.4 billion m^3 of desalted water a year (active capacity), mainly from seawater and brackish water. There are about 2 336 *Desalination* plants installed in the EU (Spain 65%, Italy 7%, Germany 4%, Netherlands 4%, and Cyprus 4%), out of which 1 779 active facilities that use seawater and brackish water, and the trend is increasing. They produce 9.37 Mm3/day of freshwater, i.e. over 80% of total production of desalinated water in Europe[144].

Desalination capacity in Europe has grown significantly over the first decade of the century, with 4.58 million m^3/day of new capacity between 2000 and 2009 with a total investment of €4 billion in Engineering, Procurement and Construction. Between 2010 and 2019 the new commissioned capacity was only 0.84 million m^3/day with an estimated investment of €630 million. Since 2010, most of the new capacity installed has been in the form of small and medium size plants. Most of the large and extra-large plants commissioned between 2000 and 2010 were built to serve large coastal cities, such as Barcelona and Alicante in Spain[145].

71% of the water produced is used for public water supply (2 billion m^3, 4.2% of total water employed in public supply)[146]. 17% of the desalinated water produced in the EU is used for industrial applications, 4% in power plants, and 8% for irrigation[147]. EU *Desalination* plants are mainly located in Mediterranean Member States, where they will be mostly needed in the future: about 1 200 plants provide a capacity of 2.37 billion m^3 (82% of total EU desalination capacity)[148].

About 65% of the operational plants in the EU are located in coastal areas or offshore. The offshore plants support offshore activities, mostly oil and gas fields. The inland plants are used for the production of drinking water and industrial water; often through a process of purification of saline/brackish water present in local aquifers.

Some of the largest suppliers of *Desalination* equipment are EU-based companies. According to the ORBIS database[149], a total of 413 large-scale companies headquartered in the EU-27 are active in the *Desalination* market value chain, as per their official trade description[150]. Of these, 20.3% are located in France (84), followed by Germany (74) with 17.9%, Spain (59) with 14.3% and Italy (42) with 10.2%.

When looking at the geographic distribution of *Desalination* plants in Europe, the picture is slightly different. Out of the 2 815 *Desalination* plants currently on record in the DesalData database, 77.4% (2 336 plants) are located in the EU-27. 39% of them (914) are located in Spain, 16.4% (387) in Greece, 14.5% (342) in Italy, 7.8% (184) in Germany, and 3.6% (85) in France. It should be noted that not all of the plants listed above are currently active. Some are under construction, while others are still in planning stage. The geographical concentration of these plants is further illustrated in Figure 30.

[142] *Ibid*.

[143] de Roo et al. 2021. The Water-Energy-Food-Ecosystem Nexus in the Mediterranean: Current Issues and Future Challenges. The Water-Energy-Food-Ecosystem Nexus in the Mediterranean: Current Issues and Future Challenges.

de Roo et al. 2023. Water-Energy-Food-Ecosystems pathways towards reducing water scarcity in Europe. https://publications.jrc.ec.europa.eu/repository/handle/JRC133439.

Post, J., De Jong, P., Mallory, M., Doussineau, M. and Gnamus, A. 2021. Smart Specialisation in the Context of Blue Economy – Analysis of Desalination Sector. https://publications.jrc.ec.europa.eu/repository/handle/JRC125905.

[144] DesalData.

[145] Post, J., de Jong, P., Mallory, M., Doussineau, M., & Gnamus, A. (2021). Smart Specialisation in the Context of Blue Economy–Analysis of Desalination Sector. Publications Office of the European Union, Luxembourg https://doi. org/10.2760/058360.

[146] DesalData (March 2024) and The European Climate Adaptation Platform (ADAPT). https://climate-adapt.eea.europa.eu/en/metadata/adaptation-options/desalinisation.

[147] Adamovic et al. 2019. Energy Nexus in Europe. EC Joint Research Centre. doi:10.2760/285180, JRC115853.

[148] The European Climate Adaptation Platform (ClimateADAPT). https://climate-adapt.eea.europa.eu/en/metadata/adaptation-options/desalinisation.

[149] Orbis is a proprietary database managed by Bureau Van Dijk, a Moody's analytics company. https://login.bvdinfo.com/R0/Orbis.

[150] Out of a total of 5045 companies having the 'desalination' in their trade or product descriptions (in any of EU-27 languages), 413 companies are headquartered in the EU-27.

Figure 30 Geographical distribution of desalination plants in the EU-27, 2024

Source: Desaldata, own elaboration.

Trends and drivers

COVID-19 impacts: the impact of the pandemic on the *Desalination* industry was evident in terms of contracted capacity, which in 2021 decreased by 1.3 million m^3/day compared to 2020[151]. Conversely, the operating capacity was not significantly affected, except for the temporary disruption of the supply chain, which increased the cost of desalinated water[152]. On a global scale, the *Desalination* sector has now recovered from the COVID-19 pandemic, as well as from the supply chain issues and price increases that hit the global markets in 2021. In 2022, the volume of newly-contracted seawater and brackish water *Desalination* capacity was 4.4 million m^3/day, up from 3.3 million m^3/day in 2021[153]. However, the development of the sector, compared to pre-COVID-19 forecasts, still reflects a slowdown in project supply. With increased shipping costs, doubled oil prices and soaring material costs, many construction projects remained inactive during the pandemic and some were cancelled or reissued.

Market expansion: *Desalination* is fast becoming a conventional method for water treatment globally. In line with global trends, the European *Desalination* market is expected to enter an expansionary phase not only to address the consequences of climate change, but also to embrace policy-driven technological developments to reduce its operational costs and environmental impacts. As an illustration of this trend, in September 2023 the Spanish government announced an investment plan of more than €12 billion to mitigate the effects of droughts, stating that the funds would be used to water reuse, the construction of desalination plants and the improvement of water infrastructure[154]. In February 2024, it was reported that two new facilities would be built south and north of Barcelona at a cost of €467 million[155].

Innovation: Increasing the supply of desalinated water to meet the growing demand for all uses requires a significant R&D effort aimed at developing viable energy-efficient technologies and deployable solutions at scale to modernise or replace obsolete facilities, while reducing operational costs. The EU supports public-private partnerships that deliver innovation in the *Desalination* sector. Under the Horizon 2020 programme, €23.3 million were allocated to innovation actions for the period 2014-2019 (Post et al., 2021)[156]. Several EU companies rank among the top patenting companies when it comes to the R&D related to desalination powered by renewable energy sources. However, RO innovations are mainly coming from China (45%), Japan (27%) and South Korea (1%) – while the EU contribution to global R&D on RO being rather modest (3%).

Decarbonisation: In 2020, the proportion of renewable energy used in *Desalination* was around 1%, which explains its relatively large carbon footprint. The *Desalination* industry must decarbonise its sources of energy in order to become more sustainable. Using an engineering costing model, it has been estimated that a large share of the population in the Mediterranean region could be serviced by photovoltaic-fuelled RO desalination at a cost below €1/m^3 (Pistocchi et al., 2020)[157]. A stand-alone plant producing desalinated water with photovoltaic production on site has higher initial capital costs, but operational costs are lower, making photovoltaic-RO plants – a virtually decarbonised solution – competitive in the long run. Other renewable energy sources may be equally valid. For instance, the EU-funded H2020 W2O project demonstrated the economic viability of the world's first wave-driven *Desalination* system, Wave2O. This operates completely 'off-grid' to supply large quantities of affordable fresh water (Cordis, 2024).

Environmental impacts: *Desalination* can create harmful environmental impacts on marine ecosystems. The process of extracting salt from seawater requires large amounts of energy. Insofar as this energy originates from fossil fuels, it contributes to greenhouse gas emissions and climate change. Moreover, the discharge of brine (salt-saturated water) back into the ocean can disrupt the balance of salinity, affecting marine flora and fauna. Approximately 1.5 litres of brine are produced as waste for every litre of fresh water. As brine is heavier than normal seawater, it accumulates on the seafloor, threatening species which are

[151] IDRA Desalination & Reuse Handbook 2023 -2024, Water Desalination Report.
[152] DesalData Market Report, July 2023.
[153] IDRA Desalination & Reuse Handbook 2023 -2024, Water Desalination Report.
[154] https://www.reuters.com/world/europe/spain-invest-1285-bln-alleviate-drought-impact-2023-09-12/.
[155] https://www.reuters.com/world/europe/spain-invest-502-mln-desalination-plants-catalonia-amid-drought-2024-02-05/.
[156] Post J., de Jong P., Mallory M., Doussineau M., Gnamus A. (2021). Smart Specialisation in the Context of Blue Economy – Analysis of Desalination Sector. Publications Office of the European Union, Luxembourg, doi:10.2760/058360.
[157] Pistocchi, A., et al. (2020). Can seawater desalination be a win-win fix to our water cycle? Water research, 115906. https://doi.org/10.1016/j.watres.2020.115906.

sensitive to the level of salinity[158]. The potential environmental impact of *Desalination* underscores the need for sustainable practices in *Desalination* processes and brine disposal, in line with the provisions of the EU Biodiversity Strategy[159] and the EU Zero Pollution Action Plan[160].

For more information visit the section on *Desalination* within the EU Blue Economy Observatory.

[158] European Environment Agency, 2012. EEA Report No 1/2012. Towards efficient use of water resources in Europe.
[159] COM/2020/380 final.
[160] *Ibid.*

CHAPTER 3

ENERGY TRANSITION IN THE EU BLUE ECONOMY AND COASTAL FLOOD IMPACTS

The EGD[161] calls for a transition towards a modern, resource-efficient and competitive economy where net greenhouse gas (GHG) emissions are gradually phased out by 2050 and the EU's natural capital is protected. In the trajectory towards EU climate neutrality, the Commission aims to reduce net GHG emissions by at least 55% by 2030[162] (Figure 31). This long-term strategy sets out a comprehensive package of measures ranging from ambitious GHG emission reductions, to cutting-edge research and innovation for the development of low carbon technologies, to the preservation of Europe's natural environment[163].

In this context, a sustainable Blue Economy offers many solutions to achieve the EGD objectives. However, this requires some of the current activities, technologies and processes to reduce their carbon footprint, while climate neutral activities and technologies need to play a central role in the EU Blue Economy.

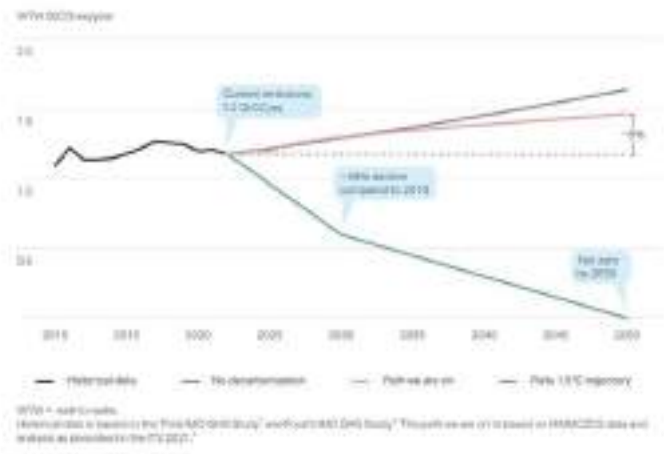
For more information, please visit the section on Energy Transition within the EU Blue Economy Observatory.

3.1. ENERGY TRANSITION IN THE EU MARITIME TRANSPORT

The European climate law makes reaching the EU's climate goal of reducing EU emissions by at least 55% by 2030 a legal obligation. While *Maritime transport* is one of the most efficient means of transport, it is estimated to cause 13.5% of the EU transport emissions[164]. Globally, it is responsible for roughly 3% of emissions caused by human activities.

In 2022, According to the Mærsk Mc-Kinney Møller Center for Zero Carbon Shipping analysis, business as usual would result in an increase of 9% in sectorial emissions, requiring direct and form action from the industry, to achieve the 1.5 target[165].

Figure 31 Maritime Decarbonisation Strategy 2022



Source: Mærsk Mc-Kinney Møller Center for Zero Carbon Shipping

The 'Fit for 55' package includes reforms to the *Maritime transport* sector. Among these reforms, the EU emissions trading system (EU ETS) has been introduced in 2024 and will limit the emissions of large ships (above 5 000 GT) carrying goods and passengers departing from and arriving in EU ports, regardless of their flag[166]. The system covers 50% of emissions from voyages starting or ending outside of the EU, and 100% for voyages occurring between two EU ports and when ships are within EU ports. The reform initially covers CO_2 emissions only, with methane and nitrous oxide scheduled from 2026 onwards. The system builds on the provisions in place for other EU ETS sectors as well as the revised EU Monitoring, Reporting and Verification Regulation for *Maritime transport*, according to which vessels are obliged to report the amounts of CO_2 emitted. Generated revenues will be channelled into the Innovation Fund[167] to drive innovation of the sector and accelerate the decarbonisation process.

Still in the context of the 'Fit for 55' package, the European Commission proposed the Alternative Fuels Infrastructure Regulation[168]. Specifically on the maritime sector, the Regulation sets targets for the deployment of shore-side electricity supply for certain seagoing container and passenger ships (above 5 000 GT) in maritime ports. Ports that have an average annual number of calls over the last three years of 50, 40 and 25 for containerships, seagoing ro-ro passenger ships and high-speed passenger crafts, and other passenger ships respectively, must guarantee sufficient shore-side power output to meet at least 90% of that demand.

Furthermore, the FuelEU maritime Regulation will oblige vessels above 5 000 GT calling EU ports, with exceptions such as fishing ships, to reduce GHG intensity of the energy used on board gradually. By 2025, these vessels will be required to reduce the annual average carbon intensity (compared to a 2020 baseline) by 2%, to as much as to 80% by 2050. Also, the vessels will be obliged to connect to onshore power supply for their electrical power needs, unless they use another zero-emission technology.

The International Maritime Organisation committed in 2023 to reaching net-zero emissions of the global transport fleet by or around 2050. By 2025, mid-term measures must be approved and

[161] Communication from the Commission to the European Parliament, the European Council, the Council, the European Economic and Social Committee and the Committee of the Regions on the European Green Deal. COM(2019) 640.
[162] Communication from the Commission to the European Parliament, the European Council, the Council, the European Economic and Social Committee and the Committee of the Regions on Stepping up Europe's 2030 climate ambition Investing in a climate-neutral future for the benefit of our people (COM/2020/562).
[163] https://ec.europa.eu/clima/policies/eu-climate-action_en.
[164] https://www.consilium.europa.eu/en/infographics/fit-for-55-refueleu-and-fueleu.
[165] Maritime Decarbonization Strategy 2022, Mærsk Mc-Kinney Møller Center for Zero Carbon Shipping, https://cms.zerocarbonshipping.com/media/uploads/publications/Maritime-Decarbonization-Strategy-2022.pdf.
[166] DIRECTIVE (EU) 2023/959.
[167] https://climate.ec.europa.eu/eu-action/eu-funding-climate-action/innovation-fund_en.
[168] COM/2021/559.

will enter into force by 2027; by 2030 CO_2 emissions should be reduced by at least 20% and by at least 70% by 2040[169]. This is in line with the IPCC call to reduce emissions in all sectors, to achieve carbon neutrality in 2050 and maintain climate change below the target of 1.5ºC.

The future fuel transition for the Maritime transport sector

Decarbonising the maritime industry will require a shift in technology (fuel cells, internal combustion engines) and operations to increase energy efficiency (slow steaming, cleaning and coating, waste heat recovery, hull and propeller design) as well as an uptake of alternative fuels (nuclear, hydrogen, ammonia, methanol)[170] and renewable energy sources (wind, solar)[171]. These all have implications for the shipbuilding sector for both in terms of new builds and retrofitting technology in existing vessels.

EU technology providers are well positioned to be involved in the future energy transition, although Asian shipyards are also increasing their technology capabilities. There are numerous EU initiatives to support the shipping sector, and in turn the EU industry, including shipowners, equipment manufacturers, port authorities, terminal operators, and shipbuilders, along the path to decarbonisation. Through the FuelEU Maritime Regulation, the European Commission – with EMSA's assistance – is aiming to increase the use of sustainable alternative fuels in EU shipping and ports, by addressing market barriers and uncertainty over which technical options are market-ready. The Net-Zero Industry Act (NZIA), as part of the Green Deal Industrial Plan, could enhance the competitiveness of the EU shipping sector by directing essential investments toward clean technologies and production capacity of shipping fuels[172]. The ERDF[173] and the Innovation Fund[174] can support projects including innovative clean and low-carbon technologies. EMSA provides industry with research on safety aspects associated with alternative propulsion technologies[175]. The European Community Shipowners Association (ECSA) is also helping the sector to co-ordinate actions and share information on alternative fuel developments[176].

The future fuel transition is leading to development of competing engine technologies, with a clear path forward yet to emerge[177]. Some of the main alternative fuels being explored for shipping are biofuels, ammonia, hydrogen, methanol[178], wind-assisted propulsion systems[179]. Each exhibit different characteristics that provide benefits and challenges relative to other options:

Biofuels (e.g. biomethanol) present viable marine fuel alternatives in the medium and long term, with the potential for swift market integration. Meeting sustainability standards, they hold promise for curbing carbon emissions compared to conventional fossil fuels. The 'drop-in' feature of biofuels allows for seamless substitution of petroleum-derived hydrocarbons, often without requiring significant adjustments to engines, fuel infrastructure, or supply chains, offering an efficient and immediate solution for current fleets[180]. One of the major challenges remains the resources needed for the production.

Ammonia is truly zero-carbon if produced with renewable energy sources; it is relatively easy to handle and has good energy density. But it is the least advanced alternative low-carbon fuel, due to a lack of commercial on-board storage solutions with concerns over its toxicity and non-carbon emissions[181]. There are no vessels currently in service, but eight vessels are being built or retrofitted for using ammonia[182].

Hydrogen has a lot of positive attributes, with green hydrogen produced with renewable energy being genuinely zero-carbon. But storage, safety and indirect GHG emission remain challenges to commercial uptake[183]. There are many EU and Norwegian hydrogen research projects working to find solutions to these and other challenges, but as of 2022 there were only two hydrogen vessels in service and a further four on order[184]. Countries such as Norway are supporting and incentivising the transition to hydrogen-based fuels for shipping, with taxing of emissions and a series of funding agencies[185].

Methanol is a very promising alternative fuel as it is a liquid at ambient temperatures, has a similar energy density to ammonia and is highly soluble in water, reducing environmental risk from spills. When burnt, methanol still results in CO_2 emissions, but the production of e-methanol by combining green hydrogen and carbon dioxide results in a lower overall emissions[186]. Up to 97% methanol can be used in new methanol engines and the EU-funded FASTWATER project[187] showed the ability to blend in up to 70% methanol into retrofitted engines. This technology-readiness has led to 18 EU vessels using methanol in service in 2022 with a further 22 on order[188]. And the ability to secure sufficient supplies of green methanol has led major shipping lines such as Maersk to introduce methanol-fuelled vessels[189].

Wind Assisted Propulsion Systems (WAPS) are most suited for (1) slower sailing vessels (2) with free deck-space (3) that sail on windier routes. Uptake in shipping has been slower than some other technologies as the return on investment is currently low and engine

[169] https://www.imo.org/en/MediaCentre/HotTopics/Pages/Cutting-GHG-emissions.aspx
[170] UNCTAD, 2023. https://unctad.org/system/files/official-document/rmt2023_en.pdf
[171] Mallouppas, G. and Yfantis, E.A., 2021. Decarbonization in shipping industry: A review of research, technology development, and innovation proposals. Journal of Marine Science and Engineering, 9(4), p.415.
[172] https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/european-green-deal/green-deal-industrial-plan/net-zero-industry-act_en
[173] European Regional Development Fund (ERDF). https://commission.europa.eu/funding-tenders/find-funding/eu-funding-programmes/european-regional-development-fund-erdf_en.
[174] Innovation Fund. https://climate.ec.europa.eu/eu-action/eu-funding-climate-action/innovation-fund_en.
[175] https://emsa.europa.eu/publications/reports.html.
[176] https://www.ecsa.eu/index.php/resources/race-zero-emission.
[177] https://www.dnv.com/maritime/publications/maritime-forecast-2023/index.html.
[178] We refer to alternative fuels that are obtained by using renewable energy sources (e.g. green hydrogen as opposed to grey hydrogen).
[179] https://afdc.energy.gov/files/u/publication/fuel_comparison_chart.pdf.
[180] EMSA - Update on Potential of Biofuels for Shipping 2023.
[181] https://www.lr.org/en/expertise/maritime-energy-transition/maritime-decarbonisation-hub/zcfm/.
[182] https://www.midc.be/ammonia.
[183] https://www.lr.org/en/expertise/maritime-energy-transition/maritime-decarbonisation-hub/zcfm/hydrogen/
[184] https://www.midc.be/hydrogen.
[185] https://wwwcdn.imo.org/localresources/en/OurWork/Environment/Documents/Air%20pollution/The%20Governments%20action%20plan%20for%20green%20shipping.pdf.
[186] https://www.lr.org/en/expertise/maritime-energy-transition/maritime-decarbonisation-hub/zcfm/methanol/.
[187] https://www.fastwater.eu/.
[188] https://www.midc.be/methanol.
[189] https://www.maersk.com/news/articles/2023/06/13/maersk-secures-green-methanol.

integration is complex. 16 vessels using WAPS technology are in service and 13 are on order[190]; five of these vessels via an EU-funded project, WASP[191]. The company Bound4blue is also using this technology (eSails) and has received funding by the EMFAF and innovation funds at regional level[192].

Electrification via hybrid propulsion or fully electric engines is dependent on battery storage and more suited to smaller vessels/shorter trips.

A milder approach to the urgent need of the sector's decarbonisation is the shift towards LNG. The EU is consolidating its global technological leadership, particularly in the infrastructure, which offers a diversity of services from large- to small-scale operations, including LNG terminals, refuelling stations, and refuelling and transhipment processes. While LNG does reduce carbon dioxide emissions, as a carbon-based fuel it continues to emit carbon dioxide and can only be used as a mitigation option[193].

The Commission published the European Maritime Transport Environmental Report (EMTER) in 2021, prepared by EMSA and the European Environment Agency (EEA). The report analyses the *Maritime transport* sector, its environmental impact, progress made so far, and the challenges it still faces going forward in terms of decarbonisation, pollution reduction to air and water, including underwater noise, protection of biodiversity, circularity and climate adaptation. A second edition of the EMTER is preparation and planned for publication in 2025.

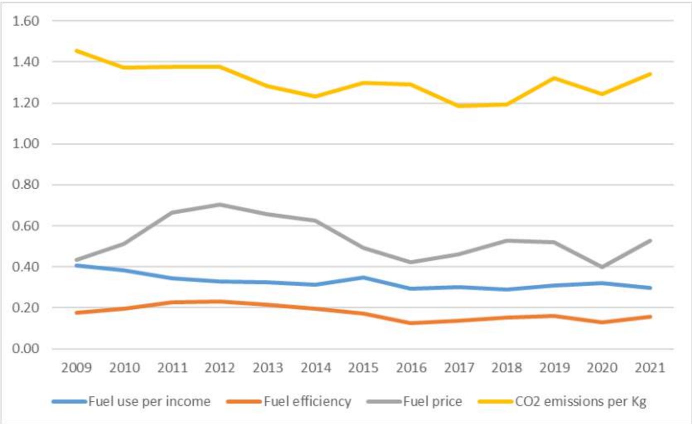
3.2. ENERGY TRANSITION IN THE EU FISHING FLEET

The process of decarbonisation also implies the necessary energy transition in the EU fishing fleet. In February 2023, the Commission presented a Communication on the Energy Transition of the EU fisheries and aquaculture sector to support the sector to become more economically resilient to high energy prices and transition towards climate neutrality[194]. The main objectives of the measures are to promote the use of cleaner energy sources and reduce dependency on fossil fuels as well as to lower the sector's impact on marine ecosystems. The communication was included in the Fisheries and Aquaculture package, which included four communications[195].

In June 2023, as a follow up to the Communication, the Commission launched the Energy Transition Partnership (ETP)[196] for fisheries and aquaculture. The partnership aims to be a platform for stakeholder cooperation on the energy transition, through which discussions with a different range of stakeholders will take place on the challenges and solutions for the energy transition in the sector.

The EU fishing fleet consumed 1.81 billion litres of fuel to land 3.6 million tonnes of fish valued 6 billion at the first sale in 2021. This fuel consumption leads to the emission of roughly 4.8 million tonnes of CO_2. Between 2009 and 2021, the fuel consumption and therefore CO_2 emissions decreased by 25%, while fish landings in weight decreased by 17%, despite increasing by 3% in value.

Figure 32 Evolution of Fuel intensity (l/kg), Fuel efficiency (%), Fuel use per income (l/€) and Fuel price for 2009-21



Source: Own elaboration from STECF data[197].

Fuel use and efficiency for the fisheries sector can be defined as follows:

CO_2 emissions per kg of fish is defined as emissions of CO_2 from the fuel consumed per quantity of fish landed, expressed as kg per kg;

Fuel efficiency is defined as the ratio between fuel costs and income from landings, expressed as a percentage;

Fuel use per income generated is defined as the ratio between the quantity of fuel consumed and the value of landings, expressed as litres per euro.

The EU fleet has become more fuel efficient over the years, yet has shown less efficiency in more recent years, mainly due to rising fuel prices (Figure 32). Fuel efficiency is largely a result of fuel prices. Fuel price increases lead to higher fuel costs, worsening the efficiency. The lower the percentage, the more fuel efficient the vessel (i.e., less income is used to cover fuel costs). Fuel costs as a

[190] https://www.midc.be/waps.
[191] https://northsearegion.eu/wasp/.
[192] https://bound4blue.com/about/.
[193] Wang et al. 2023. The use of alternative fuels for maritime decarbonization: Special marine environmental risks and solutions from an international law perspective. Frontiers in Marine Science, 9, p.1082453.
[194] COM (2023) 100 final.
[195] https://ec.europa.eu/commission/presscorner/detail/en/IP_23_828.
[196] Energy Transition Partnership - European Commission (europa.eu).
[197] STECF (Scientific, Technical and Economic Committee for Fisheries). The 2023 Annual Economic Report on the EU Fishing Fleet; Publications Office of the European Union: Luxembourg, 2023.

proportion of income were estimated at 12% in 2021, reaching the lowest historical level in 2012 and 2020.

The CO_2 emissions per kg of fish show a decreasing trend over time, an 8%-decrease between 2009 and 2021. This could be partly explained by the better status of some key fish stocks as well as the aim of the sector to reduce fuel consumption. In 2021, the EU fishing fleet directly emitted 1.34 kg of CO_2 to land a kg of fish. These emissions vary significantly by fishing method and species targeted, with pelagic trawling to catch small pelagics producing the lowest emissions. Typically, seafood has on average a lower carbon footprint than animal production on land.

The fuel price break-even is the point at which total revenues and total costs are equal, determined by the price of fuel. In 2021, the average price break-even fuel price across the different regions and fishing techniques was €/litre 1.17 for the short term of and €/litre 0.77 for the long-term break-even fuel price. The small-scale coastal fleet (SSCF) is generally more resilient to high-fuel prices, than the large-scale fleet (LSF).

GHG emissions in the fishing sector

Most studies identify fish capture as the activity causing most of the GHG emissions from fisheries, and diesel fuel consumption used to power the fishing vessel as the main source of emissions. When measuring GHG emissions from fisheries, fuel consumption is often quantified in terms of litre of fuel used per kg of edible fish landed (litre/kg). This figure can be converted to emissions of carbon dioxide equivalent per tonne of edible fish landed (CO_2eq/kg). Depending on the fishery, fuel use intensity can vary from less than 1 to up to 10 litre/kg[198], which represent emissions up to 5 CO_2eq/kg[199]. Fuel intensity and GHG emissions from fuel use are closely correlated with the type of fish and the gear used. According to studies at global level, fishes with the highest fuel use intensity are crustacean captured with traps and lift nets (2-5 litre/kg). Flatfish fishing and the use of bottom trawls are also correlated with higher fuel use intensity (1-3 litre/kg), while small pelagic fishing and the use of surrounding nets are correlated with the lowest fuel intensity (below 0.2 litre/kg)[200].

When it comes to the whole fish supply chain life cycle assessment, processing and exports of the fish are also significant in terms of GHG emissions. Frozen preservation and extra-continental exports are associated with higher emissions than fresh preservation and domestic consumption. For some cases of seafood, emissions from exports can be higher than emissions from the fishing vessel fuel consumption, while emissions from processing can reach more than half of it[201]. The use and leakage of refrigerants also have an impact on emissions[202].

According to a recent study, indirect GHG emissions due to the impact of bottom trawling on sedimentary carbon, by direct release in the atmosphere of carbon trapped in the sediments and by ocean acidification, are also significant. However, this impact is not yet precisely quantified[203]. Overfishing also has an important impact on emissions, as fishing depleted stocks require more fuel than for a healthy halieutic resource[204].

Current options for decarbonising the fishing sector

Most initiatives and projects aiming to limit the climate impact of the fishing sector target fuel consumption, which accounts for the largest part of the known GHG emissions and is more easily quantifiable than other sources. The main options currently envisioned to reduce emissions due to fuel consumption are (1) replacing diesel fuel by other propulsion technologies (i.e.. consume less carbon intensive fuels) and/or (2) increasing energy efficiency (i.e., consume less fuel)[205]. There is no single solution to the decarbonisation of the sector and solutions have to be tailored to each fleet segments according to their specificities.

Technologies of propulsion alternative to diesel fuel include LNG, biofuels, methanol, ammonia, electrification and wind. The use of hydrogen storage to support electrification minimises the volume needed to store energy compared to batteries. Ammonia and methanol are denser, but the production of these synthetic fuels requires more energy, and they remain less dense than diesel. LNG and biofuel, which are denser than ammonia and methanol, are seen as temporary solutions to reduce emissions compared with diesel fuel, before switching to synthetic fuels. Another issue is the cost of these alternatives, which is the highest for hydrogen and ammonia[206]. A few projects are also experimenting a rebirth of wind-powered fishing based on current technologies[207].

Energy efficiency measures include a large range of options involving technical and behavioural changes. The most technical-oriented of these measures include using energy efficient gears, lighter than the traditional ones and acting on vessel design to improve their efficiency and/or reduce their speed. Larger and more modern vessels can also be, by design, more energy efficient. But such gains in the technical efficiency of ships need to be accompanied by positive behavioural change, affecting the way the ship is operated (operational efficiency), for instance through the reduction of the ship speed (slow steaming). Integrating efficiency as an explicit goal of fishery management, providing tools to measure fuel consumption and adapt fishing school training, can incentivise this type of change[208].

Besides these measures, decarbonising fisheries at a significant level is likely to need a shift of a large share of the fishing fleet to less energy-intensive gears, as difference in gear types is the main explaining factor of GHG emissions. Reducing diesel fuel subsidies or tax exemptions, favouring low-impact gear types in quota allocations (Article 17 of the Common Fisheries Policy) and in special fishing zones can help achieving such a change[209].

From decarbonisation projects to structural decarbonisation

The above-mentioned options for decarbonising the fishing sector all require to deviate from the current business model, which comes

[198] https://www.europarl.europa.eu/RegData/etudes/STUD/2023/740225/EPRS_STU(2023)740225_EN.pdf.
[199] https://www.msc.org/uk/what-we-are-doing/oceans-at-risk/climate-change-and-fishing.
[200] https://www.europarl.europa.eu/RegData/etudes/STUD/2023/740225/EPRS_STU(2023)740225_EN.pdf.
[201] https://www.sintef.no/globalassets/sintef-ocean/coolfish/7-coolfish-carbon-footprint-of-fisheries-sepideh-jafarzadeh.pdf.
[202] https://sintef.brage.unit.no/sintef-xmlui/handle/11250/2684522.
[203] https://www.frontiersin.org/articles/10.3389/fmars.2023.1125137/full.
[204] https://www.europarl.europa.eu/RegData/etudes/STUD/2023/740225/EPRS_STU(2023)740225_EN.pdf.
[205] *Ibid.*
[206] *Ibid.*
[207] https://oceans-and-fisheries.ec.europa.eu/news/breton-fishing-vessel-shows-potential-sail-power-2022-11-29_en.
[208] https://www.europarl.europa.eu/RegData/etudes/STUD/2023/740225/EPRS_STU(2023)740225_EN.pdf.
[209] https://www.europarl.europa.eu/RegData/etudes/STUD/2023/740225/EPRS_STU(2023)740225_EN.pdf.
https://stecf.jrc.ec.europa.eu/c/document_library/get_file?uuid=924c1ba8-94af-440d-94cb-f9cb124d2d57&groupId=12762.

at a cost. Significant policy incentives are needed for most of these options to be tested on the short-term. For innovations to be economically viable and become 'the new normal' on the longer term, there is a need for structural changes that can address issues such as the price gap between diesel fuel use and its alternatives and the valorisation of fishery products with a lower carbon footprint.

3.3. ENERGY TRANSITION PARTNERSHIP IN FISHERIES AND AQUACULTURE

To support the sector in this transition, the European Commission adopted a Communication[210] in February 2023 with an action plan to accelerate the energy transition in EU fisheries and aquaculture. It sets out a vision for a climate-neutral fisheries by 2050 and proposes 27 actions that can help overcome the current barriers the sector is facing in stakeholder collaboration, financing, skills development and innovation. In this Communication the European Commission has also announced the set-up of the 'Energy Transition Partnership in Fisheries and Aquaculture'.

Currently, technical, financial, regulatory, and other barriers prevent many EU fishers, aquaculture producers from accelerating the energy transition in the sector. Working together with a wide range of stakeholders to achieve concrete and practical solutions is therefore essential for making the transition.

The Energy Transition Partnership invites all stakeholders interested in accelerating the transition, to work together on a voluntary basis to bring forward the energy transition in the sector.

The ETP brings together key stakeholders to:

- Gather a community of actors;
- Start a dialogue within the sector about opportunities and challenges of the energy transition on the topic of the energy transition;
- Discuss and develop common strategic approaches for furthering the energy transition in the sector;
- Contribute to a roadmap with concrete and feasible actions to accelerate the transition in the sector;
- Showcase concrete examples of initiatives from stakeholders, and give visibility to the projects and best practices on energy transition.

This platform focuses on stakeholder dialogue, collaboration, and knowledge sharing. Stakeholders expressing interest in the Partnership participate in dialogues and workshops[211] on different themes, such as innovation, knowledge gaps, technology, skills and finance. The input and outcomes will feed into the preparation of a common roadmap with measurable milestones and actions for the energy transition of the fisheries and aquaculture sectors towards climate neutrality by 2050.

Furthermore, the European Commission has identified a need to ease access to funding opportunities to the sector and published a guide[212] to provide a clear overview of the different EU funds and financing tools that could be used by the sector to support its transition.

The fishing and aquaculture sectors have already implemented various measures to advance the energy transition within the sector and the European Commission has published a compendium[213] with best practices showing how the sector is implementing innovations. To support the implementation of these technologies to a larger scale, the Commission has conducted a techno-economic analysis, which has identified potential solutions for the fisheries and aquaculture sector, assessed their financial viability and provided recommendations for overcoming barriers to implementation.

3.4. COASTAL FLOOD IMPACTS ALONG THE EUROPEAN UNION'S OUTERMOST REGIONS AND OVERSEAS COUNTRIES AND TERRITORIES

As presented in the 2023 Blue Economic Report, economic damages from coastal flooding in the EU-27 currently amount to €1 billion annually. For the sake of comparison, this is equivalent to one sixth of the total amount allocated to the EMFAF round. 72 000 people in the EU are exposed to coastal flooding every year. Damages from coastal flooding are projected to rise sharply with global warming for all EU-27 countries with a coastline if current levels of coastal protection are not raised. Annual damages grow to €814 billion and €137 billion by 2100 under a high emissions scenario and a moderate mitigation scenario respectively.

In terms of investments and climate financing needed, the average annual cost of adaptation for the EU-27 over the period 2020-2100 is €1.8 billion/year in the high emissions scenario and €1.1 billion/year in the moderate mitigation scenario. It is important to note that the average annual cost of additional coastal protection is about two orders lower than the estimated reduction in annual flood losses by the end of the century. This means that investing now in coastal protection will have very large (and growing) benefits in the long term. In other words, investments in adaptation and protection the EU coastline pay off.

To complement the global analysis for the EU-27, this section will focus on quantifying the socio-economic impacts for some of the most vulnerable territories of the EU coastal areas, the Outermost Regions (ORs) and Overseas Countries and Territories (OCTs)[214]. Scattered across the Atlantic, Caribbean, Indian Ocean, and Pacific, the EU's ORs and OCTs stand as important cultural and natural assets. From the volcanic peaks of La Réunion to the lush rainforests of Martinique, these territories boast unique geologies, beautiful landscapes, and rich biodiversity. However, their very remoteness and island nature makes them acutely vulnerable to changing climate and rising seas. Since 1900, average sea levels have risen by nearly 21 centimetres, following an accelerating trend. Over the past two decades, the rate has doubled, currently climbing at 3.7 millimetres per year. While projections vary depending on mitigation efforts, under a high-emissions scenario, sea levels could rise by up to 1 metre by 2100. This seemingly small

[210] Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions On the Energy Transition of the EU Fisheries and Aquaculture sector. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52023DC0100.
[211] The workshops - European Commission (europa.eu).
[212] guide_on_financing_the_green_energy_transition_of-KL0323424ENN.pdf (europa.eu).
[213] Best practices on energy transition in fisheries and aquaculture - European Commission (europa.eu).
[214] The ORs fully belong to France, Spain and Portugal, hence are fully fledged members of the EU. While the OCTs are associated with the EU, they are not part of the EU territory and therefore not subject to EU law. https://international-partnerships.ec.europa.eu/countries/overseas-countries-and-territories_en.

number translates to devastating consequences for low-lying coastal communities.

Europe's OCTs and ORs are diverse in geography, geology, and economy, stretching from the polar areas of Greenland to the tropical climates of the Caribbean and Pacific islands. These regions are characterised by unique geological formations, from volcanic landscapes to coral reefs, which influence their biodiversity and natural resources. Economically, they range from tourism-driven economies in areas like the Canary Islands and French Polynesia to more traditional fishing and agriculture in others. Geographically, they are dispersed, creating challenges and opportunities in connectivity, climate adaptation, and sustainable development.

Despite these differences, they share a common thread – their economies heavily rely to varying degrees on tourism, agriculture, and fisheries, all sectors profoundly impacted by rising sea levels. Most ORs and OCTs are volcanic islands characterised by steep landscapes, but there are also several low-lying atolls e.g. in French Polynesia and the Dutch OCTs (e.g. Aruba and Bonaire) which are inherently susceptible to coastal erosion and inundation, and will face the existential threat of disappearing entirely under rising sea levels. Meanwhile, even seemingly elevated regions like the Canaries are not immune, with coastal infrastructure, settlements, beaches, and agricultural land all under increasing pressure. Finally, geographical vulnerability and unfavourable land subsidence trends in some areas further compounds the issue leading to coastal inundation risk and saltwater intrusion into freshwater resources, threatening agriculture, infrastructure, and cultural heritage sites. The very fabric of island life, from traditional fishing practices to tourism-dependent economies, faces an uncertain future as sea levels keep rising. Finally, the remoteness of some of the islands, poses additional practical limitations for adaptation, related to the availability of materials, technologies and costs. In the following sections, we will dive deeper into the specific impacts of sea level rise on these diverse regions, exploring the challenges they face and touch on potential pathways towards a more resilient future.

Anticipated Coastal Flooding Risks in OCTs and ORs

A comprehensive study of future coastal flooding risks in OCTs/ORs reveals concerning trends driven by rising sea levels. Key findings indicate a potential increase in flooded areas to reach up to 0.5% of the total OCT/OR landmass by 2150, more than 2 800 km^2. This scenario translates to potential annual exposure of up to **half a million of EU citizens in OCTs/ORs to coastal inundation events.**

Direct economic damages from coastal floods are also projected to escalate significantly, with estimates suggesting an annual cost of up to €6.5 billion by 2150, representing a 35-fold increase compared to the present day. Locations with extensive coastlines and low-lying areas, such as Reunion, New Caledonia, the Canary Islands, French Guiana and Guadeloupe are identified as particularly vulnerable to these detrimental impacts. The latter two regions, together with Bonaire, Sint Eustatius and Saba, share the highest estimated of expected annual damage (EAD) as percentage of the GDP, by the year 2150; at least 10% under high emissions.

While smaller islands like Bonaire, Sint Eustatius and Saba as well as Aruba might experience a relatively smaller area of inundation, they are anticipated to face the highest proportional increase in flooded land, potentially reaching 16% of their total landmass annually by 2150. This poses a significant challenge for these low-lying island communities.

Absolute numbers of people affected are highest in locations like the Canary Islands, Guadeloupe and Reunion and the latter is also the region with the highest percentage of the population exposed to floods. Other regions with at least 7% of their population exposed to floods under high emissions and by 2150 are French Guiana, St. Barthélemy, Aruba and Guadeloupe.

However, the study emphasises the potential for **mitigating these risks** through decisive climate action. Implementing effective emission mitigation measures could offer economic benefits of up to 45% in terms of reduced damage by 2150. This underscores the critical importance of proactive efforts to combat climate change and safeguard these vulnerable regions.

Anticipated loss in Coastal Ecosystem Services

The current coastal ecosystem services in OCTs/ORs are estimated around €147.9 billion annually, half of which come from New Caledonia and 25% from French Guiana and French Polynesia. More than 90% of the ecosystem services are from tropical tree cover. Rising seas are projected to drive permanent land loss, which will deplete a part of such ecosystem services. Under a +2°C scenario, services of around €189 million are expected to be lost by the year 2050, reaching €259 million by the end of the century. Such lost ecosystem services are projected to climb to €197 and €276 million, respectively, if temperatures stabilise at +4°C. The above estimates are on the conservative side and under all studied scenarios the lost services do not exceed 1% of the present total. The reason is that we assume that shoreline retreat due to coastal erosion will not exceed 100 metres landwards. This assumption is valid for beaches backed by human development and hard artificial surfaces which are less prone to erosion. However, in natural coastlines shoreline retreat can be higher and so will be the resulting lost ecosystem services.

The way forward

These findings highlight the need for climate action as the impacts of coastal flooding in the decades to come will be too disruptive. They also imply that timely adaptation measures will be necessary. Even under low emissions scenarios, by the year 2050 several OCTs and ORs are projected to experience direct EAD exceeding 1% of GDP (e.g. French Guiana, Saint Pierre and Miquelon, Aruba, Guadeloupe, Martinique and New Caledonia); which constitute substantial economic shocks for any economy, without even considering indirect impacts, like business interruption and other spill-over effects. The affected areas tend to be among the few flatter parts of the islands and are characterised by high population density; examples are the cities of Las Palmas de Gran Canaria, Cayenne of French Guiana, Ponta Delgada in Azores, Mamouszou and Dzaoudzi of Mayotte, Saint-Denis and Saint-Pierre of Reunion, Mata-Utu of Wallis and Saint-Pierre, the capital of Saint Pierre and Miquelon. In all these cities the average elevation does not exceed 10 metres and even if large parts will not be affected by floods directly, the disruption of every-day life will be substantial by the inundation of critical assets like ports, roads and energy infrastructure, among others.

As part of the EU's Adaptation Strategy, the Commission has organised in 2022 and 2023 ten workshops in the three basins of the ORs to promote exchanges on climate adaptation solutions between the ORs and their neighbouring OCTs, for example on coastal resilience, agriculture, biodiversity, water resource management and tourism. In this context, the Commission has published a compendium of innovative good practices that could be replicated.

A critical issue is the resilience of airports and critical infrastructure which tend to be in flat, low-lying areas, given the absence of higher altitude plains, especially in volcanic islands. Several airports lie below 10 metres of elevation and will experience increasing flood risk, even under moderate sea level rise scenarios, e.g. the Dzaoudzi Pamandzi International Airport – Mayotte, Flamingo International Airport - Bonaire, Faa'a International Airport – French Polynesia, Pointe-à-Pitre International Airport – Guadeloupe and Saint-Pierre Airport – Saint Pierre and Miquelon. Airports, together with ports, which are anyway near mean sea level, are the lifelines of islandic communities, either for economic activity by ensuring the access of tourists to the island; or the other way around, by providing inhabitants with access to critical supplies and health services, among others.

All of the above implies that the majority of the affected areas cannot be abandoned and will have to be protected. However, acknowledging the challenge is only the first step. By understanding the specific vulnerabilities of each region and working collaboratively towards adaptation strategies, the ORs and OCTs can build resilience against the rising tide. The spectrum of **potential actions** is broad, from investing in coastal defences and early warning systems to exploring **nature-based solutions (NBS) like land reclamation and mangrove restoration**. The international community has also a crucial role to play in supporting these efforts, ensuring that these unique island ecosystems and their vibrant cultures survive and thrive in the face of a changing climate. Such support involves access to economic resources and climate financing through the Loss and Damage Mechanism[215], but also technical expertise to deal with still open challenges. One of them is the fact that hard protection solutions, like seawalls and dikes, which have traditionally dominated this field, offering robust flood defence, often come at the cost of exacerbating coastal erosion and harming ecosystems. While completely shielding vulnerable areas from every potential flood event may be economically impractical, a balanced approach is crucial.

NBS like beach nourishment, restoring natural features like dunes, mangroves and wetlands, offer a promising alternative as they can provide both flood protection and ecological benefits. However, rising sea levels might still necessitate some level of hard infrastructure. This opens the door to **hybrid solutions**, combining elements of both hard and soft approaches. For example, artificial reefs or constructed dunes with impermeable elements inside can leverage the strengths of both, mitigating flooding while maintaining ecosystem services. Despite their potential, hybrid solutions face adoption hurdles. Lack of clear guidelines for their appropriate use and comprehensive assessments of cost and lifespan impede their implementation. Ongoing pilot projects and intensive monitoring are necessary to better understand the suitability of different landscapes for these approaches and associated cost-effectiveness. Embracing innovation and fostering collaboration between science, policy, and engineering can lead to the development of effective coastal protection strategies that safeguard communities and ecosystems in the face of rising seas.

Furthermore, the mobilisation of significant financial resources to allow the adaptation of the EU coastal areas in ORs will be essential.

For more information, please visit the EU Blue Economy Observatory.

[215] The COP established the Warsaw International Mechanism for Loss and Damage associated with Climate Change Impacts (Loss and Damage Mechanism), to address loss and damage associated with impacts of climate change, including extreme events and slow onset events, in developing countries that are particularly vulnerable to the adverse effects of climate change at COP19.

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