COGEA

Consulenti per la Gestione Aziendale

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STUDY ON THE ESTABLISHMENT OF A FRAMEWORK FOR PROCESSING AND ANALYSING MARITIME ECONOMIC DATA IN EUROPE

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Content

Foreword

This Study comes after a long series of studies that have attempted to define and measure the blue economy in the EU. These have provided some qualitative information but they largely reinforced what was already known from the first 2009 study[1] – that national statistical organisations are reluctant or unable to provide more detailed information than they already provide to the Commission.

So the Commission has started to make its own calculations based on publicly available data from these reports – primarily Structural Business Statistics (SBS), input-output tables, tourism statistics, the Data Collection Framework for Fisheries and the Labour Force Survey.

This study aimed to cross-check these numbers and provide additional detail from other sources.

The study confirmed that the use of SBS and the NACE classification of activities as the main data source is justified by the fact that NACE offers:

- spatial and inter-industry comparability,
- temporal comparability,
- theoretical and accounting consistency,
- replicability.

At the same time, it should be noted that, as of today, the NACE classification does not permit to measure every maritime activity with a sufficient degree of precision, because some economic activities encompass a maritime and a non-maritime dimension alike, and it is extremely difficult to establish how much of them should be apportioned to the blue economy. For this reason, several other sources have been used to complement Eurostat data.

The study was developed through five tasks:

1. **Common delineation of the maritime activities**: a common definition of maritime activities was developed, by looking at literature, past studies and similar exercises carried our worldwide. A set of economic activities that make up the blue economy was selected based on the definition developed.
2. **Indicators for maritime activities**: after defining the list of maritime activities to include in the study, two sets of indicators were chosen to measure them. Some basic common indicators are common to all activities and provide information on turnover, value added and employment for each activity. Other indicators are 'sector-specific', in that they were chosen based on the specificities of each economic activity, to capture phenomena that go beyond socio-economic performance.
3. **Identification of sustainable data sources**: data sources were identified for each indicator and activity. Most data are sourced from Eurostat, but other sources were also identified when Eurostat did not have sufficient information.
4. **Collecting and processing the data**: the data were then collected, processed and imported into a database.
5. **Peer review process**: a peer-review group of external experts was set up to validate the findings of the research team. The peer-review group was made up of stakeholders from industry and academia, their expertise covering the different sectors of the blue economy.

As a general rule, the research team have based their estimations as much as possible on actual figures, trying to avoid assumptions and proxies. Nonetheless, since some sectors are characterised by poor data availability, certain assumptions and proxies were inevitable. They are detailed in an Annex to this report.

[1] Study in the field of maritime policy, "Approach towards an Integrated Maritime Policy Database", Volume 1: Main Part Study for Eurostat Contract Reference 2007/S 179-218229 – Lot 1

Despite the effort put into the study, there remain a number of sectors for which, as of today, no or very few data are available:

- Blue biotechnology (no data at all)
- Desalination (no data at all)
- Dredging (data included in NACE codes that mix different economic activities together)
- Marine equipment (very limited data available from official statistics. Sector-specific studies have elaborated methods to estimate the sector, but could not be used of this study because they do not ensure continuity in data supply)
- Other renewable energy (very few data, mainly on capacity installed)
- Public sector activities (very few data)
- Seabed mining (no data at all)
- Wind energy (very few data, mainly on capacity installed)

Despite some of these sectors are poorly covered, they have been included in the list of maritime activities anyway, in case new data are made available in the future.

The study team acknowledges with grateful thanks the input, feedback and expertise provided by the wide range of representatives from the maritime sector who kindly cooperated in the compilation of this study.

1 Common delineation of maritime activities

Since the 2012 Communication from the Commission: 'Blue Growth opportunities for marine and maritime sustainable growth'[2], the blue economy has received great attention from industry, policy makers and academics. With Europe still struggling with the consequences of the 2008 financial crisis, unleashing the economic potential of our oceans may comprehensibly be seen as an enormous opportunity to spur growth and jobs, while at the same time ensuring sustainability.

A number of studies have been carried out worldwide in the past few years to measure the size of the blue economy and forecast its evolution over time. Nonetheless, in spite of the vast literature – or probably because of it – a common definition of what the blue economy is and which economic activities it should encompass does not seem to have yet been established.

Hence, the first effort of this study has been to develop a definition of the blue economy that could be accepted by policy makers and industry alike, and could be used by the European Commission in the years to come, upon updating the results of the study.

1.1 List of previous definitions of the blue economy

As mentioned above, several different definitions of the blue economy have been developed in the past few years across the world. Different definitions usually reflect different views of the blue economy, as well as different policy and research priorities. However, all the definitions developed are in principle equally valid, as whether or not to consider any economic activity as part of the blue economy is a largely arbitrary exercise, which ultimately responds to the definition developed.

The research team has identified at least 14 definitions of the blue economy worldwide. Apart from Eurostat's USA's, Canada's and New Zealand's the definitions below should not be considered 'official':

1. **Eurostat**[3]: The maritime economy is now often referred to as the 'blue economy'. It covers all marketable activities linked to the sea. The link between activities and the sea may be explained by the use of marine resources, maritime areas or regions or by the vicinity of these spatial units. The relationship between the activities and the sea can be more or less direct and maritime sectors cannot be seen as a single sector activity within the NACE classification but rather as a set of activities.
2. **SIDS (Small Island Developing States) Concept Paper**[4]: "Blue Economy" is marine-based economic development that leads to improved human well-being and social equity, while significantly reducing environmental risks and ecological scarcities.
3. **An Economist Intelligence Unit briefing paper for the World Ocean Summit 2015**[5]: Difference between the ocean economy and the blue (sustainable) ocean economy: a sustainable ocean economy emerges when economic activities are in balance with the long-term capacity of ocean ecosystems to support this activity and remain resilient and healthy.

[2] COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS Blue Growth opportunities for marine and maritime sustainable growth, COM/2012/0494 final. Available at http://eur-lex.europa.eu/legal-content/en/ALL/?uri=CELEX%3A52012DC0494

[3] IFREMER, Study in the Field of Maritime Policy, 2009. Study for Eurostat Contract Reference 2007/S 179-218229 https://webgate.ec.europa.eu/maritimeforum/en/node/1616

[4] SIDS, Blue Economy Concept Paper, 2014. Available at : https://sustainabledevelopment.un.org/content/documents/2978BEconcept.pdf

[5] The Economist Intelligence Unit, The Blue Economy. Growth, opportunity and a sustainable ocean economy. An Economist Intelligence Unit briefing paper for the World Ocean Summit 2015. Available at: http://www.economistinsights.com/sites/default/files/Blue%20Economy_briefing%20paper_WOS2015.pdf

4. **WWF**[6]: Blue Economy is intended as the use of the sea and its resources for sustainable economic development. For others, it simply refers to any economic activity in the maritime sector, whether sustainable or not. WWF has developed a set of "Principles for a Sustainable Blue Economy". The Principles offer a clear definition of a sustainable Blue Economy. This definition makes it clear that the Blue Economy must respect ecosystem integrity, and that the only secure pathway to long-term prosperity is through the development of a circular economy.
5. **ECORYS**[7]: Marine economy comprises all sectoral and inter-sectoral economic activities relating to the oceans, seas and coastal regions. This definition also includes the group of activities that serve as direct and indirect support for the functioning of maritime economic sectors, thus, apart from coastal zones, these activities can also be found in countries without coastline.
6. **USA (NOEP - National Ocean Economics Program)**[8]: Any economic activity which is a) an industry whose definition explicitly ties the activity to the ocean, or b) which is partially related to the ocean and is located in coastal zones or regions (shore-adjacent zip code)
7. **UK ("Socio-economic indicators of marine-related activities in the UK economy" D. Pugh)**[9]: Those activities which involve working on or in the sea. Also, those activities that are involved in the production of goods or the provision of services that will directly contribute to activities on or in the sea.
8. **Canada (DFO – Department of Fisheries and Oceans)**[10]: Industries that are established in Canadian maritime zones and the coastal communities adjoining these zones, or those that are dependent on these areas for their income.
9. **New Zealand (New Zealand's environmental statistics team)**[11]: Any economic activity that takes place in or uses the marine environment, or produces goods and services necessary for those activities, or makes a direct contribution to the national economy.
10. **Australia (based on Allen Consulting study)**[12]: Ocean-based activities that use sea resources, or that are linked to the provision of services relating to maritime transport or others that benefit from the positive attributes of the marine environment
11. **Ireland ("Socio-Economic Marine Research Unit, Ireland's ocean economy, Reference Year 2012")**[13]: Economic activities which directly or indirectly use the sea as an input, as well as any economic activity that produces an input for use in a sea-specific activity.

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[6] WWF, Principles for a Sustainable Blue Economy, 2015. Available at : http://d2ouvy59p0dg6k.cloudfront.net/downloads/15_1471_blue_economy_6_pages_final.pdf

[7] ECORYS,, Blue Growth. Scenarios and drivers for Sustainable Growth from the Oceans, Seas and Coasts. Final Report, 2012 Available at: https://webgate.ec.europa.eu/maritimeforum/sites/maritimeforum/files/Blue%20Growth%20Final%20Report%2013092012.pdf

[8] Colgan et al., State of the U.S. Ocean and Coastal Economies, 2014. Available at: http://www.oceaneconomics.org/download/

[9] Pugh D. Socio-economic indicators of marine-related activities in the UK economy. London: The Crown Estate; 2008. Available at: http://www.thecrownestate.co.uk/media/5774/socio_economic_uk_marine.pdf

[10] Pinfold G., Economic impact of ocean activities in Canada, 2009. Available at: http://www.dfo-mpo.gc.ca/ea-ae/cat1/no1-2/no1-2-eng.pdf

[11] Statistics New Zealand, New Zealand's Marine Economy 1997-2002, 2003. Available at: http://www.stats.govt.nz/~/media/Statistics/browse-categories/environment/natural-resources/marine/nz-marine-economy-1997-2002.pdf

[12] The Allen Consulting Group, The economic contribution of Australia's marine industries 1995-96 to 2002-03, 2004. Available at: http://www.marinenz.org.nz/documents/marine_economic.pdf

[13] Vega A. et al., Socio-Economic Marine Research Unit, Ireland's ocean economy, 2012. Available at: http://www.nuigalway.ie/semru/documents/semru__irelands_ocean_economy__web_final.pdf

12. **China (Zaho et al., "Defining and quantifying China's ocean economy. 2014")**[14]: The sum of all kinds of activities associated with the development, utilization and protection of the marine.
13. **Japan (Nomura Research Institute. "The report on Japan's marine industry" 2009)**[15]: Industry exclusively responsible for the development, use and conservation of the ocean
14. **South Korea ("A Study on rebuilding the classification system of the Ocean Economy" Kwang Seo Park)**[16]: The economic activity that takes place in the ocean, which also includes the economic activity plus the goods and services into ocean activity, and uses the ocean resources as an input.

Based on the definition adopted as well as on data availability, generally speaking each country maps a different set of activities, e.g.:

[14] Hynes R. et al., Defining and quantifying China's ocean economy. Mar Policy 2013.
Available at: http://www.sciencedirect.com/science/article/pii/S0308597X1300122X
[15] Nomura Research Institute, The report on of Japan's marine industry, March 2009. Not available online.
[16] Kwang Seo Park, A study on re building the classification system of the Ocean Economy, 2014. Available at: https://www.researchgate.net/publication/276487430_Rebuilding_the_Classification_System_of_the_Ocean_Economy

Table 1 - The Industries defined as part of the marine economy within International Studies

	Australia	Canada	China	France	Indonesia	Ireland	Japan	New Zealand	OECD	South Korea	Spain	UK	USA
Maritime Transport	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓
Port & Maritime Logistics	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Tourism	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓
High Tech Services		✓	✓	✓		✓		✓		✓		✓	
Commerce			✓	✓		✓		✓		✓	✓	✓	
Other Services			✓	✓	✓	✓		✓		✓	✓	✓	
Aggregates			✓	✓			✓			✓		✓	
Fisheries	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Aquaculture	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓
Seafood Processing		✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	
Seaweed			✓	✓		✓	✓	✓		✓		✓	
Biotechnology			✓			✓				✓			
Oil & Gas	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓
Renewable Energy			✓	✓		✓			✓	✓		✓	
Boat Building	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Construction		✓	✓	✓	✓	✓	✓	✓		✓		✓	✓
Engineering			✓	✓		✓	✓	✓		✓		✓	
Manufacturing		✓	✓		✓	✓	✓			✓		✓	
Seawater Utilisation			✓										
Defence/Government		✓		✓						✓		✓	n/a
Research & Education		✓		✓						✓	✓	✓	
Coastal & marine environmental protection				✓									

Source: Morrissey K., The Economics of the Marine: Modelling Natural Resources (2017, forthcoming), plus own elaboration.

Furthermore, it is worth mentioning the exercise carried out by the **OECD** to explore the growth prospects for the ocean economy, its capacity for future employment creation and innovation, and its role in addressing global challenges. OECD's work[17] mainly focuses on growth prospects, which are outside the scope of this study. However, in doing so the OECD establishes a list of activities (included in the table above) that make up the ocean economy.

In terms of sectors covered, the OECD's list is quite similar to the list developed for this study (see §1.2 below). Sectors such as blue biotechnology, extraction of aggregates, extraction of salt, desalination, renewable energy other than wind, and activities carried out by the public sector are missing from the OECD's report. Apart from 'marine biotechnology', which is not captured in the report due to lack of data, the exclusion of the other sectors is most certainly due to the fact that the geographical scope of the exercise carried out by the OECD is much wider than this study, which inevitably implies a certain degree of simplification. At the same time, the OECD's report acknowledges that marine biotechnology and renewable energy should be integrated in the database in the future, given that they are significant emerging sectors. On the other hand, 'marine equipment' is not included in the list in §1.2 below. This is because marine equipment does not correspond to any economic activity mapped in the NACE classification, thus making it impossible to collect any useful data[18]. The OECD estimates the value of 'marine equipment' based on a report by Balance Technology Consulting (2014)[19], which, however, is a one-off exercise that cannot be used for this study, as it does not offer any guarantee of continuity in supplying data.

It is interesting to note that in terms of methods, the OECD's work should be almost perfectly compatible with this study, since it is based on the ISIC classification Rev. 4, for which there is correspondence with NACE Rev. 2.

1.2 List of maritime activities

The wide range of definitions reported in the previous paragraph reflects the plethora of studies and viewpoints that inform the blue economy worldwide.

For the purpose of this study, it has been necessary to develop a definition of the blue economy that takes into account the following objectives:

- Establishing a stable and reliable system which over the next decade can provide ready-to-use information and figures to monitor the performance of the blue economy.
- Designing the system as much as possible based on actual figures, and indulge as little as possible in speculation and assumptions.
- Ensuring that the system be reliable in such a way that it will not be confronted with negative reactions from stakeholders.

Furthermore, the specific selection of sectors to include should also be conditioned by the overall existing data that is publicly accessible. This is because, far from being a merely theoretical exercise, this study aims to establish a realistic framework for future data collection. In other words, "it would be necessary to adopt a methodology that, while maintaining the rigour of socio-economic estimations, is compatible with the

[17] OECD, The Ocean Economy in 2030, 2016. Available at: www.keepeek.com/Digital-Asset-Management/oecd/economics/the-ocean-economy-in-2030_9789264251724-en

[18] Enquires are being submitted to private information providers to understand whether they can make available any data.

[19] Balance Technology Consulting, Competitive Position and Future Opportunities of the European Marine Supplies Industry, 2014.

availability of the information drawn up by the countries' official statistical sources, as well as with territorial, social and political organisation of the EU"[20].

By combining definitions #7, #9 and #11 above, at EU level this study defines the activities that make up the blue economy as

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> ***economic activities that (i) take place in the marine environment or that (ii) use sea resources as an input, as well as economic activities that (iii) are involved in the production of goods or the provision of services that will directly contribute to activities that take place in the marine environment.***

This definition incorporates a geographic criterion (activities that take place in the marine environment), with other criteria related to the process and nature of other economic activities that may also take place on land. In the authors' opinion, it is paramount to acknowledge the land-sea interaction that informs the marine economy. For the most part, people only think of a marine activity as something that takes place in the marine environment, i.e. shipping and fishing. However, the marine sector is actually supported by several on-land sectors – seafood processing on land, ports, ship building, manufacturing more broadly, commerce (such as insurance). These are all part of the marine economy, just as agricultural activities such as tractor sales take place outside of farms.

Based on the above-mentioned definition, all economic activities included in the NACE classification[21] have been mapped; those that match with the definition have thus been included as part of the blue economy.

The NACE classification of economic activities is the foundation on which to build the new definition of the blue economy. Inter alia, it makes it possible to meet four fundamental requirements identified by Colgan[22] in a study on the ocean economy carried out for the National Ocean Economics Project in the US:

- spatial and inter-industry comparability;
- temporal comparability;
- theoretical and accounting consistency;
- replicability.

However, as emerged from the mapping exercise, the NACE classification also has some limitations. More specifically, NACE is a classification of economic activities arranged in such a way that entities can be classified according to the activity they carry out. While several economic activities can easily be classified as maritime (e.g. fishing), some others are not maritime by nature, in that – for instance – they can be carried out both onshore and offshore (e.g. production of wind energy).

As a classification, NACE was not conceived to distinguish between the maritime and the non-maritime economy, therefore it is only concerned with the nature of an activity, rather than with where it takes place or which industries it serves. This implies that, in a good number of cases, data based on NACE classification needs to be integrated with other sources or criteria in order to estimate the 'maritime proportion' of a given economic activity.

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[20] Surís-Regueiro, J. C. et al. (2013). Marine economy: A proposal for its definition in the European Union. Marine Policy 42(0): p. 116.

[21] http://ec.europa.eu/eurostat/statistics-explained/index.php/Glossary:Statistical_classification_of_economic_activities_in_the_European_Community_(NACE)

[22] Colgan CS, Measurement of the ocean and coastal economy: theory and methods. National Ocean Economics Project, USA; December 2003.
See also Colgan CS, A guide to the measurement of the market data for the ocean and coastal economy in the National Ocean Economics Program. National Ocean Economics Program, USA; January 2007.
Both studies are available at http://www.oceaneconomics.org

Additional sources may thus need to be used to bridge gaps in NACE, most likely when dealing with new and emerging maritime activities, which have not yet been included in the current classification system. Additional sources may also be used to elaborate estimations and / or proxies when detailed data is not available through NACE. At the same time, it should be noted that the process of integrating different data sources may result in a 'violation' of one or more of the above-mentioned principles. Therefore, case-by-case, one should carefully evaluate the benefits yielded to the database by the addition of a new source against the potential problems that may arise in terms of comparability, consistency and replicability.

It should be noted that NACE is a 4-digit classification providing the framework for collecting and presenting a large range of statistical data according to economic activity in the fields of economic statistics (e.g. production, employment and national accounts) and in other statistical domains developed within the European statistical system (ESS). However, a six-digit classification is also available: the statistical Classification of Products by Activity (CPA) is the classification of products (goods as well as services) at EU.

Product classifications are designed to categorise products that have common characteristics. They provide the basis for collecting and calculating statistics on the production, distributive trade, consumption, international trade and transport of such products. CPA product categories are related to activities as defined by the Statistical classification of economic activities in the European Community (NACE). Each CPA product – whether a transportable or non-transportable good or a service - is assigned to one single NACE activity. This linkage to NACE activities gives the CPA a structure parallel to that of NACE at all levels.

Furthermore, there also exists an 8-digit classification on production of manufactured goods together with related external trade data (Prodcom). Prodcom consists of about 3900 products. The 8-digit codes used in the list are based on the 6-digit CPA headings and hence the 4-digit NACE rev 2. The purpose of the statistics is to report, for each product in the Prodcom List, how much has been produced in the reporting country during the reference period. This means that Prodcom statistics relate to products (not to activities) and are therefore not strictly comparable with activity-based statistics such as Structural Business Statistics. Nonetheless, in many cases, 6- and 8-digit codes provide more detailed information that makes it possible to estimate the 'maritime proportion' of an activity, whereas the same cannot be done with 4-digit NACE codes. An example of this can be found with NACE code C 28.11 "Engines and turbines, except aircraft, vehicle and cycle engines". This activity, inter alia, includes firms that are in the shipbuilding value chain, as they produce engines for ships and boats. However, due to the current classification system, it is impossible to estimate how much of this production can be apportioned to the maritime economy. This problem is partially solved if one resorts to 6-digit CPA codes such as:

- C 28.11.11 "Outboard motors for marine propulsion"
- C 28.11.12 "Marine propulsion spark-ignition engines; other engines"

By providing an additional layer of detail, the two CPA codes make it possible to estimate how much of the production of "Engines and turbines, except aircraft, vehicle and cycle engines" is actually used in the maritime industry.

The biggest caveat that comes with the use of 6-digit codes is that, at Eurostat level, the CPA classification only provides data on quantity and value of production of manufactured goods, while for the purpose of this study information such as turnover, value added, and employment are also necessary. Furthermore, at Eurostat level, CPA codes can only be used with manufactured goods and not with services, although more detailed data may be available at Member State level. Most employment in the blue economy is in services, and in common with the broader EU economy, the services component is growing.

The economic activities – which ultimately correspond to NACE codes – included have been grouped in a number of sectors as follows:

Table 2 – List of sectors and activities

Sector	NACE	Activity

	code	
Fisheries and aquaculture	A.03.11	Marine fishing
	A.03.21	Marine aquaculture
	A.03.22	Freshwater aquaculture
	C.10.20	Processing and preserving of fish, crustaceans and molluscs
	C.10.85	Prepared meals and dishes
	C.10.89	Other food products n.e.c
	C.10.41	Manufacture of oils and fats
Blue biotechnology	M.72.11	Research and experimental development on biotechnology
Extraction of oil and gas	B.06.10	Extraction of crude petroleum
	B.06.20	Extraction of natural gas
	B.09.10	Support activities for petroleum and natural gas extraction
Extraction of aggregates	B.08.12	Operation of gravel and sand pits; mining of clays and kaolin
	B.08.99	Other mining and quarrying n.e.c.
	B.08.11	Quarrying of ornamental and building stone, limestone, gypsum, chalk and slate
	B.09.90	Support services for other mining and quarrying
Extraction of salt	B.08.93	Extraction of salt
	C.10.84	Manufacture of condiments and seasonings
Seabed mining	B.07.10	Mining of iron ores
	B.07.21	Mining of uranium and thorium ores
	B.07.29	Mining of other non-ferrous metal ores
	B.09.90	Support services to other mining and quarrying
Desalination	E.36.00	Natural water; water treatment and supply services
Maritime transport	H.50.10	Sea and coastal passenger water transport
	H.50.20	Sea and coastal freight water transport
	H.50.30	Inland passenger water transport
	H.50.40	Inland freight water transport
	H.52.29	Other transportation support activities
	K.65.12	Non-life insurance
	K.65.20	Reinsurance
	N.77.34	Rental and leasing services of water transport equipment
Ports (including dredging)	H.52.24	Cargo handling
	F.42.91	Construction of water projects
	H.52.22	Service activities incidental to water transportation
	H.52.10	Warehousing and storage services
Shipbuilding	C.30.12	Building of pleasure and sporting boats
	C.30.11	Building of ships and floating structures
	C.28.11	Manufacture of engines and turbines, except aircraft, vehicle and cycle engines
	C.32.30	Sports goods
Ship repair	C.33.15	Repair and maintenance of ships and boats
	E.38.31	Dismantling of wrecks
Tourism	n.a.	Coastal tourism
	n.a.	Cruise tourism
Wind energy	n.a.	Offshore wind energy
Other renewable energy	D.35.11	Production of electricity
	D.35.12	Transmission services of electricity
Public sector	E.38.12	Collection of hazardous waste
	0.84.22	Defence activities
	0.84.26	Environmental protection

	0.84.11	General public administration activities
	0.84.24	Public order and safety activities
	E.39.00	Remediation activities and other waste management services

The sectors and activities in the table have further been grouped into:

Table 3 – List of groups and sectors

Group	Sector
Living resources	Fisheries and aquaculture
	Blue biotechnology
Non-living resources	Extraction of aggregates
	Extraction of oil and gas
	Extraction of salt
	Seabed mining
	Desalination
Shipping	Maritime transport
	Ports (including dredging)
Shipbuilding	Shipbuilding
	Ship repair
Renewable energy	Wind energy
	Other renewable energy
Coastal tourism	Coastal tourism
Other	Public sector

Some important notes:

- **Some activities are not consistent with the above-mentioned definition,** namely, 'freshwater aquaculture' and 'inland water transport' (both freight and passenger). However, it has been decided to include them in the database, because they may be relevant to the blue economy of some countries (e.g. inland freight water transport is considered a part of the blue economy in the Netherlands). This choice has also been made on account of the fact that, when querying the database, users are allowed to exclude certain activities.
- **Coastal tourism is not a single economic activity, but** rather is a set of activities undertaken by a specific type of consumer (the tourist). Tourism is an umbrella for all relationships and phenomena associated with people who are travelling, whatever the reason. Because it embraces several economic activities, and although the link with oceans and / or coastal regions is sometimes weak, coastal tourism tends to outweigh all the other sectors of the blue economy in terms of turnover, value added and employment.
- **Blue biotechnology**: as of today, with currently available data, it is believed that no reliable method can be developed to estimate the size of this sector. A specific section of this report analyses current gaps and possible solutions to bridge them in the future.
- **Extraction of salt**: currently available data do not make it possible to distinguish between salt extracted from sea water, and salt extracted from other sources. The study team has liaised with EuSalt (EU sector association) which are carrying out their own study to estimate the size of the sector. Their data will be made available in February 2016 and may be included in future updates of the database.
- **Seabed mining**: as an emerging sector, it is not captured in the statistical classification system. Enquiries with private information providers have revealed that the activities taking place in EU waters (the geographical scope of this study) are negligible, with only 9 vessels carrying out research and exploration activities. Therefore, no data on this sector has been reported.

Nevertheless, it is important to keep it in the list of maritime activities, as it is believed that there is potential for growth in the future.

- **Desalination**: official statistics do not capture the sector. Limited data are available from private information providers. Enquiries have revealed that there is a market for desalination only in Cyprus, Italy and Spain, of which only Spain's has an appreciable size. For the time being, no data are thus reported.
- **Insurance and re-insurance services**: insurance and re-insurance services are virtually bought by all economic activities. However, it is quite difficult to establish the share bought by each maritime activity individually. At this stage, it has been possible to do so only for the maritime transport sector, through input-output tables. It should be possible to do the same also for the fisheries and aquaculture sectors. On the other hand, it may be more challenging to do the same with other sectors. At the same time, it should be noted that, when not listed separately, insurance and re-insurance services are captured when measuring the 'indirect impact' of each maritime activity.
- **Ports (including dredging)**: a set of activities that take place in ports are included in this sector. However, the budget of port authorities – which in many EU Member States are public bodies – and their employment is not included in our measurement. We are liaising with the European Organisation of Sea Ports (ESPO) to understand whether they may share data that could be useful for the study. Among the activities included in the sector are 'construction of water projects' and 'site preparation'. To our knowledge, these activities include operations that are normally considered as dredging activities. Dredging happens to be an important economic sector in several countries, especially in Northern Europe. Therefore, it would be desirable to single it out as a separate sector. Several attempts have been made to liaise with the European Dredging Association to solve this issue, without success. Furthermore, it should be noted that some ports contacted by ESPO have pointed out that the estimates provided in this Study seem to underestimate the size of the sector, at least in some countries.
- **Marine equipment and supplies**: manufacture of equipment and supplies is an industry in which Europe is a world leader. However, the industry as such is not captured in the classification system of economic activities. By combining NACE and Prodcom data, it is possible to single out certain economic activities that manufacture equipment installed on ships: "manufacture of engines and turbines", "manufacture of cordage, rope, twine and netting", "manufacture of instruments and appliances for measuring testing and navigation", "manufacture of made-up textiles articles, except apparel". However, upon further research, it has emerged that these activities only make up a very small part of the EU marine equipment industry, because the greatest part (in terms of value) of equipment installed on ships is produced by industries that manufacture components that can be installed indifferently on several means of transport. As a result, a preliminary estimation of the size of the industry made during the study has been judged by stakeholders considerably lower than the actual size of the industry. Another study has been looked at[23] to benchmark the method used, but, upon discussing with its authors, it has emerged that the method is based on statistical data, interviews with manufacturers, and the authors' personal knowledge, and thus could not be replicated in the time frame of the study. Furthermore, the study is not updated every year. Therefore, it has been decided not to include manufacture of marine equipment and supplies in the direct measurement of the blue economy. Nonetheless, the value added and employment generated by the sector is captured in the indirect impact of shipbuilding.
- **Public sector activities**: public sector activities are measured differently from the rest of the economy. The only common indicators available are public expenditure and employment. While employment can be tallied up with the employment generated by private activities, public expenditure is a separate indicator, only available for this sector. Furthermore, the public sector is

[23] BALance Technology Consulting, "Competitive Position and Future Opportunities of the European Marine Supplies Industry", 2014.

also inherently difficult to measure, as Member States' budget categories differ to a great extent, and the statistical classification available at EU level (COFOG) is not as detailed as NACE. A specific section of this report delves into the method developed to estimate the size of the public sector.

On a general level, it is worth mentioning that, when moving down the value chain of a sector, the link with the ocean may become weak to the point of disappearing completely. Deciding when to stop is a choice that inevitably implies a certain degree of arbitrariness, as testified by the great diversity of approaches in the various attempts to map the blue economy worldwide.

In view of reducing arbitrariness, the criterion adopted has been to map all the activities that at the initial stage of the value chain respond to the definition of the blue economy developed for this study. When moving down the value chain, activities have been included either because they continue to respond to the definition of maritime activity, or based on the consideration that they could not exist without the ocean and / or its resources.

For instance, the fish processing industry uses sea resources as an input (although the peer-review group set up for this study noted that most fish is imported) and, without fish, would cease to exist altogether. On the other hand, when it comes to offshore renewable energy, only production and transmission services have been considered 'maritime', on account of the fact that after energy enters the grid, its link with the ocean is weakened to the point that it is no longer possible to distinguish its source. Furthermore, the energy retail market and its jobs would still exist even without the ocean, this being only one of a multitude of sources.

The research team acknowledge that the criterion adopted remains arbitrary to some extent. Nevertheless, the final selection of activities has been validated by the EU Commission and by a peer-review group specifically set up for this study. The discussion that has taken place should at least ensure that the final selection is in line with the general view of stakeholders.

2 Definition of indicators

The activities included in the database are monitored through two sets of indicators:

The first set includes economic indicators that are common to all the activities:

- **Turnover**: it comprises the totals invoiced by the observation unit during the reference period, and this corresponds to the total value of market sales of goods and services to third parties[24].
- **Value added at factor cost**: it is the gross income from operating activities after adjusting for operating subsidies and indirect taxes. It can be calculated as the total sum of items to be added (+) or subtracted (-):
    - turnover (+);
    - capitalized production (+);
    - other operating income (+);
    - increases (+) or decreases (-) of stocks;
    - purchases of goods and services (-);
    - other taxes on products which are linked to turnover but not deductible (-);
    - duties and taxes linked to production (-)

[24] It includes:

- all duties and taxes on the goods or services invoiced by the unit with the exception of the value-added tax (VAT) invoiced by the unit vis-à-vis its customer and other similar deductible taxes directly linked to turnover;
- all other charges (transport, packaging, etc.) passed on to the customer, even if these charges are listed separately on the invoice.

Reductions in price, rebates and discounts as well as the value of returned packing must be deducted.

- **Number of persons employed**: it is defined as the total number of persons who work in the observation unit (inclusive of working proprietors, partners working regularly in the unit and unpaid family workers), as well as persons who work outside the unit who belong to it and are paid by it (e.g. sales representatives, delivery personnel, repair and maintenance teams). It excludes manpower supplied to the unit by other enterprises, persons carrying out repair and maintenance work in the enquiry unit on behalf of other enterprises, as well as those on compulsory military service.
- **Number of full-time equivalent units**: a full-time equivalent, sometimes abbreviated as FTE, is a unit to measure employed persons in a way that makes them comparable although they may work a different number of hours per week. The unit is obtained by comparing an employee's average number of hours worked to the average number of hours of a full-time worker. A full-time person is therefore counted as one FTE, while a part-time worker obtains a score in proportion to the hours they work. For example, a part-time worker employed for 20 hours a week where full-time work consists of 40 hours, is counted as 0.5 FTE.
- **Average personnel costs** (or unit labour costs): they equal personnel costs (made up of wages, salaries and employers' social security costs) divided by the number of employees (persons who are paid and have an employment contract).

N.B.: turnover and value added are not reported for public sector activities, for which 'public expenditure' is used.

The second set of indicators is defined as 'sector-specific indicators'. These indicators are necessary because economic indicators alone may not be sufficient to track the performance of a sector, in that certain emerging trends in an industry are better described through indicators that measure non-strictly economic variables.

At the time of writing, a list of sector-specific indicators has been agreed with DG MARE and submitted to the peer-review group. The final list may thus slightly differ from the one below, depending on the remarks of the peer-review group:

Table 4 - List of sector-specific indicators

Group	Sectors included	Indicators	Source
1. Living resources	Fisheries (production)	1. Rate of Utilization of quotas 2. Number of enterprises 3. Energy consumption 4. Fishing days 5. Volume of landings 6. Value of landings 7. Repair and maintenance costs 8. Variable costs 9. Non-variable costs	EUR-Lex DCF/JRC DCF/JRC DCF/JRC EUMOFA/DCF/EUROSTAT EUMOFA/DCF/EUROSTAT EUMOFA/DCF/EUROSTAT DCF/JRC DCF/JRC DCF/JRC
	Aquaculture (production)	1. Number of enterprises ≤ 5 employees 2. Number of enterprises 6 - 10 employees 3. Number of enterprises > 10 employees 4. Volume of sales 5. Value of sales 6. Raw material costs 7. Repair and maintenance costs 8. Other operational costs	DCF/JRC DCF/JRC DCF/JRC EUMOFA/DCF/EUROSTAT EUMOFA/DCF/EUROSTAT DCF/JRC DCF/JRC DCF/JRC
	Fish processing	1. Number of enterprises ≤ 10 employees	DCF/JRC DCF/JRC

Group	Sectors included	Indicators	Source
		2. Number of enterprises 11 - 49 employees 3. Number of enterprises 50 - 249 employees 4. Number of enterprises ≥ 250 employees 5. Energy costs 6. Raw material costs 7. Other operational costs 8. Self-sufficiency rate	DCF/JRC DCF/JRC DCF/JRC DCF/JRC DCF/JRC To be calculated
	Blue biotechnology	1. Percentage of biotechnology R&D (NACE Rev2 M 72.11) 2. Number of national institutes working on marine biotechnology; % of total 3. No of researchers involved in marine biosciences 4. Public funding of research in MBt 5. Number of publications 6. Patent applications/granted patents 7. Translational companies based on marine bioresources	No single source can provide these indicators. They can be compiled by collating a number of sources: EuropaBio European Biotechnology Network European Marine Board ERRIN ScanBalt
2. Non-living resources	Extraction of oil and gas	1. Offshore production of oil 2. Offshore production of gas 3. Price of crude oil 4. Price of natural gas 5. Historical volatility of oil price 6. Historical volatility of gas price 7. Share of renewable energy	Production: sources at national level Prices: OPEC and World Bank Share of renewable energy: Eurostat
	Extraction of aggregates	Estimated production of marine aggregates	UEPG
	Extraction of salt	Production of sea salt	British Geological Survey
	Seabed mining	-	
	Desalination	Data on water quality are available on https://www.desaldata.com. Its cost varies from £ 2200 to £ 4000.	
3. Shipping	Maritime transport	1. Gross weight of goods handled 2. Gross weight of goods transported 3. Volume of containers handled 4. Passengers embarked and disembarked 5. Number and gross tonnage of vessels in main ports	Eurostat
	Ports (including dredging)	-	
4. Shipbuilding	Shipbuilding (including leisure boating and water sport equipment)	1. Number of enterprises (includes ship repairs) 2. Number of new orders 3. Number of completions 4. Turnover of naval shipbuilding 5. GVA of naval shipbuilding 6. Persons employed in naval shipbuilding	Eurostat Sea Europe Sea Europe

Group	Sectors included	Indicators	Source
		7. FTE in naval shipbuilding	
	Ship repair	-	
5. Tourism	Coastal tourism	1. Nights spent at tourist accommodation establishments in coastal areas 2. Number of establishments, bedrooms and bed-places in coastal areas 3. Total tourist expenditure in coastal areas	Eurostat
	Cruise tourism	1. Number of cruise passengers 2. Direct expenditure 3. Average cruise ticket value 4. Turnover of cruise tourism 5. GVA of cruise tourism 6. Persons employed in cruise tourism 7. FTE in cruise tourism	Eurostat CLIA CLIA
6. Equipment	Equipment	1. Exports of marine navigation equipment	Prodcom / Comext
7. Renewable energy	Wind energy	2. Number of farms 3. Number of turbines 4. Capacity installed (MW) 5. Investments 6. Gross electricity generation main activity (main activity and autoproducer)	EWEA Eurostat
	Other renewable (tide, wave and ocean)	Primary production 1. Gross inland consumption 2. Energy available for final consumption 3. Electricity price 4. Gross electricity generation (main activity and auto-production)	Eurostat
8. Other	Public activities for environmental protection, and marine and coastal security	-	

3 Approach to measuring the indirect impact of the blue economy

3.1 Introduction and key concepts

The blue economy has linkages with many other sectors that are partly or wholly maritime and those that are not maritime. For example, maritime transport requires steel for ships and fuel to power those ships. Steel production is not a maritime activity, but increased demand for ships will increase the demand for steel. Maritime shipping thereby has an indirect effect on the steel sector.

The first phase of the study has defined to what extent economic activities should be included for the numerous economic sectors that involve land-based and maritime activities.

This stage of the analysis identifies those products/services whose end use is indirectly maritime or are inputs to maritime activities.

Input-output tables quantify the relationship between different sectors. They also allow the quantification of impact that a change in demand in one sector will have on another sector; these are termed 'multipliers'.

3.2 Multipliers

Multiplier analysis studies the effect of changes in final demand on output and related aspects of the economy. These effects have three different economic drivers:

1. **Direct**: this is the immediate effect caused directly by the change in final demand, e.g. if there is an increase in final demand for a particular product, we can assume that there will be an increase in the output of that product, as producers react to meet the increased demand;
2. **Indirect**: this is the subsequent effect caused by the consequent changes in intermediate demand i.e. as producers increase their output, there will also be an increase in demand on their suppliers and so on down the supply chain;
3. **Induced**: this is the effect attributable to the ensuing change in compensation of employees and other incomes, which may cause further spending and hence further changes in final demand, e.g. as a result of the direct and indirect effects the level of household income throughout the economy will increase as a result of increased employment. A proportion of this increased income will be re-spent on final goods and services: this is the induced effect.

Type 1 multipliers consider direct and indirect effects of changes in demand, while Type 2 multipliers also include induced effects. GVA and Output multipliers are Type 1 multipliers. These multipliers underestimate the effect on the economy as they do not estimate induced effects.

Type 1 multipliers estimate the impact on the supply chain resulting from a producer of a certain product increasing their output to meet additional demand. In order to meet the additional demand, the producer must in turn increase the goods and/or services they purchase from their suppliers to produce the product in question.

These suppliers in turn increase their demands for goods and services and so on down the supply chain. The multipliers refer to the impacts associated with additional purchases of inputs from suppliers required to meet a given increase in the demand of a specific product.

Example:

The direct impact on total GVA caused by an increase of €5m in the GVA of products in the 'water transport' group is an increase of €5m.

To estimate the indirect effect on the industries that produce these products, we multiply the direct impact (€5m) by the GVA multiplier for this product grouping (e.g. 1.50) giving a total of direct plus indirect impact of €7.5 million

3.3 Method

In this analysis, Type 1 multipliers have been identified or derived to estimate the indirect GVA and employment associated with Europe's Blue Economy. This can then be applied to the direct GVA and employment derived in the previous section to better appreciate the scale and linkages of Europe's blue economy.

Note that this underestimates the total effect on the economy as induced effects are not included.

EUROSTAT gathers input-output (I-O) and supply and use tables (SUT) from Member States and also produces input-output tables for the EU area and by Member State[25]. Under the European system of national and regional accounts (ESA 2010), EU Member States transmit to EUROSTAT supply and use tables annually and input-output tables 5-yearly (EUROSTAT).

EUROSTAT tables are presented at a consistent level of detail: NACE 2-digit codes for 65 sectors producing or using goods and services. These do not generally define maritime sectors. Therefore, this study has sought to identify whether at Member State level there may be input / output tables available at a higher level of detail, i.e. beyond the 2-digit level normally available through EUROSTAT.

The study team has reviewed the I-O and SUT tables published by the national statistical offices (NSO) in the 23 coastal Member States and contacted those offices to identify if additional detail is available (see at the end of this section).

Maritime clusters in coastal member states have also been contacted to identify where additional detail is collected and/or bespoke studies had been conducted. NSOs in land-locked Member States have also been contacted, recognising that the maritime sector may be supplied from land-locked states.

Five Member States (Denmark, France, Italy, Portugal and the UK) have identified that more detail is available for some sectors compared to the standard ESA 2010 sectors presented in the Supply and Use tables:

- Denmark produces I-O tables with 97 rather than the usual 65 sectors reported under ESA 2010. Of these, two enable more maritime detail: processing & preserving of fish (C.10.20) and 'Manufacture of ships and other transport equipment' (included within C30). Indirect employment is also provided for 4 sectors (extraction of oil and gas, maritime transport, shipbuilding and 'other renewables').
- France provides an occasional 'highlights' document, the first table shows VA and employment data on salt mining (sector 0893), shipbuilding (301), ship repair & maintenance (3315), maritime and coastal transport (501 and 502). However, this does not give extra detail to enable indirect GVA or employment to be calculated.
- Italy indicates that direct GVA data on fisheries and aquaculture, ports, ship building and ship repair is available from the quarterly national accounts. They also report that annual cruise tourism data is available from a CLIA report and there may also be data in annual reports of the Italian Navy and Coastguard.
- Portugal provides additional information from its Maritime cluster that has undertaken a similar exercise based on nine maritime sectors. It provides direct GVA and employment (which is a useful comparison with overall results from this study), but not as estimate of indirect GVA and employment.
- The United Kingdom SUT tables capture 96 sectors and some of these additional sectors are relevant to the blue economy (fish processing, 'ships & boats' and 'repair and maintenance of ships and boats') to enable % contribution of other industries to be identified. The UK reports a range of multipliers (type 1) and effects in relation to these sectors.

The additional detail for the above MS is mainly data that can be used to calculate or compare with calculations of direct GVA. Only the UK and Danish analytical tables provide additional detail for some maritime sectors that can be used to calculate indirect GVA.

[25] http://ec.europa.eu/eurostat/web/esa-supply-use-input-tables/data/database

3.4 Approach used to determine indirect GVA

A hierarchy of methods is proposed to determine indirect GVA:

1. Apply SUT-derived multipliers to maritime component (as determined by sector experts based on a range of information sources)
2. Apply SUT-derived multiplier from another MS
3. Use multiplier from a study of the MS itself
4. Use multiplier from a study from another MS

This approach recognises the importance of comprehensive and consistent data collection as the objective is to replicate these calculations in the future. SUT-derived multipliers are favoured wherever available as ad-hoc studies only cover one MS and may not be updated.

Table 5 - Approach to determining indirect GVA per sector

Sector description	Approach to indirect GVA	Approach code	Related NACE	MS data used	Rationale for use/Comment
Fisheries	Apply SUT-derived multiplier to marine component	1	CPA A03	all	
Aquaculture	Apply SUT-derived multiplier to marine component	1	CPA A03	all	
Fish processing	Apply SUT-derived multiplier from another MS	2	(DK) 100020	DK	DK is specific to fish processing, UK is broader: "Processing and preserving of fish, crustaceans, molluscs, fruit and vegetables"
Prepared meals and dishes	Not calculated				CPA_C10-C12 Food products beverages and tobacco products too broad to determine marine component. Fish processing expected to contribute to this to a very limited extent
Other food products n.e.c.	Not calculated				CPA_C10-C12 Food products beverages and tobacco products too broad to determine marine component. Fish processing expected to contribute to this to a very limited extent
Manufacture of oils and fats	Not calculated				CPA_C10-C12 Food products beverages and tobacco products too broad to determine marine component. Fish processing expected to contribute to this to a very limited extent
Blue biotechnology	Not calculated				Difficulties in defining the scale of blue biotech.
Extraction of oil and gas	Apply SUT-derived multiplier from another MS	2	DK 60000	DK	DK specifically "extraction of oil and gas", while UK includes metal ores
Extraction of aggregates	Apply SUT-derived multiplier to marine component	2	DK 80090	DK	DK category is "Extraction of gravel and stone"
Extraction of salt	Not calculated				No data and v small scale
Seabed mining	Apply SUT-derived multiplier to marine component	1	CPA B	all	Marine component reported as 0%

Sector description	Approach to indirect GVA	Approach code	Related NACE	MS data used	Rationale for use/Comment
Desalination	Not calculated				Activity no long included:only in Spain, Italy and Cyprus (and only of significant scale in Spain)
Maritime Transport	Apply SUT-derived multiplier to marine component	1	CPA H50	all	inland % of H50 v minor
Ports (including dredging)	Results from a study from another MS	4	n/a	IE	includes PORTS
Shipbuilding	Apply SUT-derived multiplier from another MS	2	UK 30	UK	Category is "ships and boats" (DK includes '…and other transport equipment'
Ship repair	Apply SUT-derived multiplier from another MS	2	UK 33	UK	Category is "Repair and maintenance of ships and boats"
Coastal tourism	Apply SUT-derived multiplier to marine component	1		all	See below
Cruise tourism	Not calculated				Reliance on CLIA report for direct data
Wind Energy	Results from a study from another MS	4	n/a	UK	Oxford Economics 2011
Other renewable	Results from a study from another MS	4	n/a	UK	Oxford Economics 2011
Public sector	Not calculated		CPA 084		Public administration and defence services; compulsory social security services. As only have data on expenditure, GVA mutiplier not calculated

The method for calculating indirect GVA using the SUT tables is:

- Using the I-O or SUT tables identify the proportional contribution to inputs from economic sectors in the supply of goods and services to maritime sectors.
- The GVA of those sectors at basic prices as a % of total supply is identified from the tables.
- A multiplier is calculated based on the proportion that each sector contributes to supplying the primary sector.
- To avoid double-accounting, suppliers with the same NACE code are removed (e.g. CPA03 inputs are not included in the calculation for CPA03)
- This results in the indirect GVA from domestic suppliers resulting from an increased demand in a primary sector.
- To estimate the indirect GVA from imports, the proportion of use of imports by the primary sector given in the I-O table is used. In some cases, this can be divided into intra EU and extra EU imports.
- Where an I-O table is not provided (7 coastal member states), the supply table is used to determine the proportion of imports for a given sector.
- It is assumed that imports show the same supplier profile as domestic inputs.
- The GVA from domestic and imported supply sectors are then added to give the overall indirect GVA multiplier.

Example:

Maritime sector X is supplied by a range of sectors: 60% by domestic economic sectors and 40% by imports. The following domestic economic sectors supply the sector A, B, C, D and X in the following proportions:

Economic sectors	% of supplies to x	GVA
A	25%	45%
B	10%	50%
C	35%	30%
D	10%	20%
X	20%	40%

The domestic indirect GVA impact is then calculated as:

(0.25 x 0.45) + (0.1 x 0.5) + (0.35 x 0.3) + (0.1 x 0.2) = 0.2875

note: sector X is not included to avoid double-accounting.

The imported indirect GVA is calculated as

(0.2875 / 0.6) x 0.4 = 0.192

The total indirect GVA impact is: 0.2875 + 0.192 = 0.479

The type I output multiplier for maritime sector X is therefore 1.479

As is evident from the table above, there are no SUT sectors within the CPA 64 that are by definition 100% maritime. Even 'water transport' may include an inland component. Therefore, the maritime component must be determined for each activity in each Member State. This has been achieved through sector experts reviewing available information and data to report the maritime component for each sector.

The SUTs enable the identification of indirect sector activities that make a partial contribution to some categories. However, for several categories the necessary disaggregation to identify the maritime proportion is lacking. For example, CPA D35 'Electricity, gas, steam and air-conditioning' does not disaggregate production types and methods to enable specific sub-sectors such as 'wind energy' from which the maritime component, 'offshore wind' can be derived. The sectors supplying the various components of CPA D35 will be very different, making it inappropriate to use the SUT to derive indirect GVA. In such instances, specific sector data is sought.

Where maritime data is available for some sectors, e.g. shipbuilding in the UK, these same relationships (e.g. proportions of materials used) are applied to the shipbuilding sector in other member states. A key assumption is that the proportion of imported supplies are the same for all Member States, which is unlikely to be correct.

Some additional data and information sources have been identified for several coastal Members States. These maritime-specific sources are used where available and applied to other member states where appropriate. For example, researchers have developed GVA and employment multipliers for certain maritime sectors in Ireland (Morrisey & O'Donoghue, 2013). The Netherlands maritime cluster also publishes estimates of indirect GVA and employment. Studies of the economic impact of the UK maritime industries and business services by Oxford Economics also calculate indirect GVA and employment.

In instances where the indirect GVA or employment is calculated using assumptions related to another MS, the team will list all assumptions made and provide a rationale for the approach.

3.5 Assumptions

The I-O approach to derive indirect GVA is based on a number of assumptions:

1. The supply side is passive, so that the final demands drive economic activity. This assumes excess capacity (and thus also involuntary unemployment) or very elastic factor supplies, so that the economy can expand without putting any upward pressure on wages and prices.
2. Prices are assumed to be fixed, and therefore no crowding out effects occur.
3. Supplies from Intra and extra EU imports are assumed to have the same supplier profile (i.e. they are made up of the supplies from the same sectors) as domestic supplies.
4. When applying a multiplier derived in one MS to the sector of another MS, a key assumption is that the sector is structured in a similar way with similar proportional use of goods and services from supply sectors.

3.6 Indirect Employment

The calculation of indirect employment follows the same approach to that set out in the DG MARE paper "The size, nature and dynamics of the blue economy". However, additional detail is sought via the SUT tables where available on the location of indirect employment.

Indirect employment resulting from an increase in GVA within the country itself can be calculated based on the indirect GVA calculated (as per above). The SUT tables are used to identify the proportion of inputs from intra EU trade and extra-EU trade. These enable the identification of indirect employment that can be attribute to within and outside the EU.

As with GVA, it is assumed that indirect employment resulting from imports has the same supplier profile as domestic inputs.

4 Results of the study

A database with the full results of the study is provided in electronic format as a complement to this report. This section gives a short overview of the main findings of the study. It should be noted that the study aims to set up a framework for data collection on the blue economy, and not to explain the reasons behind its performance. Nonetheless, the availability of data will undoubtedly contribute to a better comprehension of certain phenomena.

In 2014, the blue economy of the EU[26] generated a value added (direct and indirect) of nearly 215 billion euros. This figure tends to underestimate the actual size of the blue economy, because:

- Data are not available for certain activities (blue biotechnology, seabed mining, desalination, salt extraction). However, it is believed that having data on these sectors would not change the overall picture to a great extent.
- There are occasional data gaps.
- Indirect employment multipliers are not available for extraction of aggregates. Again, it is believed that the impact on the total value of the blue economy would be negligible.

The direct impact alone is of course lower, amounting to nearly 156 billion euros.

In terms of employment, in 2014 the blue economy generated about 5,7 million jobs directly and indirectly, while direct employment amounts to 3,2 million jobs:

The graphs below provide a detailed breakdown of direct and indirect GVA and employment by sector:

[26] N.B. The full database also includes data on Norway, which, however, are not presented in the graphs.

Figure 1 - Direct and indirect value added of the blue economy by sector, 2014

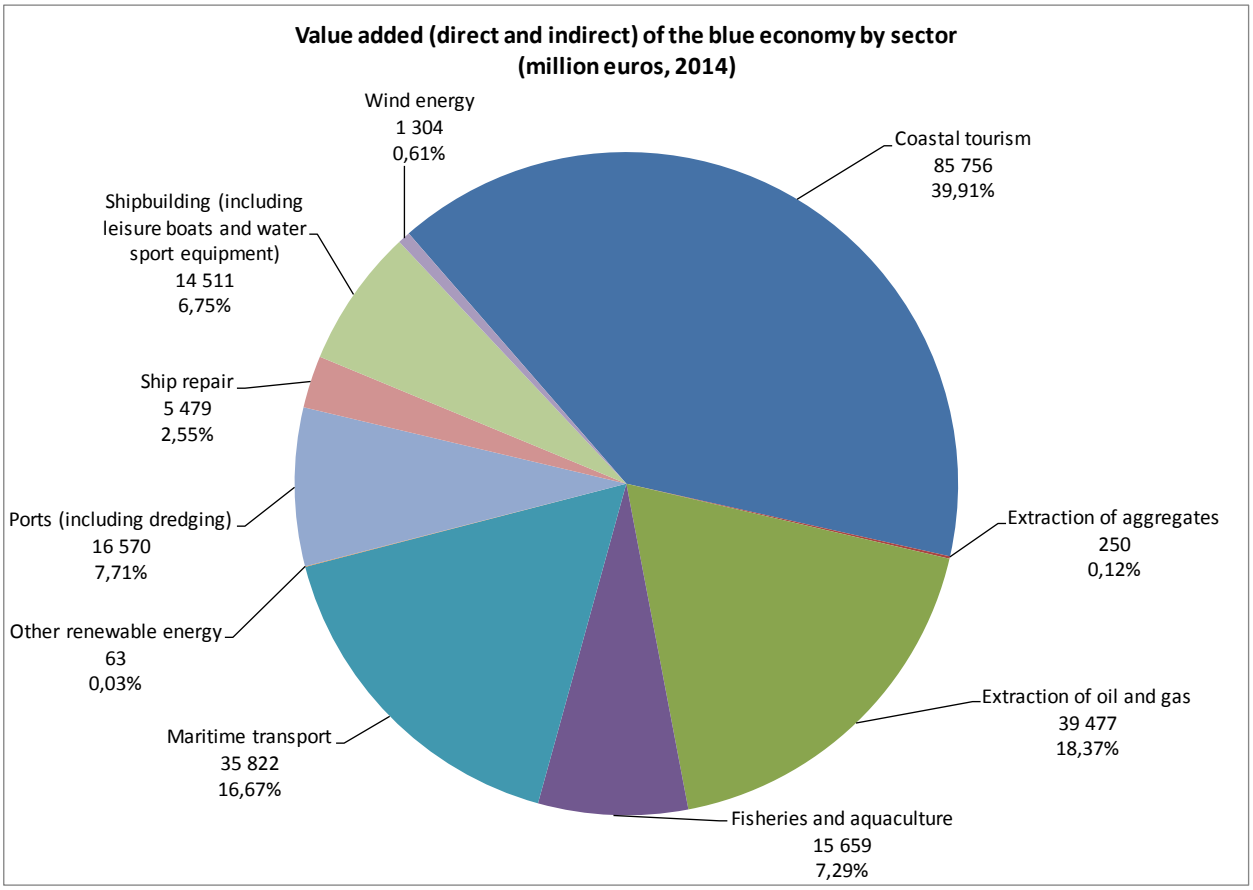
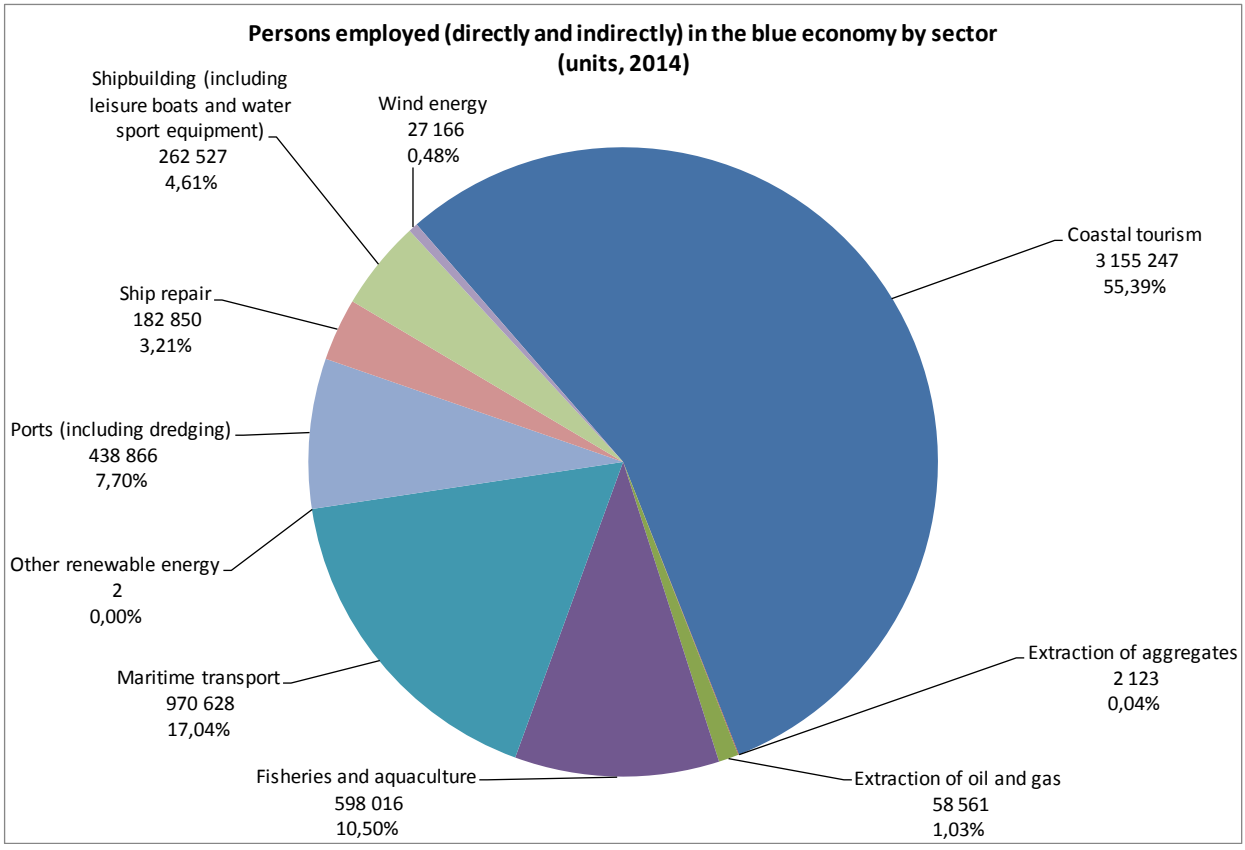


Figure 2 - Persons employed in the blue economy (directly and indirectly) by sector, 2014



Coastal tourism is by far the largest economic activity in terms of value added and jobs generated. This is because tourism is not a single economic activity, but it rather encompasses a wide set of activities centred around the tourist (accommodation, food and restaurants, transport etc.).

It may be interesting to note that traditional sectors still make up most of the blue economy. Besides coastal tourism, extraction of oil and gas generates more than 18% of the value added of the whole blue economy, despite fossil fuels are losing their market share in Europe, as a result of low oil price and more sustainable alternatives.

Maritime transport is another 'traditional' activity that still plays a significant role, making up about 17% of overall value added.

There are revealing differences between the graphs of value added and employment. As one may expect, capital-intensive activities tend to generate more value added than employment, and the opposite is true for labour-intensive activities. Tourism, which makes up nearly 40% of value added, employs more than 3 million people, accounting for 55% of employment. By the same token, fisheries and aquaculture (a sector that also includes the fish processing industry) make up only 7,3% in terms of value added, but their share increases to 10,5% when it comes to employment.

The most interesting example in this sense is extraction of oil and gas, which alone generates 18,4% of the value added of the blue economy, but employs only 1% of the total workforce.

As suggested in § 1.2 of this Report, the above sectors can be further grouped as follows:

Group	Sector	Value added (direct and indirect)	Persons employed (direct and indirect)
Living resources	Fisheries and aquaculture	€ 15 659 mln	598 016
	Blue biotechnology *(no data)*		
Non-living resources	Extraction of aggregates	€ 39 727 mln	60 683
	Extraction of oil and gas		
	Extraction of salt *(no data)*		
	Seabed mining *(no data)*		
	Desalination *(no data)*		
Shipping	Maritime transport	€ 52 393 mln	1 409 494
	Ports (including dredging)		
Shipbuilding	Shipbuilding	€ 19 990 mln	445 377
	Ship repair		
Renewable energy	Wind energy	€ 1 367 mln	27 168
	Other renewable energy		
Coastal tourism	Coastal tourism	€ 85 756 mln	3 155 247

The above graphs give an idea of the dimension of the blue economy, which does not include the public sector. However, the public sector[27] also pumps additional resources into the economy, with more than 30 billions of public expenditure[28] and about 370 000 persons employed. Once again, it is believed that this figure underestimates the total contribution of the public sector to the blue economy. Activities such as public research and education, for instance, could not be included in the database, because very few data are available at Member State level.

[27] For more details on the activities included in the public sector, please see Annex I - § 16.

[28] It is inherently more difficult to measure the 'maritime' public sector in EU Member State, because the classification of public expenditure is not sufficiently detailed. The actual value is probably much higher.

Figure 3 – Public expenditure in maritime activities, 2014

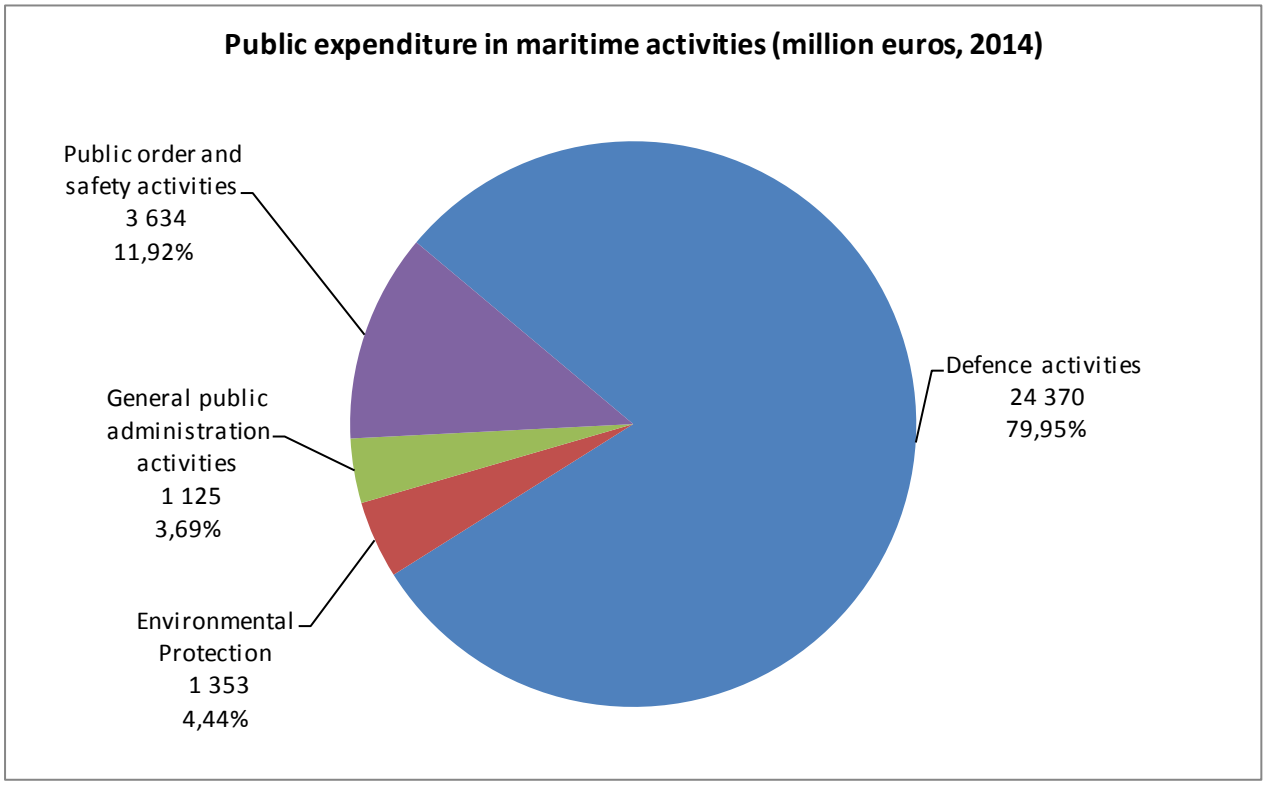
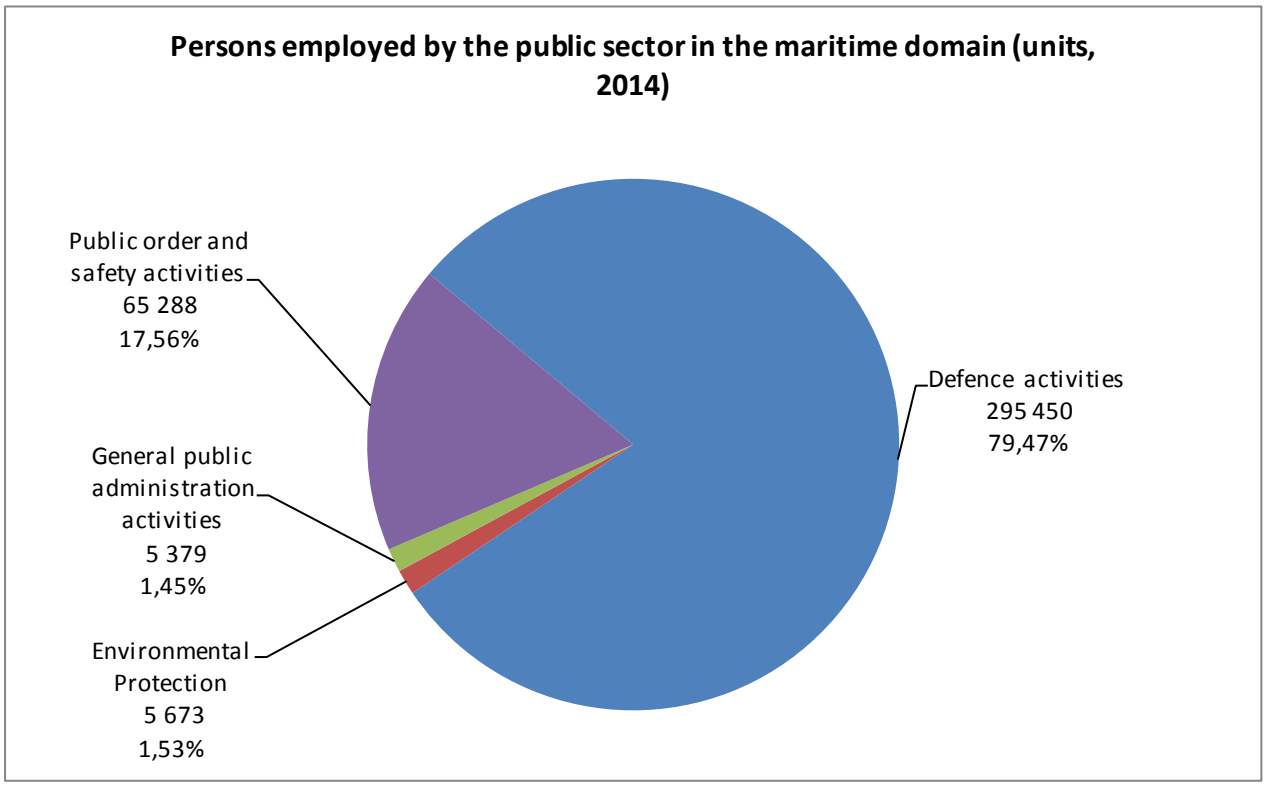
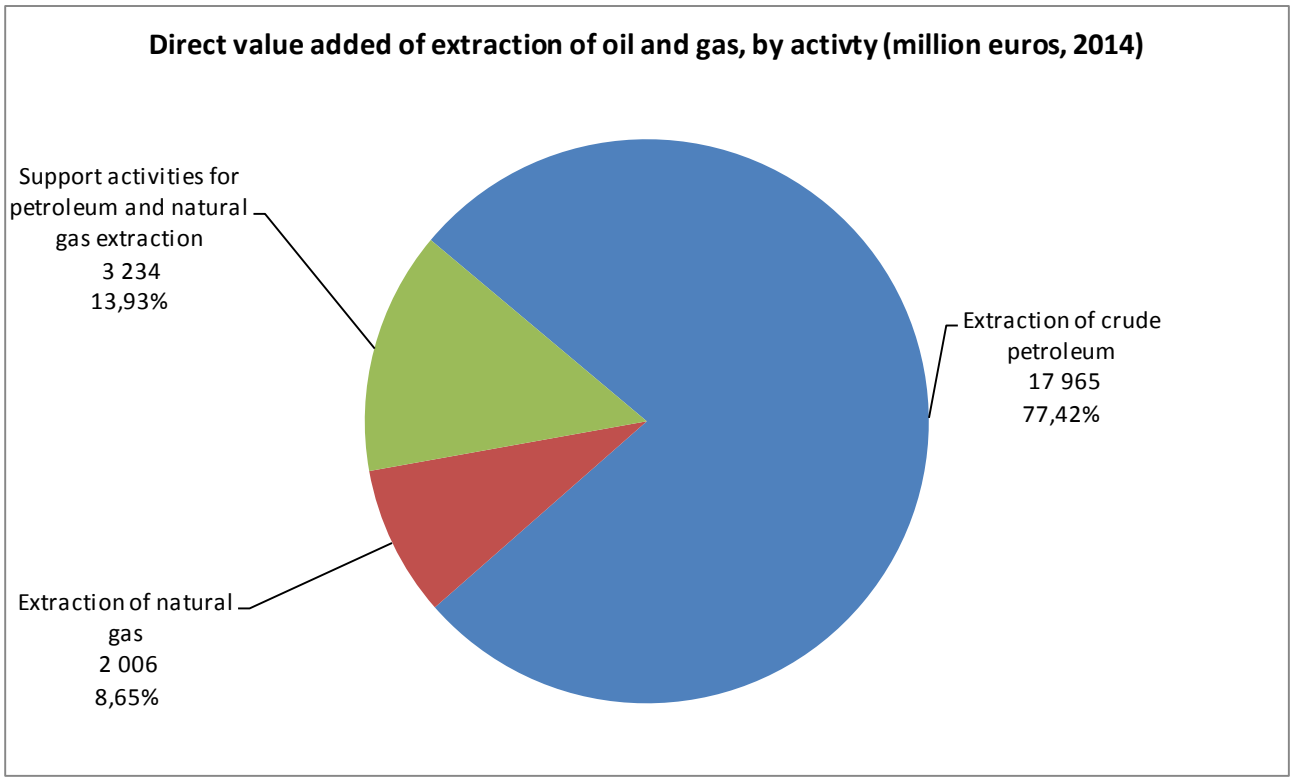


Figure 4 – Persons employed by the public sector in the maritime domain, 2014



It may be worth looking at some sectors more in detail. For instance, the direct value added generated by extracting oil and gas from the seabed amounts to nearly 23 billion euros, and it is possible to break down the sector[29] to understand how the different economic activities contribute to that figure:

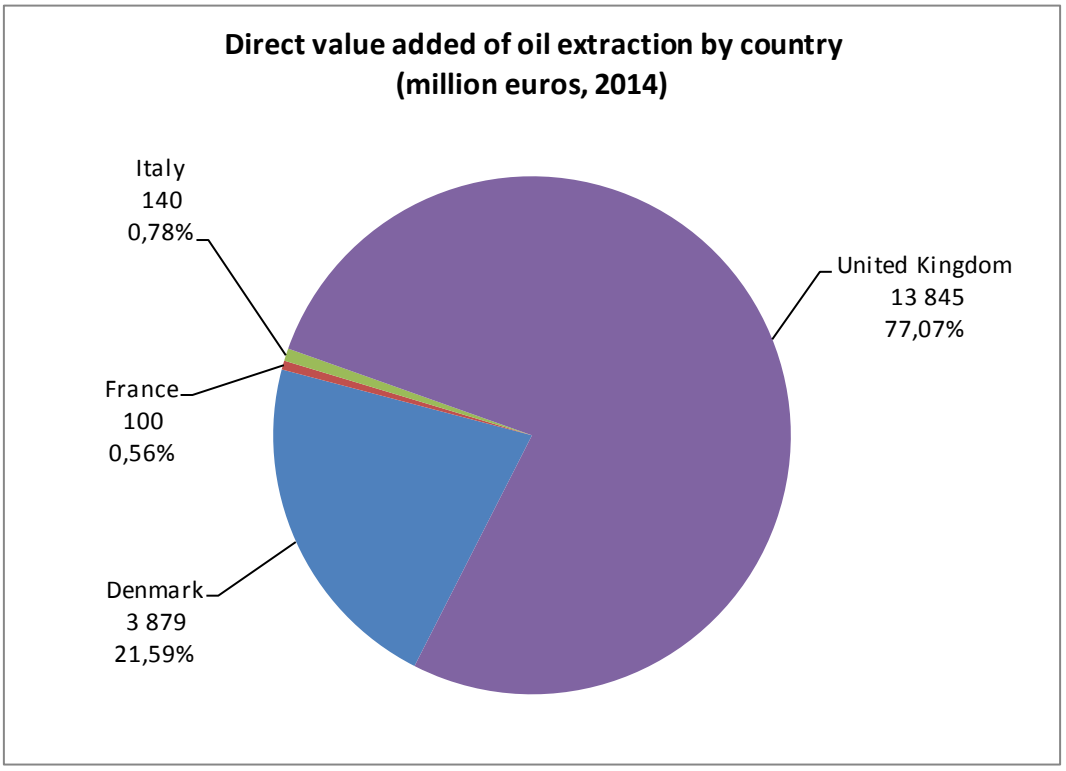
Figure 5 Direct value added of extraction of oil and gas by activity, 2014



Extraction of oil makes up about 77% of the total value added generated by the sector. Such a high share can be explained by the fact that the UK, the largest oil producer in the EU, mostly produces oil:

[29] For more details on the activities making up the sector, please see Annex I § 3.

Figure 6 – Direct value added of oil extraction by country, 2014

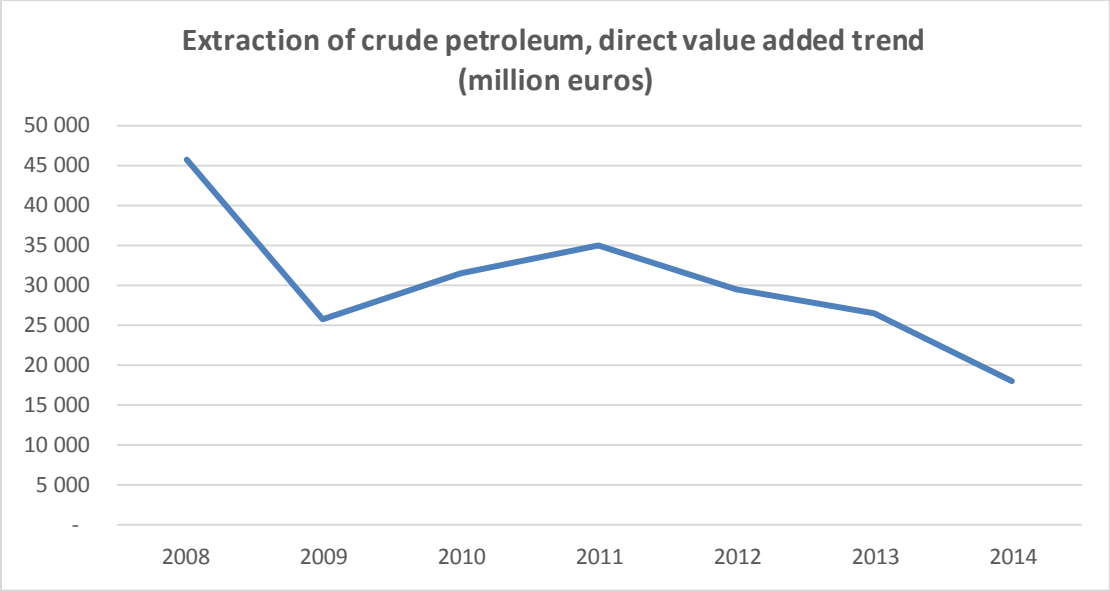


N.B. no data available for Romania on 2014.

It should be mentioned that, for reasons such as low price and more sustainable alternatives, the oil sector is undergoing a difficult moment. The impact of low price is especially evident in the offshore industry, because offshore activities normally have higher costs.

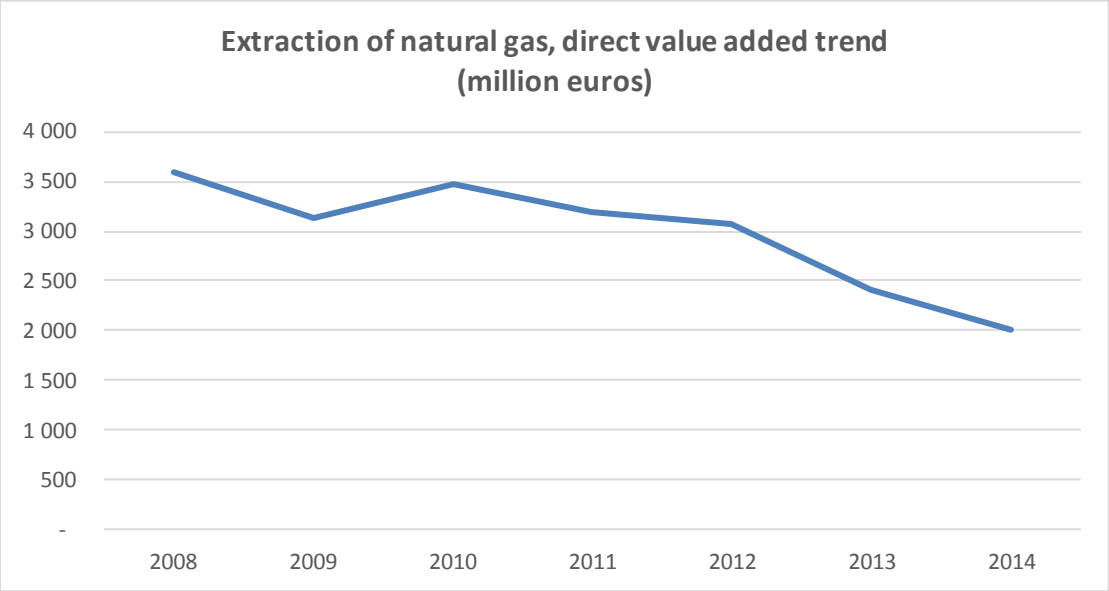
This is clear by looking at the GVA trend from 2008 to 2014:

Figure 7 – Extraction of crude petroleum, direct value added trend



There is a steep decline between 2008 and 2009 as a consequence of the economic crisis. Then the curve shows that the sector was slowly recovering, although it started to decline again in 2012. A similar trend was experienced in extraction of natural gas:

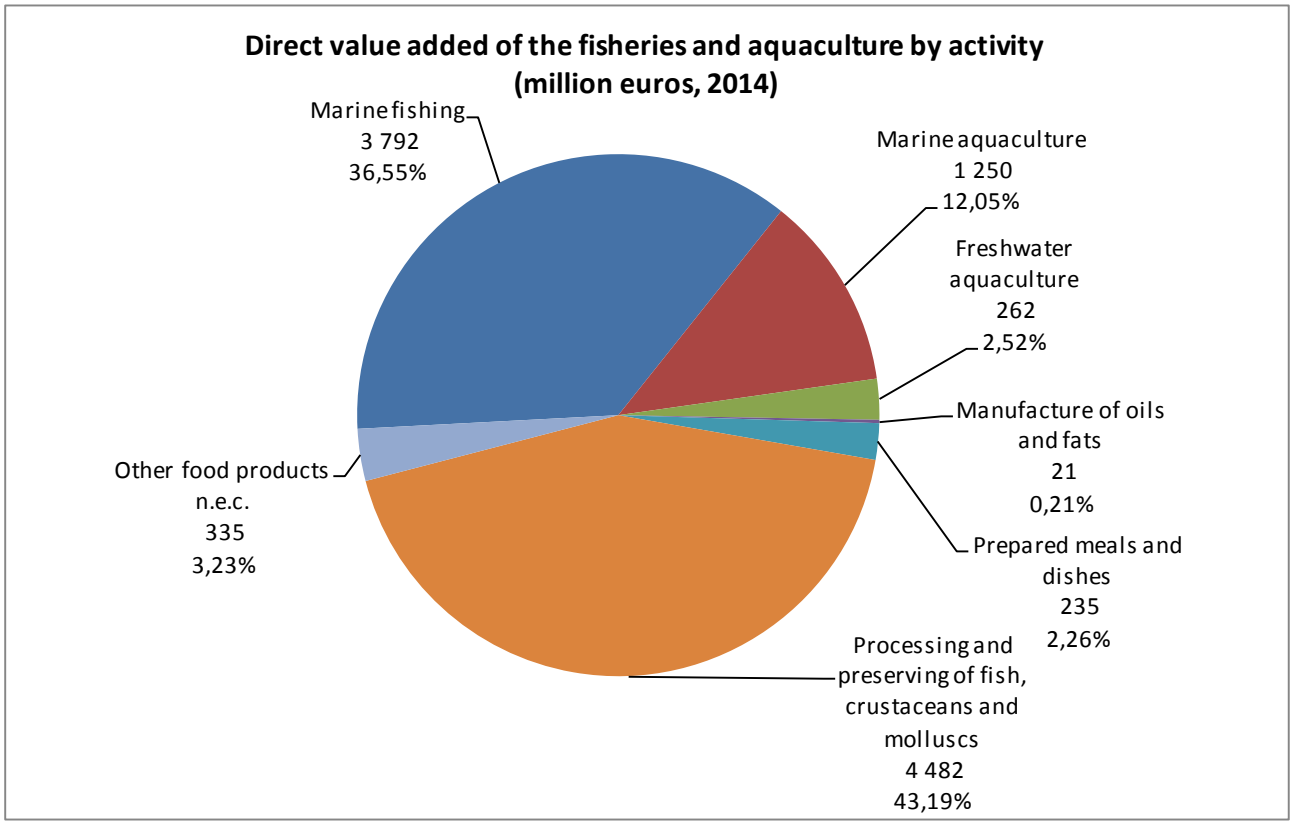
Figure 8 - Extraction of natural gas, direct value added trend



Fisheries and aquaculture[30] is another sector which is interesting to look at. It is actually made up of several activities:

[30] For more details on the activities making up the sector, please see Annex I § 1.

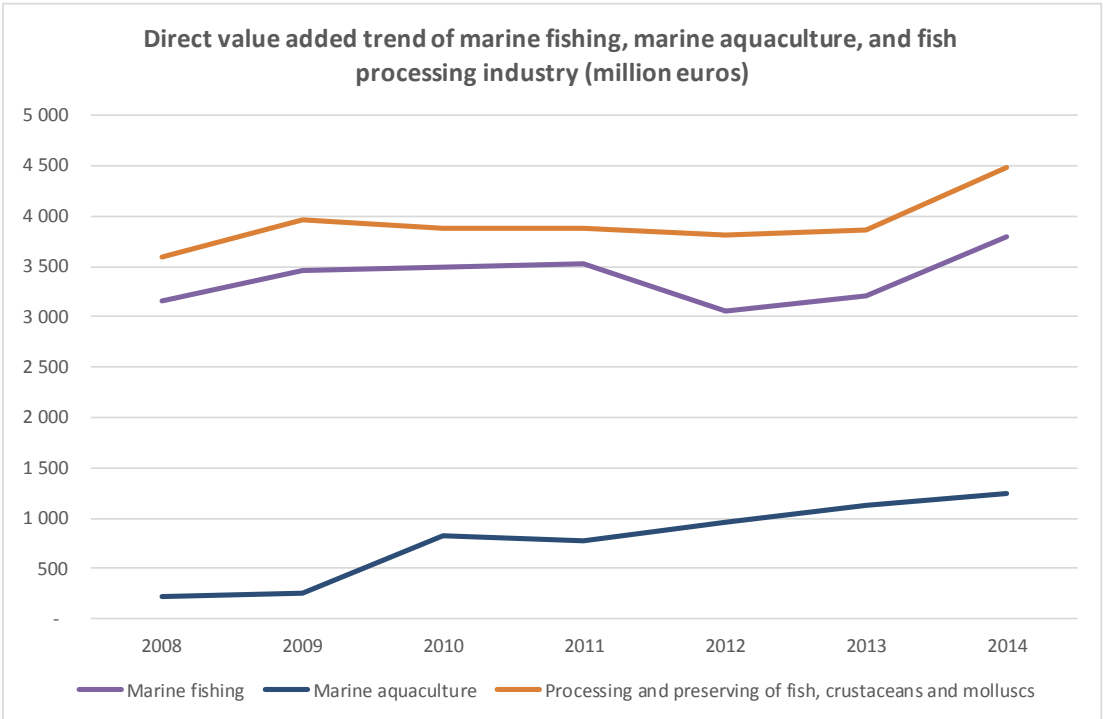
Figure 9 – Direct value added of the fisheries and aquaculture sector, 2014



The primary sector (marine fishing, marine aquaculture and freshwater aquaculture) makes up about 49% of value added, while the rest is generated by the processing industry, which however relies to a great extent on imported fish resources.

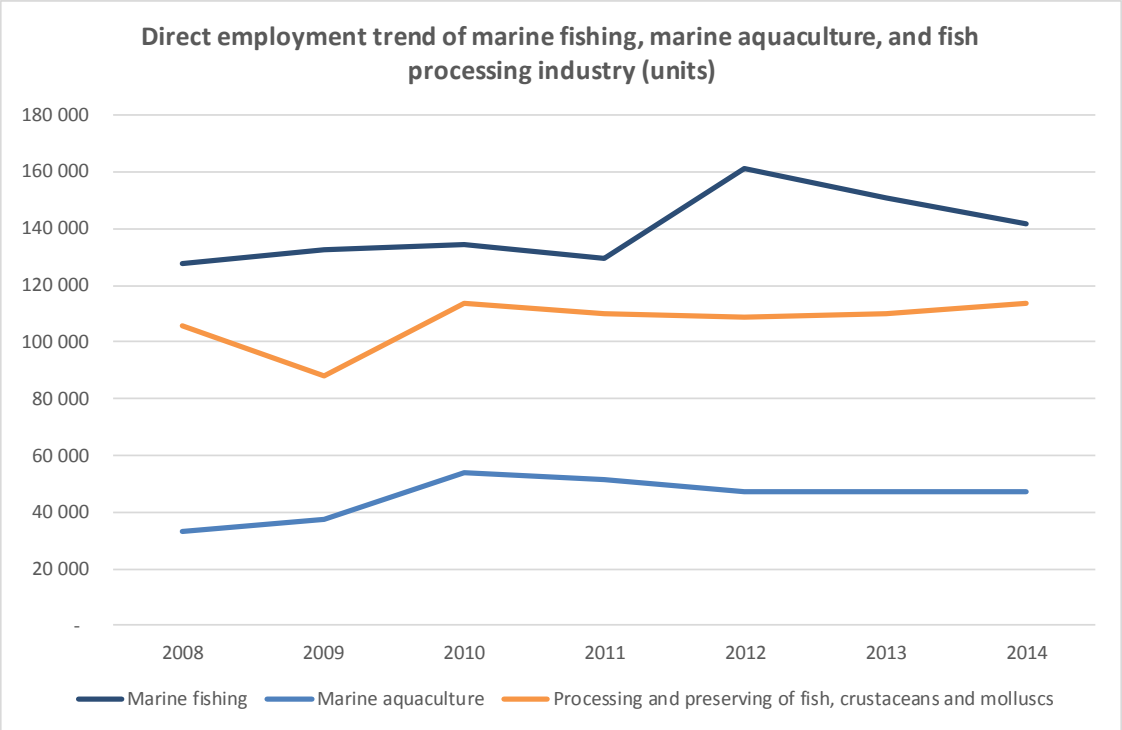
Marine fishing, marine aquaculture and the processing industry all increased in terms of direct value added between 2008 and 2014, despite the economic crisis:

Figure 10 – Direct value added trends of marine fishing, marine aquaculture, and fish processing industry



When it comes to the employment trend, the situation looks slightly different

Figure 11 – Direct employment trend of marine fishing, marine aquaculture and fish processing industry

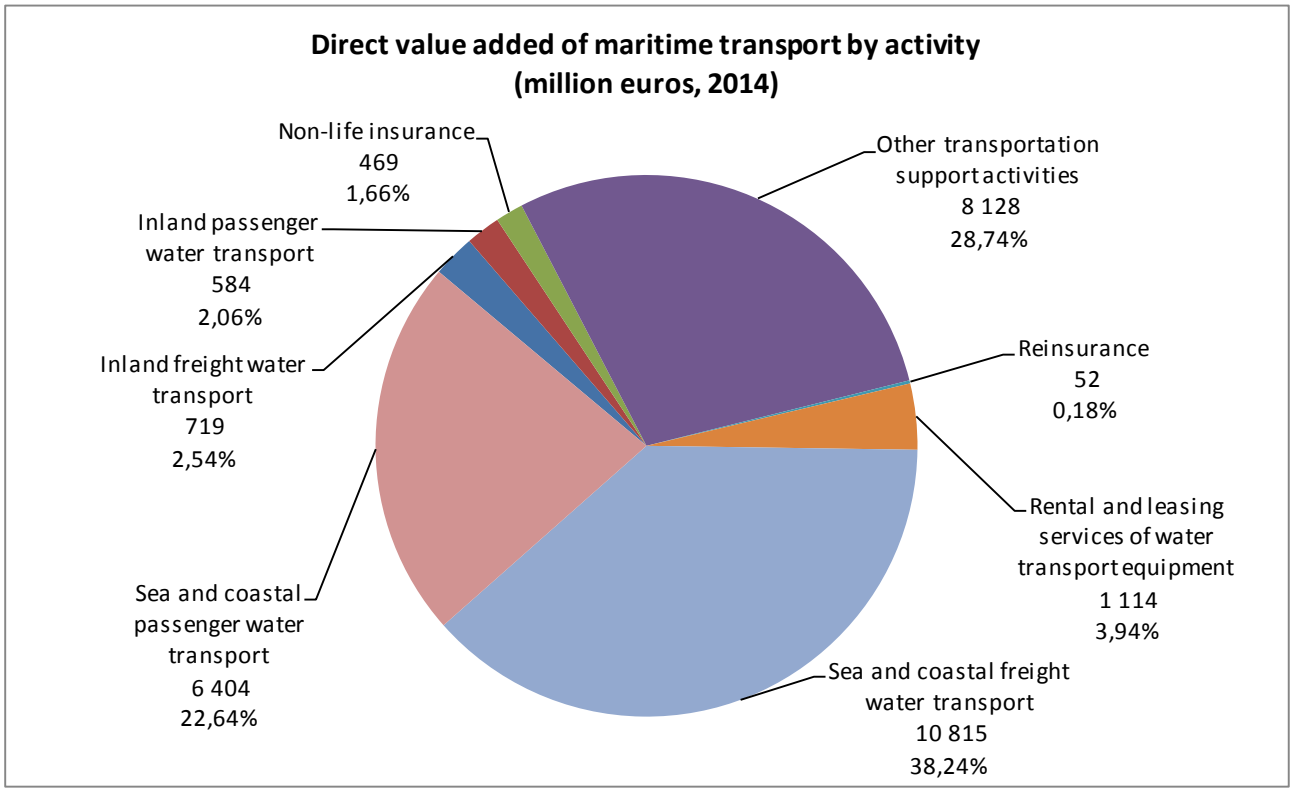


Data on 2014 are rather complete, but the same cannot be said for the rest of the time series. Some countries did not report data regularly, so harsh increases and decreases are due to one or more countries that started or stopped reporting (e.g. data employment in marine fishing in Greece are available only from 2012). In actuality, if all countries had reported data regularly, the curves would probably look flatter than they are, with a steady level of number of persons employed in these sectors, or in some cases a slight decline.

The pie chart below provides a breakdown by activity of maritime transport[31] direct value added:

[31] For more details on the activities making up the sector, please see Annex I § 8.

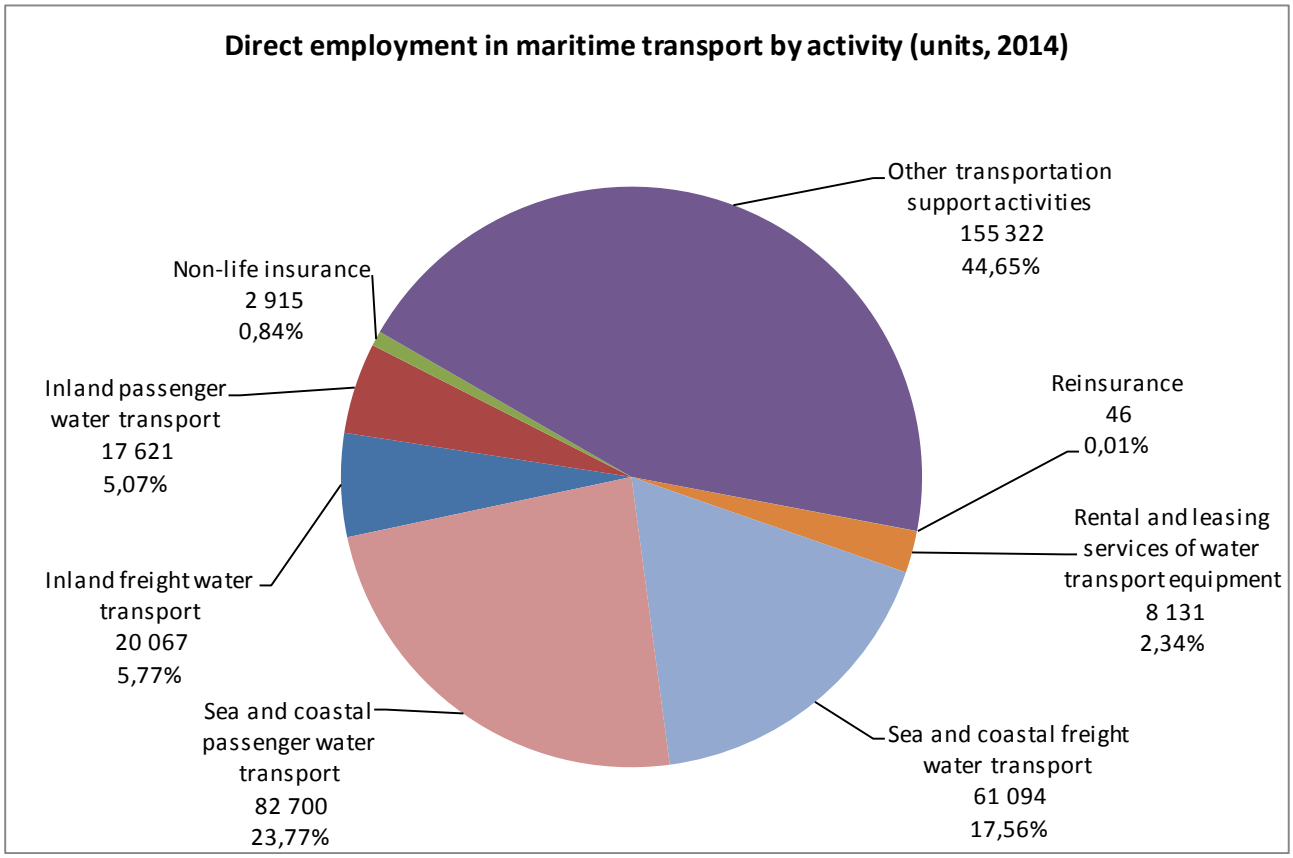
Figure 12 - – Direct value added of maritime transport, 2014



38% of value added is generated by maritime freight transport, while maritime passenger transport (which includes part of cruise tourism) contributes to 23% of value added. Nearly 28% of GVA is generated by 'other transportation support activities', a broad category that includes services such as forwarding of freight, arranging or organising of transport operations by rail, road, sea or air, organisation of group and individual consignments, issue and procurement of transport documents and waybills, activities of customs agents, activities of sea-freight forwarders and air-cargo agents, brokerage for ship and aircraft space, goods-handling operations.

In terms of employment, the situation is slightly different:

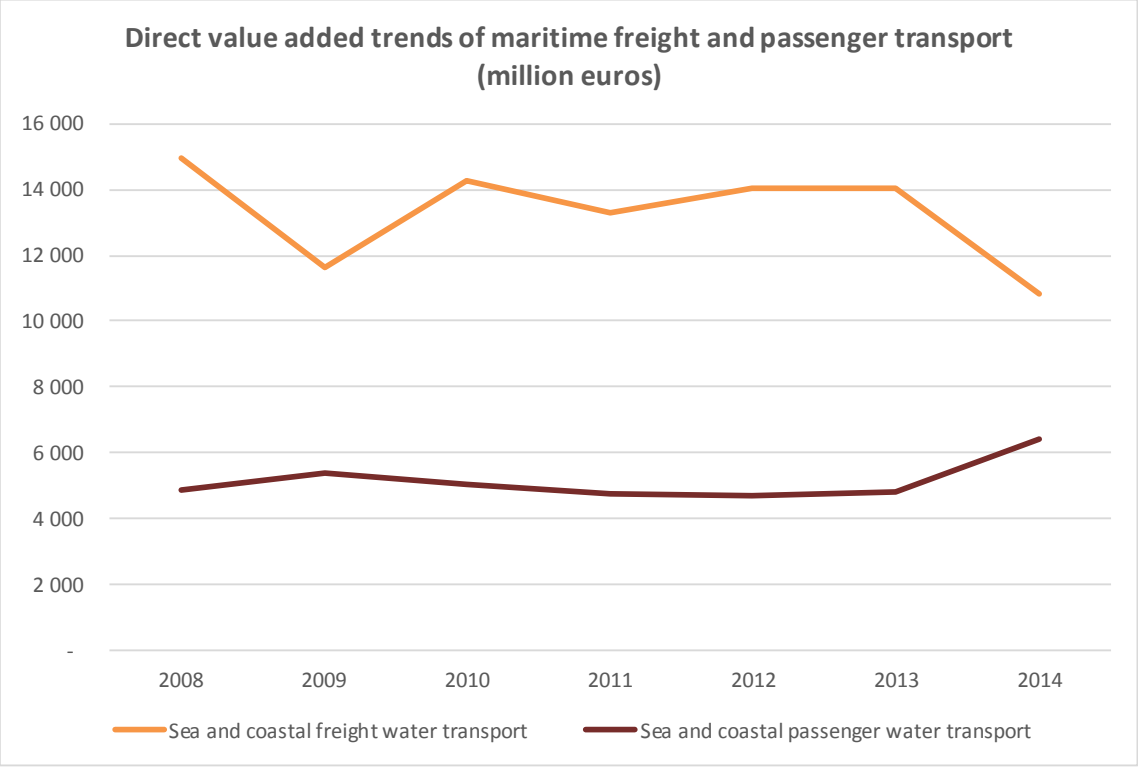
Figure 13 – Direct employment in maritime transport by activity, 2014



More than 40% of persons are employed in 'other transportation support activities', which alone almost equal the number of persons employed in maritime freight and passenger transport.

It may be interesting to look at the diverging trends between passenger and freight transport:

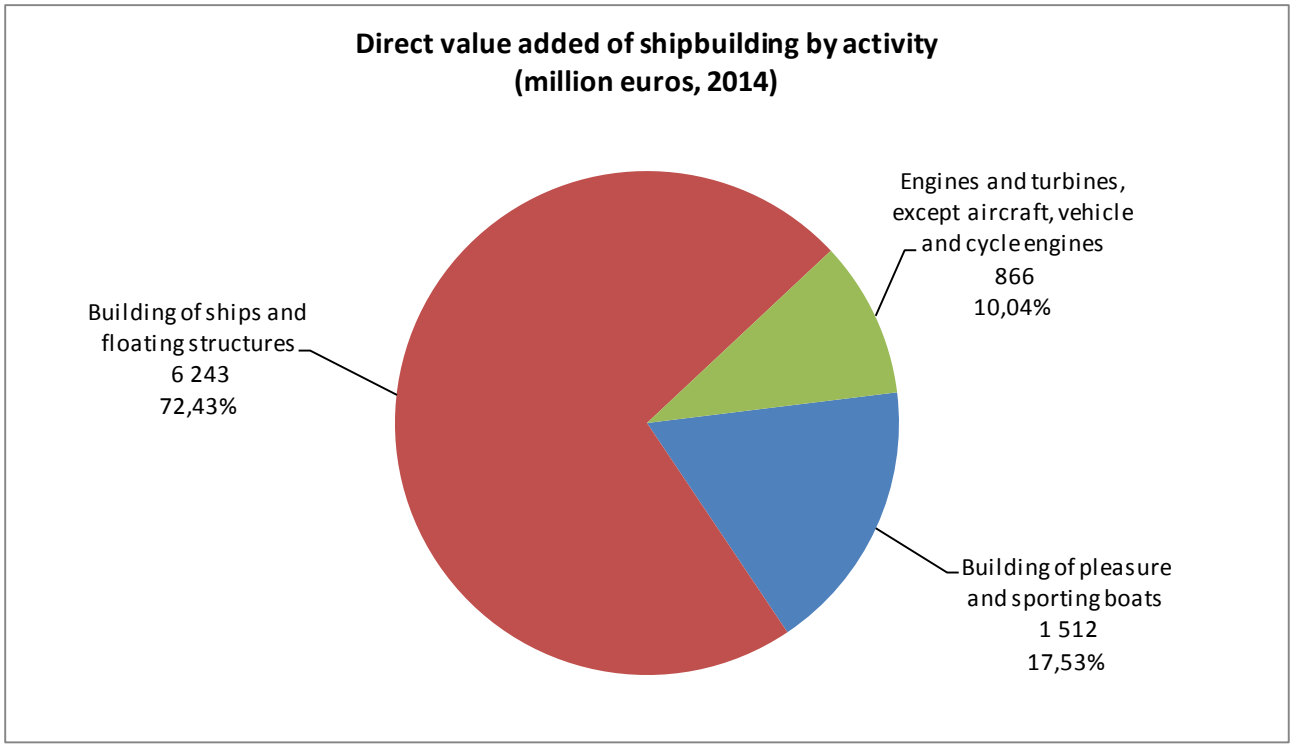
Figure 14 – Direct value added trends of maritime freight and passenger transport



However, it should be noted that the decline of freight transport in 2014 may be attributed to missing data from Denmark. The data series also suffers from other gaps, but these are not as dramatic as to affect the trend at EU level.

When it comes to the shipbuilding sector[32], the data show that 72% of value added is generated by building of ships and floating structures:

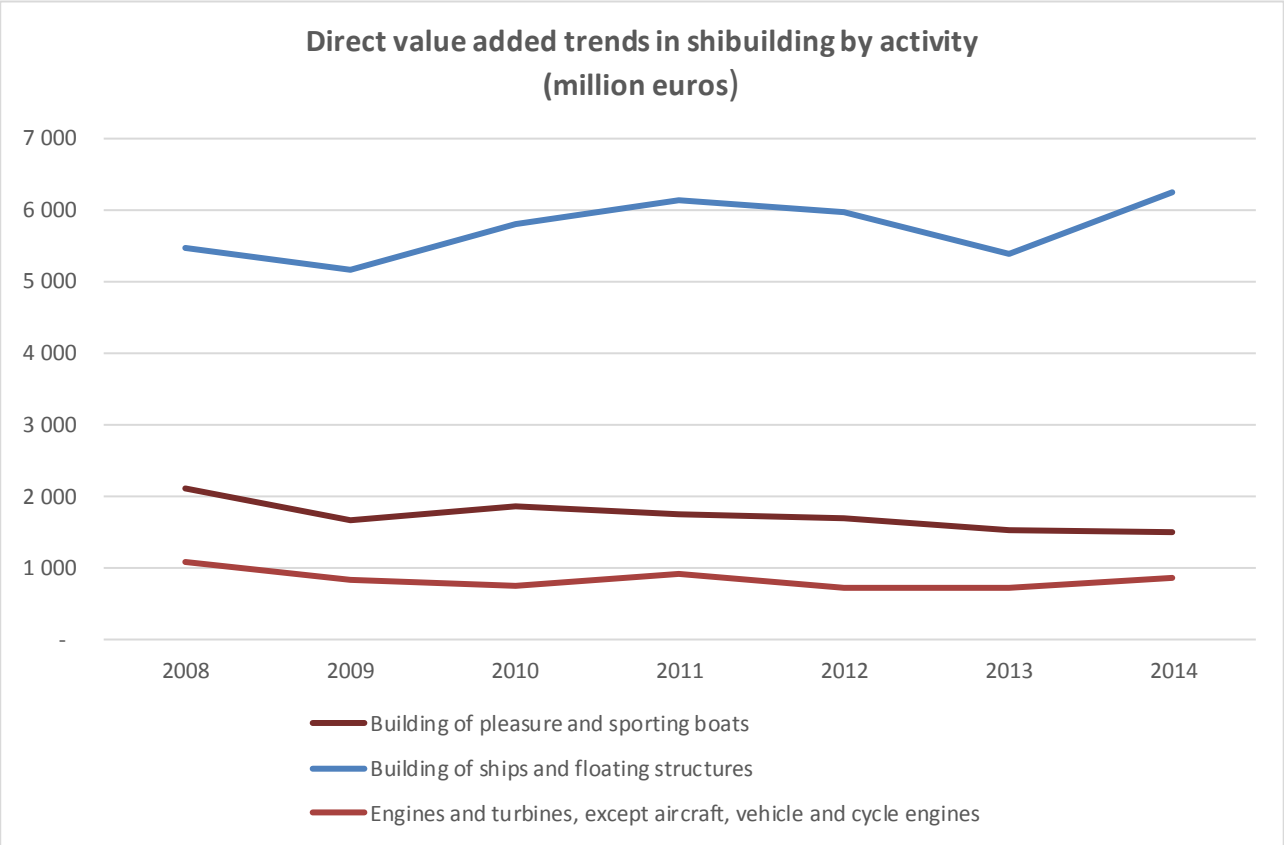
Figure 15 – Direct value added of shipbuilding by activity



Building of pleasure and sporting boats probably tends to suffer more from the consequences of the economic crisis, as shown in the graphs below:

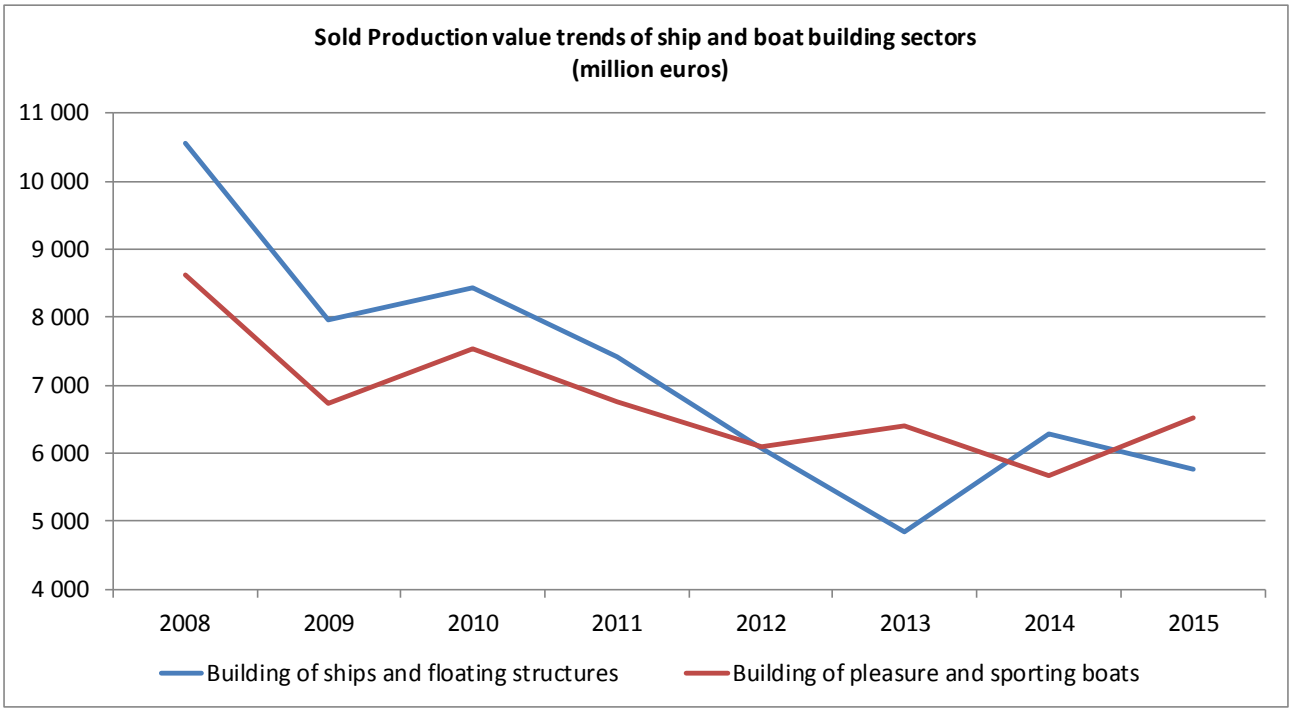
[32] For more details on the activities making up the sector, please see Annex I § 10.

Figure 16 – Direct value added trends in shipbuilding



It is possible to use Prodcom data to show what happened to the sector in terms of sold production:

Figure 17 – Sold production trends of ship and boat building



N.B. sold production does not take into account changes in stocks and work in progress. The total value of production may be considerably higher.

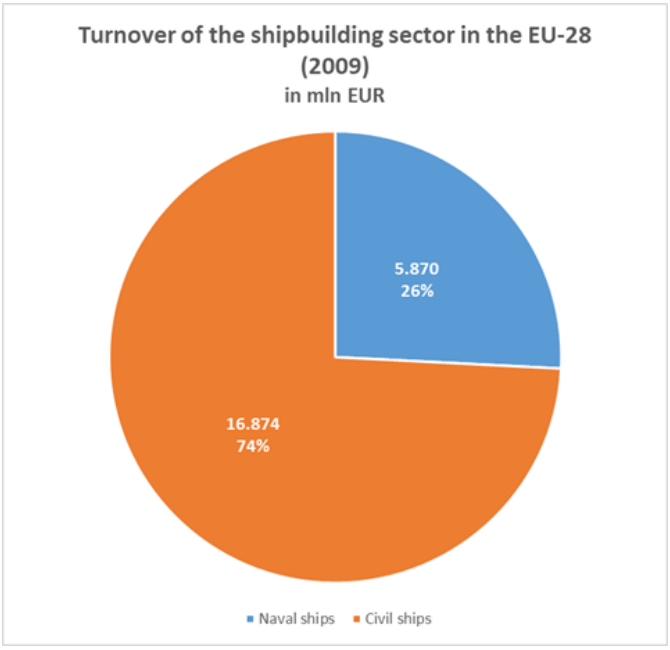
The steep decline in terms of sold production suggests that the sector was able to restructure itself during the time period and not lose ground in terms of value added generated.

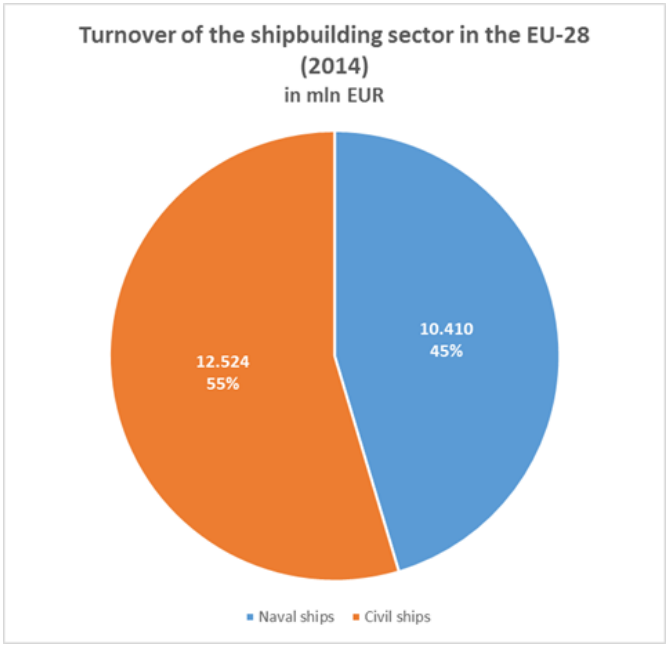
Figure 18 -Sold production trend by type of ship and boat (million euros)

Activity	Type of ship / boat	2008	2009	2010	2011	2012	2013	2014	2015
Building of ships and floating structures	Bulk carriers	2,9	28,5	233,8	122,5	49,6	20,9	0,0	24,4
	Chemical tankers	106,5	225,5	114,1	123,6	142,9	69,3	0,0	37,8
	Container carriers	1 713,9	44,6	194,4	292,2	0,0	0,0	275,3	0,0
	Conversion and reconstruction of ships, floating platforms and structures	317,4	587,5	517,9	510,6	367,6	232,4	360,8	316,2
	Crude oil tankers	0,0	89,4	91,2	41,1	0,0	0,0	0,0	0,0
	Cruise vessels	2 007,3	2 206,7	2 841,1	3 000,6	1 400,2	921,5	362,3	832,0
	Dredgers	371,7	261,6	558,4	236,1	391,3	144,6	124,6	169,0
	Ferries	856,1	638,7	386,0	239,0	227,4	310,7	93,5	250,9
	Fish factory vessels	3,8	0,9	1,7	1,9	1,4	24,4	22,4	0,0
	Fishing vessels	132,7	71,6	95,8	31,1	43,8	88,3	238,1	271,8
	Fitting out services of ships and floating platforms and structures	481,8	777,3	1 145,3	1 088,0	1 037,6	640,0	755,6	860,3
	Gas carriers	111,1	0,0	0,0	0,0	0,0	0,0	0,0	0,0
	General cargo ships	325,4	159,0	125,8	0,0	110,8	139,6	409,8	81,3
	Offshore infrastructures	192,9	5,1	15,2	131,8	210,2	483,2	660,5	420,7
	Offshore vessels	327,9	57,1	14,9	62,5	251,4	175,4	789,6	1 028,3
	Oil product tankers	0,0	41,5	41,3	0,0	0,0	0,0	0,0	0,0
	Other dry cargo ships	184,8	354,3	26,2	0,0	0,0	501,0	180,7	0,0
	Other floating structures (including rafts, tanks, coffer-dams, landing stages, buoys and beacons)	358,6	345,3	540,9	348,4	375,0	215,8	592,0	648,0
	Other non-cargo carrying vessels	509,2	591,5	936,8	753,5	1 313,3	662,8	801,7	692,0
	Refrigerated vessels, except tankers	0,0	0,0	0,0	43,4	0,0	0,0	0,0	0,0
	Ro-ro cargo ships	139,8	422,3	168,6	177,1	53,2	0,0	85,1	30,5
	Tugs and pusher craft	2 419,3	1 048,2	385,0	223,2	95,5	205,2	535,1	104,7
	Total	**10 563,3**	**7 956,7**	**8 434,3**	**7 426,6**	**6 071,3**	**4 835,2**	**6 287,1**	**5 767,8**
Building of pleasure and sporting boats	Inflatable vessels for pleasure or sports	323,0	194,5	142,2	183,8	141,5	113,1	94,0	141,4
	Motor boats and motor yachts, for pleasure or sports (excluding outboard motor boats)	4 336,0	4 193,3	5 535,2	4 633,7	4 057,9	4 573,7	3 884,1	4 442,2
	Other vessels for pleasure or sports n.e.c.; rowing boats and canoes	1 724,3	868,3	657,5	654,2	512,2	452,0	450,6	487,6
	Sailboats (except inflatable) for pleasure or sports, with or without auxiliary motor	2 231,2	1 464,8	1 201,0	1 280,6	1 388,3	1 250,5	1 233,8	1 455,7
	Total	**8 614,6**	**6 720,9**	**7 535,9**	**6 752,4**	**6 099,9**	**6 389,3**	**5 662,4**	**6 526,8**

The table above gives an overview of the trend in sold production at EU level by type of ship / boat.

Ships and floating structures also include naval ships. The proportion between naval ships and civil ships cannot be inferred from Eurostat data. However, a sector-specific indicator has been developed based on data purchased from IHS – Jane's Defence.

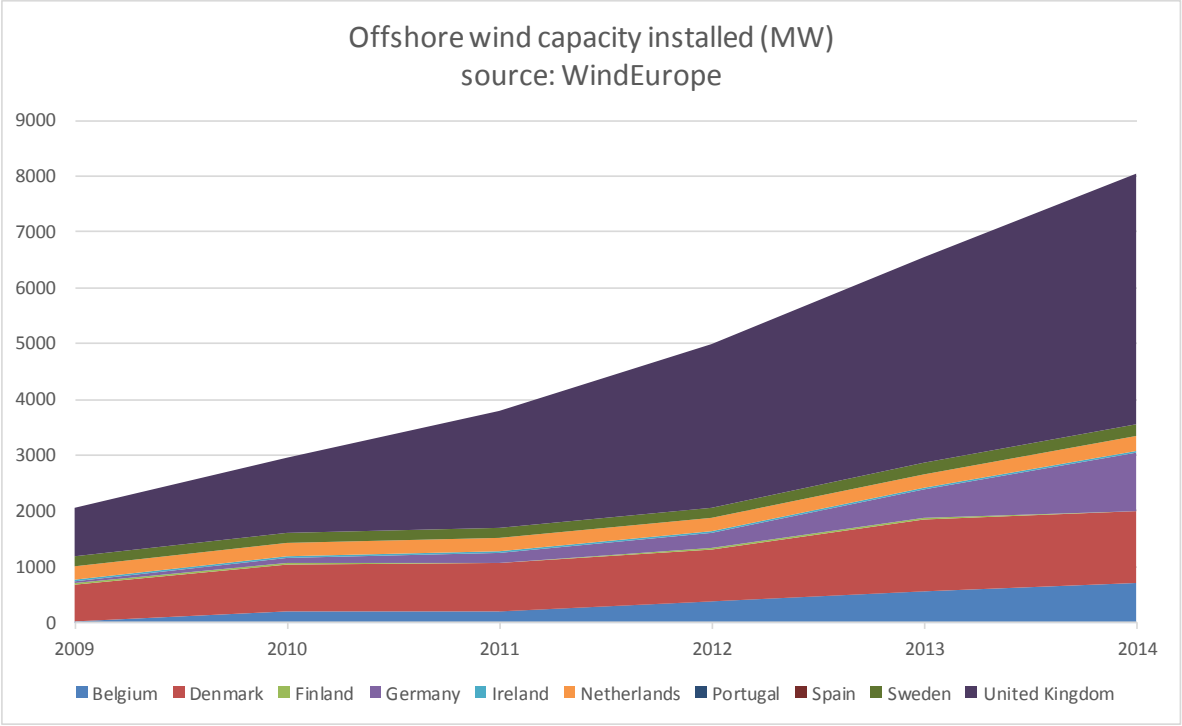




Source: own elaboration base on HIS – Jane's Defence.

The share of naval ships increased considerably in the period between 2009 and 2014.

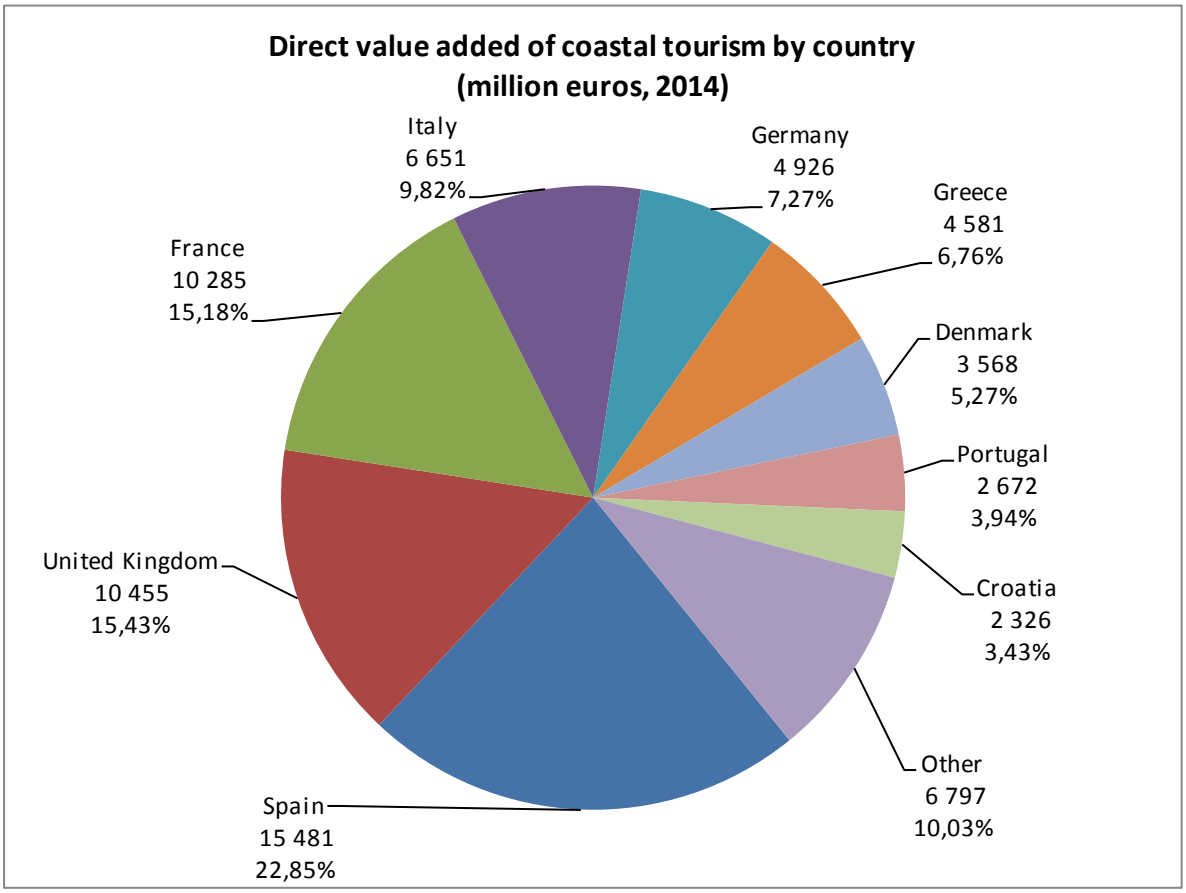
It may also be worth looking at what is happening in the wind energy sector. The sector is still small compared with the traditional industries, so rather than looking at absolute values, it may be interesting to understand what is happening in terms of installed capacity (which is one of the sector specific indicators):



The chart shows that the capacity installed increased considerably from 2009 to 2014. The sector has thus to be looked with great attention, as it clearly has great potential that can be further exploited.

The following graph shows the value added of coastal tourism in 2014 by country:

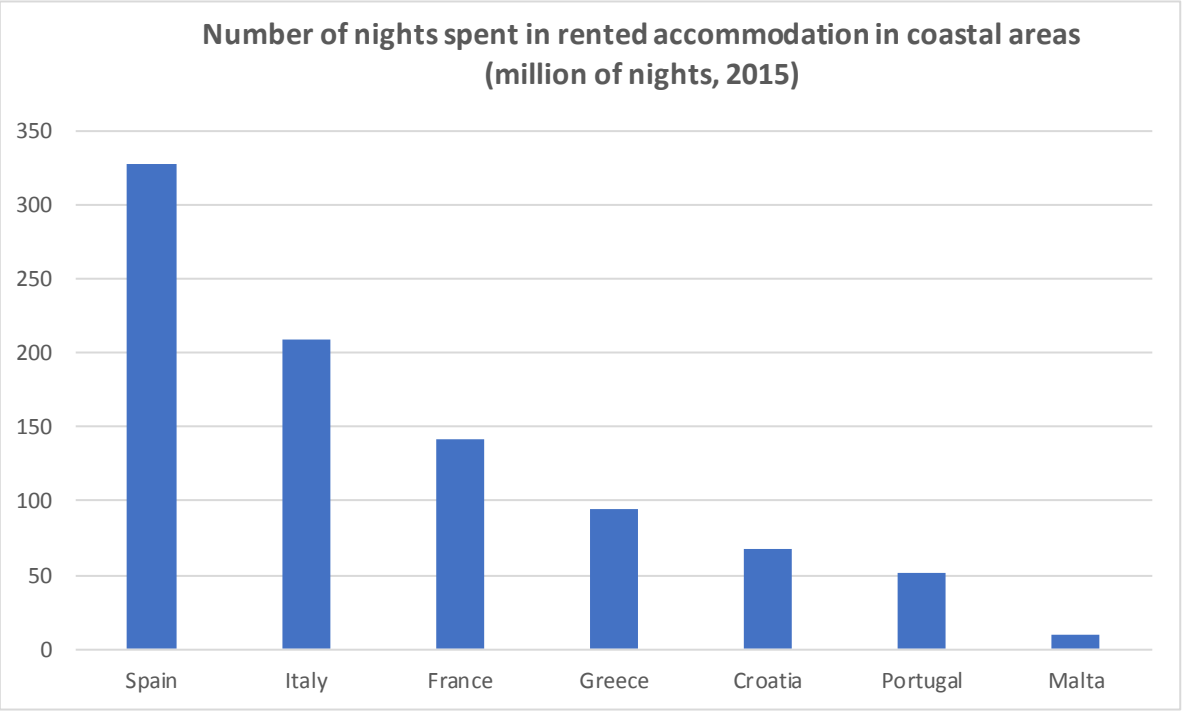
Figure 19 – Direct value added of coastal tourism by country



As one may expect, Spain ranks first. However, countries such as the UK, France and Germany ranks higher than other countries which would normally be perceived as tourist destinations. This is due to two factors:

1. Coastal tourism is defined as tourism in coastal areas, i.e. municipalities (LAU-2) bordering the sea and municipalities that have 50% of their territory within 10 km from the coast. Eurostat provides data on the number of nights spent in rented accommodation in coastal areas. A tourist is whoever goes to a destination other than their place of residence, whatever the purpose. The figures thus include business travellers and people who visit friends and relatives.
2. The size of coastal tourism has been estimated based on tourist spending in coastal areas. Tourist spending has been considered as 'turnover', while value added has been estimated based on the turnover/GVA ratio of the industries that make up coastal tourism. Coastal areas with a high cost of living are thus 'over-represented', even though the total number of nights spent by tourist is relatively low. This is made clearer by the graph below:

Figure 20 – Number of nights spent in rented accommodation in coastal areas



Italy ranks second in terms of number of nights spent in coastal areas in 2015, while it ranked fourth in terms of value added in 2014. More nights are spent in the coastal areas of France than in Greece and Croatia, which seems counterintuitive, but, again, this is because business travellers are also included. There are no data available on the UK for 2015. The most recent data available date back to 2012, when the number of nights spent in UK coastal areas was about 150 millions.

5 Description of main challenges encountered

Measuring the size of the blue economy is not a straightforward exercise. Generally speaking, the current classification system of economic activities does not take into account the maritime economy as such, hence several maritime sectors cannot be measured easily, either because of complete lack of data, or because several assumptions are required to produce an estimation.

Over the course of the study, the research team have had to deal with a number of challenges, some of which have been pointed out by and discussed with the numerous stakeholders consulted. It is paramount to report them, because, despite the effort put into the study, there are still obstacles that make it difficult to measure the whole blue economy, and will most certainly require further research in the coming years:

- **Timeliness of information**: data collected from Eurostat have the undoubtable advantage of being available for all EU countries consistently. Furthermore, they are also consistent with statistical data collected worldwide, as the NACE classification has a strong relation with the ISIC classification, developed by the United Nations[33]. However, the inherent limit of statistical information is that collating, processing and harmonising data can be a time-consuming endeavour. Therefore, generally speaking, statistical data on turnover, value added and employment are available two years after the year of reference. Such a time lag can be acceptable to analyse the past evolution of the blue economy and to identify historical trends, but many stakeholders pointed out that it may not be ideal for the industry, when it comes to making decisions that affect its

[33] For further details, please see http://unstats.un.org/unsd/cr/registry/regcst.asp?Cl=27

business. The industry generally relies on nearly real-time data, or even forecasts. In theory, one could decide to abandon Eurostat as the main source of the study, and use a variety of data sources in each Member State that make available more recent data. This would solve the problem of data that are too old to make business decisions, but it would seriously undermine the reliability, consistency and replicability of the method.

- **Not all Member States report their data to Eurostat with regularity**: this translates into a series of gaps in the time series, which can be observed in the database attached to this report. The result is that the size of the blue economy is inevitably underestimated, although most certainly not to an enormous extent. It should also be mentioned that, looking at the time series, it seems that for most sectors the situation has improved considerably in the last couple of years, compared to the first few years after the NACE classification was revised. There is a dilemma when it comes to deciding how to treat gaps in a time series. One may decide to preserve integrity and try to fill them, e.g. by assuming that the data have not changed since the previous year, or by calculating an average growth rate for each maritime activity at EU level and applying it to the Member States that do not report data for that activity; the alternative approach is to acknowledge the existence of gaps and not try to bridge them so as to preserve reliability. Generally speaking, the latter approach has been preferred for this study, the only exception being costal tourism, where gaps in the time series of nights spent by tourists have been filled through the aforementioned methods, on account of the fact that no dramatic variations could be observed.
- **The current statistical classification system does not take into account the blue economy**: economic activities are currently classified according to their function rather than to where they take place, or which industry they serve. As a consequence, for many activities (among which are extraction of oil and gas, manufacturing of navigation equipment, extraction of aggregates, wind energy, blue biotechnology, etc.) it is not possible to know to what extent they contribute to the blue economy, unless strong assumptions are made. This situation calls for a revision of the current statistical classification system to better take into account the blue economy. However, revising a statistical classification is not an easy task, may take an extremely long time, and could also undermine accounting consistency, unless it is embraced worldwide. In addition, the very idea of revising the classification system may be rejected altogether, because not every actor involved in process may think that it is necessary and cost-efficient to do so. Furthermore, even revising the classification system of economic activities may not necessarily work for all industries. For instance, a firm that manufactures navigation equipment that can be used on ships, trains, or planes indifferently may find it difficult to register its business with a code that is too restrictive. Therefore, alternative approaches, more realistic to be pursued in the short run, should also be looked at. A solution could be to use 'tags' to complement current activity codes. For instance, a biotechnology company registered under 'Research and experimental development on biotechnology' may be asked to report how much of its turnover, value added and employment are generated from their operations with marine compounds. The reporting would consist in an estimation and would not be as rigorous as the information deriving from balance sheets and chambers of commerce. However, an educated guess from a business professional might be preferred as an estimation method, or could be used to compare results obtained through other more formal methods.
- **Emerging activities are inherently more difficult to capture**: quite often emerging economic activities have not yet been included in the statistical classification system. Even when data are available through other sources (in this study it is the case of seabed mining, or desalination), the size of the sector could be so negligible that it would be impossible to make any reliable estimation. The approach adopted for this study has been to keep in the list emerging activities or activities for which it is difficult to collect data, because in this way they may be included in the future, should their market grow to an appreciable size, or as new data sources become available.
- **Indirect impact of maritime activities**: economic data are collected to a higher level of detail by many Member States, but this level of detail is not continued in the production of supply and use

tables (SUT). In the great majority of cases, data are collated and reported to Eurostat under the 64 industrial and service sectors based on the ESA 2010 method. Only SUT published by Denmark and the UK provide more detailed sector differentiation, but these still do not enable other maritime sectors to be distinguished. However, additional data and information sources have been identified for all coastal Members States. These maritime-specific sources enable gaps in data to be filled, the corroboration of sector-based information and the ground-truthing of results.

- **Seabed mining**: there seems to be no extraction activity in Europe, and it is extremely difficult to measure the value added and the employment generated by exploration activities. Despite having good potential, the impact of seabed mining on the marine economy of the EU is probably negligible. Enquiries with private information providers have revealed that there are only 9 deep-sea mining vessels active in EU waters, and they only carry out research and exploration activities. It is true that EU-based companies may be taking part in seabed mining projects outside the EU, but if that is the case, then, in accordance with economic accounting principles, the turnover, value added and employment generated should be apportioned to the countries where these projects take place.
- **Non-commercial activities**: the size of these activities cannot be measured through data based on NACE. This makes data collection particularly challenging, as it is based entirely on reports and studies at the national level. A specific section of this report outlines the methods used and the assumptions made to estimate the size of public sector activities. Their estimation, however, remains fraught with uncertainties.
- **Will the blue economy embrace other activities in the future?** While it can be perfectible like any other human effort, the current list of maritime activities is rather comprehensive, and in line with similar studies carried out worldwide. Furthermore, the list reflects actual data availability, because special attention has been placed to ensuring that our exercise could be replicated in the future. Nonetheless, the blue economy is constantly evolving, and it is important to start discussing now what should or may be added in the future. Thinking ahead is important, because it makes it possible to be better prepared to face future challenges related to data collection.
  In a series of interviews with the members of the European Network of Maritime Clusters, it has emerged that it could be interesting to include maritime education as part of the blue economy. Today's students will be tomorrow's professionals, and trends in maritime education may help us predict what is going to happen in the blue economy in the coming ten years. Unfortunately, apart from isolated initiatives[34] or one-off studies, there does not seem to be sufficient information at Member State level to have a clear picture of how much is spent on maritime education, how many people are working in the sector, and how many students are signing up. As a matter of fact, it is extremely difficult to define maritime education in the first place, as only few universities worldwide exclusively deal with the maritime domain, while the vast majority offer education in a broad range of fields, some of which only partially identifiable as maritime.
  Another interesting point made regards ICT companies that locate their server farms near (or in) the ocean, to use the natural cooling power of water as well as wave and tidal energy. Such an activity would perfectly fit the definition of the blue economy developed for this study, as it takes place in the marine environment and uses sea resources.

[34] A very interesting method has been elaborated by Vega A. and Corless R, "A Measurement of Third Level Marine Education & Training in Ireland". The report proposes a framework to measure marine education and training in Ireland, which could be replicated in other countries.

6 Recommendations

One of the objectives of this study is to develop a set of recommendations as to how the framework for collecting data on the blue economy can be improved further in the future. In view of this, the research team has engaged in a consultation process that involved several stakeholders as well as a peer-review group of external experts from industry and academia alike.

The process culminated in a workshop that took place in Brussels in November 2016, during which the research team presented the preliminary results of the study, and elicited feedback from participants. A series of meetings were also organised with the European Network of Maritime Clusters, which shared their views on how the database could better serve the needs of the maritime industry.

Last but not least, a Steering Committee, made up of representatives of several DGs of the EU Commission also provided an invaluable contribution to the study.

Keep the database developed in this study up-to-date

Differently from previous attempts at measuring the size of the blue economy, this study was specifically conceived not to be a one-off exercise that merely returns a 'photograph' of the blue economy as it is at the time of writing. It is paramount to update the database every year as new data are made available. By doing so, it will be possible to build a consistent time series to keep track of the evolution of the blue economy over time.

Make the database public

Besides regular updates, several stakeholders have pointed out that it is important to ensure that the database is made available to the widest possible public, so that results and methods could be critically reviewed by stakeholders, even though, for various reasons, they have not been involved in the study. The yearly updates could be shared by DG MARE on the Maritime Forum in the form of Excel spreadsheets and Access tables. The findings of the study could also be highlighted through press releases or tweets from DG MARE account.

Set-up an interactive tool to query the data

At the same time, it should be noted that many users may not be familiar with spreadsheets and database tables, and for this reason could find it difficult to access the data. It has been suggested that in the future an interactive online tool could be developed to make sure that even non-experts are allowed to query the database. Special attention should be paid to ensuring that the tool be as user-friendly as possible.

Complement the current framework based on statistical data with qualitative information

The framework developed for this study mainly relies on data available on Eurostat Structural Business Statistics. This approach has several advantages: it ensures accounting consistency, it delivers homogeneous and comparable data, and it is compatible with similar exercises carried out worldwide, because the statistical classification of economic activities is agreed at international level[35]. However, the approach also has a number of disadvantages. Structural Business Statistics are normally available on Eurostat with a time lag of two years, and emerging activities are poorly covered. Several stakeholders suggested that it might be useful to complement the current framework based on quantitative data, with

[35] The Statistical Classification of Economic Activities in the European Union is the European implementation of the UN classification ISIC, revision 4http://unstats.un.org/unsd/cr/registry/isic-4.asp

qualitative information collected through interviews with key industry players in each Member State. This would make it possible to obtain more recent information on the state of each sector of the blue economy, which, albeit not as rigorous as statistical data, would turn out to be particularly useful to stakeholders that need to make business decisions. The qualitative information would not replace the current framework, but would rather complement it with 'market intelligence' that returns the 'sentiment' of the industry on certain economic trends. Furthermore, as the time series becomes longer, it will be possible to compare the entrepreneurs' forecasts and expectations with actual data collected from statistical offices and fine-tune the overall framework. Qualitative information may also contribute to filling gaps due to lack of data on emerging activities.

Develop alternative methods to measure maritime activities that are not fully maritime

One of the disadvantages of the NACE classification when used to measure the blue economy is that activities are classified according to their economic nature, rather than on whether they are 'maritime'. While a number of economic activities are clearly 'maritime' by nature (e.g. maritime transport, fishing), some activities can take place on shore of offshore indifferently (e.g. production of energy) or may serve maritime and non-maritime industries alike (e.g. manufacture of certain types of equipment). As a consequence, for some sectors it is necessary to develop methods or use assumptions to determine how much of turnover, value added an employment can be attributed to the blue economy. However, the more assumptions are made, the less reliable the database becomes. Revising the NACE classification to better take into account the blue economy would be the perfect solution, but it may not be feasible in the short run, because, as discussed above, statistical classifications are agreed at the international level.

A solution could be to develop a series of 'tags' that can be 'attached' to existing NACE codes, when data are collected or reported. The tags would consist of a self-reporting declaration from entrepreneurs in certain sectors that specifies how much of the turnover, value added an employment of their business is generated from activities that have a 'marine or maritime connotation'. As a data collection method, self-reporting does not possess the scientific and accounting rigour of statistical data, especially because entrepreneurs may have a vested interest in reporting inaccurate information. Yet, it is to be preferred to the assumptions necessary to extrapolate the maritime dimension of certain activities. Furthermore, the 'tags' approach has the advantage of being relatively easy to implement in the short run, at only a negligible cost.

Encourage research on methods to measure emerging activities

Another disadvantage of the NACE classification is that it offers poor coverage of emerging sectors. The sectors that are currently not covered will probably be included in the next revisions of the classification, as their business grows to a more significant size. However, to cope with the lack of data in the meantime, a solution could be to carry out sector-specific studies that go beyond statistical data and collect new information from the industries concerned. By way of an example, the data collected on marine equipment have been compared with a study on the marine supplies industry[36]. It has emerged that the data collected from Eurostat Structural Business Statistics for our study underestimate the production of marine equipment to an enormous extent, because only a negligible part of the equipment manufactured in Europe can be clearly identified as maritime from the data. To increase the level of detail, it would be necessary to look at companies' balance sheets and carry out interviews with the main manufacturers (which has not been possible in the time framework of this study).

Bespoke studies may improve data availability on a number of key sectors, among which are blue biotechnology, wind energy, dredging, desalination, etc. At the same time, these studies require the

[36] Competitive position and future opportunities of the European marine supplies industry, Balance Technology Consulting, 2014.

mobilisation of significant financial resources. Horizon 2020 calls could become a potential source of funding for this type of exercises. The call would set the general objectives to be achieved, but the exact methods would be developed with a bottom-up approach

Take into account ecosystem services

Ecosystem services are defined as the benefits that people obtain from ecosystems. This study does not deal with economic evaluation of ecosystem services, because these are not strictly speaking economic activities. However, a more comprehensive approach to measuring the blue economy should also take into account the value generated by ecosystem services, because a healthier environment yields benefits to the society that can also be quantified in economic terms. Activities such as the production of renewable energy do not only create direct value added and job, but also contribute to cleaner air, which can be assigned an economic value that should be included in the measurement of the blue economy. A healthier environment can also guarantee that ocean resources can be exploited for a longer time and continue generating value added and employment, because the risk of depletion is minimised.

Set up a permanent blue economy data expert group

One of the innovative elements of this study is to be found in the setting up of an external peer-review group that periodically reviewed the findings of the research team. The peer-review group was made up of experts from industry and academia alike, to make sure that the methods developed for the study were at the same time sound, realistic and pragmatic. The peer-review group provided an invaluable contribution to the research team, by suggesting improvements to the framework and highlighting the needs of stakeholders.

If the data collection exercise is to be continued in the coming years, then it may be worth to set up a permanent expert group on blue economy data. The expert group should include representatives from every maritime sector to make sure that all economic activities are covered. Experts from several EU DGs may also contribute to focusing on different policy objectives, since the blue economy deals with a wide range of issues, not all of which are necessarily in the remit of DG MARE. The group could also link with working groups dealing with Economic and Social Analysis related to maritime policies, e.g. the WG POMESA.

An option could be to expand and keep active the Member States' Expert Group which met in Brussels in September 2015[37]. The group was set up by the EU Commission's Directorate General for Maritime Affairs and Fisheries to work on estimating the size and nature of the blue economy, based on numbers that Member States report to Eurostat. The aim of the group was to examine the method and results and compare with similar efforts in Member States.

The expert group could meet once a year, before the update of the database is release, to establish whether the framework can be improved, because new data have been made available or better methods could be used.

[37] For further information, please see https://webgate.ec.europa.eu/maritimeforum/en/node/3778

Annex I – Framework for data collection

One of the objectives of this study is to develop a framework for data collection that makes it possible to update the database every year. This Annex aims to give a clear overview of how to replicate the data collection exercise carried out by the research team, by explicitly listing all economic activities, sources, methods, and assumptions used for the study.

1 Fisheries and aquaculture

1.1 A 03.11 Marine fishing (production)

Description: this economic sector includes fishing activities on a commercial basis in ocean and coastal waters.

Source of data: Data Collection Framework / JRC: data can be exported in Excel format from https://stecf.jrc.ec.europa.eu/dd/fleet/graphs

How to calculate maritime proportion: The activity takes place in the marine environment, and thus not further calculations are needed.

Notes: DCF indicators' names slightly differ from SBS. 'Income' in the DCF is equivalent to SBS Turnover (income from subsidies must be included for the sake of consistency). 'Total employees' is equivalent to 'number of persons employed'. It should be noted that DCF data are updated constantly, so, upon updating the database, it is recommended to look at the whole time series and not just to add the latest available year. Revisions are not dramatic, but they are very frequent.

Growth potential: it is a mature economic activity with limited growth potential, considering the threats linked with the overexploitation of fish stocks. At EU level, the focus is more on fostering fishing practices that do not harm the ability of fish populations to reproduce.

The OECD's report on ocean economy[38] classifies marine fishing among the activities with modest business and employment growth prospects, on account of a continuous decline of total production worldwide, which is expected to continue over the coming ten years. Climate change, with the consequent reduction of some stocks in certain areas, also poses a serious threat to the future development of the sector.

Environmental considerations: fish stocks may be renewable, but they are finite. Some of these fishing stocks, however, are being overfished. As a result, EU countries have taken action to ensure the European fishing industry is sustainable and does not threaten the fish population size and productivity over the long term. The Common Fisheries Policy (CFP) aims to ensure that fishing activity is environmentally, economically and socially sustainable whilst providing a source of healthy food for EU citizens.

1.2 A 03.21 Marine aquaculture (production)

Description: this class includes:

- fish farming in sea water including farming of marine ornamental fish
- production of bivalve spat (oyster mussel etc.), lobsterlings, shrimp post-larvae, fish fry and fingerlings

[38] OECD, The Ocean Economy in 2030, 2016. Available at: www.keepeek.com/Digital-Asset-Management/oecd/economics/the-ocean-economy-in-2030_9789264251724-en

- growing of laver and other edible seaweeds
- culture of crustaceans, bivalves, other molluscs and other aquatic animals in sea water
- aquaculture activities in brackish waters
- aquaculture activities in salt water filled tanks or reservoirs
- operation of fish hatcheries (marine)
- operation of marine worm farms

Source of data: Data Collection Framework / JRC: data can be exported in Excel format from https://stecf.jrc.ec.europa.eu/dd/aqua/graphs

Maritime proportion: The activity also included freshwater aquaculture, which should not be considered as a maritime activity, according to the definition developed for this study. Nonetheless, it has been decided to include freshwater aquaculture in the blue economy, therefore the activity can be considered as 100% maritime, and thus no further calculations are needed.

Notes: DCF indicators' names slightly differ from SBS. 'Total employees' is equivalent to 'number of persons employed'. GVA of marine aquaculture is not included in the original dataset, so it has been estimated through a proxy: GVA = Total income – (energy cost + Raw material costs and Feed cost + Raw material costs and Livestock costs + Other operational costs). It should be noted that DCF data are updated constantly, so, upon updating the database, it is recommended to look at the whole time series and not just to add the latest available year. Revisions are not dramatic, but they are very frequent.

Growth potential: the expansion of aquaculture in the EU, both for finfish and shellfish, suffered a sudden change in its development trend at the beginning of the 21st century, most likely because of costs related to authorization and licensing process, and the competition from extra-EU countries. Simplification of administrative procedures, better coordination with competing uses of the sea through Maritime Spatial Planning, together with funding available through the EMFF and Horizon 2020 may give new boost to the sector. Although competition from third countries cannot probably be won based on price only, the extremely high animal health and consumer protection standards in the EU may be received favourably by domestic consumers. In order to reduce the costs associated with farming fish, a possible option is to co-locate mariculture farms with offshore installations such as wind farms and oil and gas platforms. Co-locating different activities optimises the use of ocean space and makes it possible to share fixed costs across more industries.

The OECD's report on ocean economy[39] classifies marine aquaculture among the activities with high long-term growth of business and employment, mainly because the global demand for fish is expected to continue to rise over the next decades, as a consequence of increased world population, growing purchasing power, and more people entering the middle class.

Environmental considerations: Aquaculture is expected to contribute to the preservation of the food production potential on a sustainable basis throughout the EU to guarantee long-term food security, growth and employment for EU citizens, and to contribute to meeting the growing world demand for aquatic food. Shellfish and algae culture are considered to contribute environmental benefits as biofilters, easing the effects of eutrophication and carbon sequestration (blue carbon).

However, aquaculture also poses threats to the marine environment: farmed carnivorous fish, such as salmon, require a food source which is high in fish-derived proteins. This generally comes from wild capture fish at the bottom of the food chain. If this wild fish is not caught sustainably, aquaculture may contribute to threatening fish stocks. Organic waste accumulation from fish farms may also have a negative impact on the environment as well as generate conflicts with other marine activities (this problem could be effectively mitigated through Maritime Spatial Planning). A range of chemicals can be used in marine aquaculture operations such as disinfectants, anti-foulants and medicines (including vaccines) that could affect marine wildlife.

[39] OECD, The Ocean Economy in 2030, 2016. Available at: www.keepeek.com/Digital-Asset-Management/oecd/economics/the-ocean-economy-in-2030_9789264251724-en

1.3 C 10.20 Processing and preserving of fish, crustaceans and molluscs

Description: This activity includes the:

- preparation and preservation of fish, crustaceans and molluscs: freezing, deep-freezing, drying, cooking, smoking,
- salting, immersing in brine, canning etc.
- production of fish, crustacean and mollusc products: fish fillets, roes, caviar, caviar substitutes etc.
- production of fishmeal for human consumption or animal feed
- production of meals and solubles from fish and other aquatic animals unfit for human consumption

Source of data: Eurostat SBS (sbs_na_ind_r2).

Maritime proportion: The activity uses marine resources as an input and can be considered 100% maritime. No further calculations are needed.

Growth potential: It is a mature economic activity. Its growth is related to per capita fish consumption, which, according to EUMOFA, has been increasing in the last few years[40]. At the same time, it should be noted that the STECF Report on the fish processing industry (2014)[41] reports that significant net disinvestment in the near future is expected in quite a number of countries. This difference could be explained by the fact that the STECF report is based on 2012 data, while EUMOFA makes available more recent figures.

Environmental considerations: environmental issues in fish processing industries primarily include water consumption and wastewater generation, solid waste generation and by-products production, emission to air and energy consumption.

1.4 C 10.41 Manufacture of oils and fats

Description: This activity includes the:

- manufacture of crude vegetable oils: olive oil, soya-bean oil, palm oil, sunflower-seed oil, cotton-seed oil, rape,
- colza or mustard oil, linseed oil etc.
- extraction of fish and marine mammal oils
- manufacture of non-defatted flour or meal of oilseeds, oil nuts or oil kernels
- manufacture of refined vegetable oils: olive oil, soya-bean oil etc.
- processing of vegetable oils: blowing, boiling, dehydration, hydrogenation etc.

Source of data: Eurostat SBS (sbs_na_ind_r2) and PRODCOM (DS-066341)

Maritime proportion: The maritime proportion is calculated by identifying 'maritime' sources of oil and fats. There is a full list of products for NACE C 10.41 on PRODCOM. The production value (PRODVAL is the name of the indicator) of 'Fats and oils and their fractions of fish or marine mammals (excluding chemically

[40] For further details, please see https://www.eumofa.eu/supply-balance

[41] For further details, please see https://stecf.jrc.ec.europa.eu/documents/43805/861045/2014-12_STECF+14-21+-+EU+Fish+Processing+Industry_JRC93340.pdf

modified)' (10411200) should be divided by the total production value of the 10.41 class. The resulting ratio can be used as the maritime proportion.

Type of market: B2B.

Geographic distribution: this activity does not necessarily take place in the marine environment or in coastal areas.

Type of provider: private

Growth potential: no particular considerations are to be reported for this activity.

Environmental considerations: environmental issues in fish processing industries primarily include water consumption and wastewater generation, solid waste generation and by-products production, emission to air and energy consumption.

1.5 C 10.85 Prepared meals and dishes

Description: This class includes the manufacture of ready-made (i.e. prepared, seasoned and cooked) meals and dishes. These dishes are processed to preserve them, such as in frozen or canned form, and are usually packaged and labelled for re-sale, i.e. this class does not include the preparation of meals for immediate consumption, such as in restaurants. To be considered a dish, these foods have to contain at least two distinct ingredients (except seasonings etc.).

Source of data: Eurostat SBS (sbs_na_ind_r2) and PRODCOM (DS-066341)

Maritime proportion: The maritime proportion is calculated by identifying prepared meals and dishes based on fish or fish products. There is a full list of products for NACE C 10.85 on PRODCOM. The production value (PRODVAL is the name of the indicator) of 'Prepared meals and dishes based on fish, crustaceans and molluscs' (10851200) should be divided by the total production value of the 10.85 class. The resulting ratio can be used as the maritime proportion.

Growth potential: It is a mature economic activity. Its growth is related to per capita fish consumption, which, according to EUMOFA, has been increasing in the last few years[42]. At the same time, it should be noted that the STECF Report on the fish processing industry (2014)[43] reports that significant net disinvestment in the near future is expected in quite a number of countries. This difference could be explained by the fact that the STECF report is based on 2012 data, while EUMOFA makes available more recent figures.

Environmental considerations: environmental issues in fish processing industries primarily include water consumption and wastewater generation, solid waste generation and by-products production, emission to air and energy consumption.

1.6 C 10.89 Other food products n.e.c.

Description: This activity includes the:

- manufacture of soups and broths
- manufacture of artificial honey and caramel
- manufacture of perishable prepared foods, such as sandwiches or fresh (uncooked) pizza

[42] For further details, please see https://www.eumofa.eu/supply-balance

[43] For further details, please see https://stecf.jrc.ec.europa.eu/documents/43805/861045/2014-12_STECF+14-21+-+EU+Fish+Processing+Industry_JRC93340.pdf

- manufacture of food supplements and other food products n.e.c.

Source of data: Eurostat SBS (sbs_na_ind_r2) and PRODCOM (DS-066341)

Maritime proportion: The maritime proportion is calculated by identifying food products based on fish or fish products. There is a full list of products for NACE C 10.89 on PRODCOM. The production value (PRODVAL is the name of the indicator) of 'Extracts and juices of meat, fish, crustaceans, molluscs or other aquatic invertebrates' (10891400) should be divided by the total production value of the 10.89 class. The resulting ratio can be used as the maritime proportion.

Growth potential: It is a mature economic activity. Its growth is related to per capita fish consumption, which, according to EUMOFA, has been increasing in the last few years[44]. At the same time, it should be noted that the STECF Report on the fish processing industry (2014)[45] reports that significant net disinvestment in the near future is expected in quite a number of countries. This difference could be explained by the fact that the STECF report is based on 2012 data, while EUMOFA makes available more recent figures.

Environmental considerations: environmental issues in fish processing industries primarily include water consumption and wastewater generation, solid waste generation and by-products production, emission to air and energy consumption.

2 Blue biotechnology

It has not been possible to develop a reliable method to measure the size of blue biotechnology.

3 Extraction of oil and gas

N.B.: It has been noted by DG MARE that there may be an anomaly in the SBS figures reported by Eurostat for the oil and gas sector. More specifically, since 2010 the Italian turnover has been consistently higher than countries such as the UK or the Netherlands, despite lower production. An enquiry has been submitted to Eurostat by the study team, which however did not reveal any anomaly. Eurostat's contact point has suggested that the high turnover in Italy might be due to excise duties. However, upon further research[46], it is evident that this explanation cannot possibly hold true, in that excise duties in the UK are often higher than in Italy.

On a different note, if one looks at other indicators such as value added and gross operating surplus, the figures reported for Italy are significantly lower than those reported for UK, and consistent with the respective levels of production. Eurostat has confirmed that the there are no reporting errors and the accounting methods used by MSs are essentially the same. An explanation must be sought elsewhere, possibly by liaising with business professionals and oil and gas companies. Nevertheless, even though a plausible explanation were to be found, it might be extremely difficult – if not impossible – and methodologically incorrect to alter the figures reported for Italy accordingly.

[44] For further details, please see https://www.eumofa.eu/supply-balance

[45] For further details, please see https://stecf.jrc.ec.europa.eu/documents/43805/861045/2014-12_STECF+14-21+-+EU+Fish+Processing+Industry_JRC93340.pdf

[46] For further details, please see http://ec.europa.eu/taxation_customs/resources/documents/taxation/excise_duties/energy_products/rates/excise_duties-part_ii_energy_products_en.pdf

DG MARE has also noted that Romania has fairly high employment in the oil and gas sector, despite low production. This is most certainly due to the fact that Romania has the lowest well productivity in Europe and one of the lowest production per field in Europe, indicating maturity of onshore fields[47].

3.1 B 06.10 Extraction of crude petroleum

Description: This activity includes:

- extraction of crude petroleum oils
- extraction of bituminous or oil shale and tar sand
- production of crude petroleum from bituminous shale and sand
- processes to obtain crude oils: decantation, desalting, dehydration, stabilisation etc.

Source: Eurostat SBS (sbs_na_ind_r2), plus a variety of sources at Member State level (see below).

Maritime proportion: The class includes activities that take place onshore and offshore. To calculate the maritime proportion, it is possible to collect data on production (which normally distinguish between offshore and onshore) from a variety of sources at Member State level:

- Bulgaria: http://euoag.jrc.ec.europa.eu/node/63
- Croatia: http://euoag.jrc.ec.europa.eu/node/63
- Denmark: https://ens.dk/en/oil-gas/oil-gas-related-data/monthly-production-20132014-yearly-production-1972-2012
- France: http://www.ifremer.fr/demf/en/reports/2013/7-off-oil-gas-serv
- Germany: http://euoag.jrc.ec.europa.eu/node/63
- Greece: http://euoag.jrc.ec.europa.eu/node/63
- Italy: http://unmig.mise.gov.it/unmig/produzione/produzione.asp
- Netherlands: http://www.nlog.nl/en/production/production.html
- Poland: http://geoportal.pgi.gov.pl/surowce/energetyczne
- Romania: http://euoag.jrc.ec.europa.eu/node/63
- Spain: http://www.minetur.gob.es/energia/balances/Balances/LibrosEnergia/La_Energ%C3%ADa_2014.pdf
- UK: https://www.gov.uk/guidance/oil-and-gas-uk-field-data#uk-production-data

Notes: the UK did not use to report turnover, value added and employment separately for oil and gas. Until 2012, data were available only for NACE B06 'Extraction of crude petroleum and natural gas'. However, by using data on production at national level (see source above), the values can be apportioned according the production of oil and gas in the country. Whenever there is a data gap in the SBS time series, it is recommended to look whether the data are available for NACE B06, and then try to apportion them across the two industries by using data on production. Alternatively, if no data on production are available, it can be assumed that the proportion has not varied to a great extent since the previous year.

[47] Deloitte, Observation on royalties and similar taxes – 'An overview', 2015. Available at https://www2.deloitte.com/content/dam/Deloitte/ro/Documents/energy-resources/Deloitte-Royalties_upstream_14_feb_2015_EN.pdf

The above-mentioned sources do not update their data every year. However, one can assume that the ratio between offshore and onshore production generally tends to be relatively stable at least in the short term (unless new fields are discovered or some fields dry out).

Furthermore, for some countries (Bulgaria, Croatia, Germany, Greece, Romania) it has not been possible to find a national source. The ratio between offshore and onshore production has been taken from a study by the JRC (http://euoag.jrc.ec.europa.eu/node/63). Some data date back to a few years ago and must be taken with a word of caution.

Growth potential: The oil and gas industry is at a mature stage of development, and it is believed that there is limited growth potential in Europe, which cannot boast reserves as large as those of Middle Eastern countries. In addition, the share of renewable energy is increasing in the energy mix of several Member States.

Shale (tight) oil could play a significant role. However, there are uncertainties about the size of Europe's shale deposits and for now it seems unlikely that the EU will repeat the US experience in terms of the scale of unconventional oil production.

The OECD's report on ocean economy[48] classifies both oil and gas extraction among the activities with modest business and growth prospects. With increasing efforts to decarbonise the economy in the Western world, weak market demand, as well as concerns about safety and the ocean environment, may hinder the future development of the sector.

Environmental considerations: Environmental impacts may arise at all stages of oil activities, including initial exploration, production and final decommissioning. There is a broad range of environmental concerns including those relating to oil discharges from routine operations, the use and discharge of chemicals, accidental spills, drill cuttings, atmospheric emissions, low level naturally occurring radioactive material, noise, and to some extent the placement of installations and pipelines on the sea bed[49].

At the same time, Oil and Gas platforms act as artificial reefs and provide hard substrate in open water that might otherwise be unavailable to marine organisms requiring such habitat. Oil platforms may act as stepping stones, increasing regional biodiversity and production but they may also be vectors for invasive species. For instance, in Emilia Romagna off the coast of Italy, molluscs have found the ideal habitat for natural breeding, thanks to a ban on fishing and approaching boats.

3.2 B 06.20 Extraction of natural gas

Description: This activity includes:

- production of crude gaseous hydrocarbon (natural gas)
- extraction of condensates
- draining and separation of liquid hydrocarbon fractions
- gas desulphurisation
- mining of hydrocarbon liquids, obtained through liquefaction or pyrolysis

Source: Eurostat SBS (sbs_na_ind_r2), plus a variety of sources at Member State level (see below).

[48] OECD, The Ocean Economy in 2030, 2016. Available at: www.keepeek.com/Digital-Asset-Management/oecd/economics/the-ocean-economy-in-2030_9789264251724-en

[49] For further information, please see http://www.ospar.org/documents?v=7154.

Maritime proportion: The class includes activities that take place onshore and offshore. To calculate the maritime proportion, it is possible to collect data on production (which normally distinguish between offshore and onshore) from a variety of sources at Member State level:

- Bulgaria: http://euoag.jrc.ec.europa.eu/node/63
- Croatia: http://euoag.jrc.ec.europa.eu/node/63
- Denmark: https://ens.dk/en/oil-gas/oil-gas-related-data/monthly-production-20132014-yearly-production-1972-2012
- France: http://www.ifremer.fr/demf/en/reports/2013/7-off-oil-gas-serv
- Germany: http://euoag.jrc.ec.europa.eu/node/63
- Greece: http://euoag.jrc.ec.europa.eu/node/63
- Italy: http://unmig.mise.gov.it/unmig/produzione/produzione.asp
- Netherlands: http://www.nlog.nl/en/production/production.html
- Poland: http://geoportal.pgi.gov.pl/surowce/energetyczne
- Romania: http://euoag.jrc.ec.europa.eu/node/63
- Spain: http://www.minetur.gob.es/energia/balances/Balances/LibrosEnergia/La_Energ%C3%ADa_2014.pdf
- UK: https://www.gov.uk/guidance/oil-and-gas-uk-field-data#uk-production-data

Notes: the UK did not use to report turnover, value added and employment separately for oil and gas. Until 2012, data were available only for NACE B06 'Extraction of crude petroleum and natural gas'. However, by using data on production at national level (see source above), the values can be apportioned according the production of oil and gas in the country. Whenever there is a data gap in the SBS time series, it is recommended to look whether the data are available for NACE B06, and then try to apportion them across the two industries by using data on production. Alternatively, if no data on production are available, it can be assumed that the proportion has not varied to a great extent since the previous year.

The above-mentioned sources do not update their data every year. However, one can assume that the ratio between offshore and onshore production generally tends to be relatively stable at least in the short term (unless new fields are discovered or some fields dry out).

Furthermore, for some countries (Bulgaria, Croatia, Germany, Greece, Romania) it has not been possible to find a national source. The ratio between offshore and onshore production has been taken from a study by the JRC (http://euoag.jrc.ec.europa.eu/node/63). Some data date back to a few years ago and must be taken with a word of caution.

Growth potential: The oil and gas industry is at a mature stage of development, and it is believed that there is limited growth potential in Europe. However, the European Commission Energy Roadmap 2050 identifies gas as a critical fuel for the transformation of the energy system in the direction of more renewables and lower CO2 emissions.

As far as shale gas is concerned, the most important driver for its development is the potential for higher security of energy supply, since Europe currently imports 60% of its gas requirements, a number that is projected to rise to 80% by 2030. However, there are concerns about the total potential of shale gas in Europe as a whole and in the Member States, since there is relatively little knowledge on the source rocks for the gas, their quality and distribution and how easily producible the gas is.

The OECD's report on ocean economy[50] classifies both oil and gas extraction among the activities with modest business and growth prospects. With increasing efforts to decarbonise the economy in the Western world, weak market demand, as well as concerns about safety and the ocean environment, may hinder the future development of the sector.

Environmental considerations: As a fossil fuel, burning natural gas produces emissions that pollute the atmosphere. At the same time, it should be noted that natural gas is considered to be the "cleanest" fossil fuel. As such, the European Commission Energy Roadmap 2050 identifies it as a critical fuel for the transformation of the energy system in the direction of more renewables and lower CO2 emissions. It can be argued that in Europe natural gas replacing coal and oil will undoubtedly contribute to emission reduction in the short and medium term, and that natural gas will have a permanent role in the future energy mix (https://ec.europa.eu/energy/en/news/commission-proposes-new-rules-gas-and-heating-and-cooling-strategy)

3.3 B 09.10 Support activities for petroleum and natural gas extraction

Description: This activity includes:

- oil and gas extraction service activities provided on a fee or contract basis:
- exploration services in connection with petroleum or gas extraction, e.g. traditional prospecting methods, such as making geological observations at prospective sites
- directional drilling and redrilling; "spudding in"; derrick erection in situ, repairing and dismantling; cementing oil and gas well casings; pumping of wells; plugging and abandoning wells etc.
- liquefaction and regasification of natural gas for purpose of transport, done at the mine site
- draining and pumping services, on a fee or contract basis
- test drilling in connection with petroleum or gas extraction
- oil and gas field fire fighting services

Source: Eurostat SBS (sbs_na_ind_r2), Eurostat Energy statistics (nrg_109a), plus a variety of sources at Member State level (see below).

Maritime proportion: The class includes support activities for both petroleum and natural gas, both onshore and offshore. The first step is to apportion support activities among oil and gas. To do so, one can use Eurostat Energy Statistics (nrg_109a) on primary production of oil and gas for each Member State. After doing that, it is possible to apply the maritime proportions identified above to apportion support activities between the onshore and offshore industry.

Growth potential: the growth potential of support activities is directly linked to the growth of oil and gas extraction.

Environmental considerations: Environmental impacts may arise at all stages of oil and gas activities, including initial exploration, production and final decommissioning. There is a broad range of environmental concerns including those relating to oil discharges from routine operations, the use and discharge of chemicals, accidental spills, drill cuttings, atmospheric emissions, low level naturally occurring radioactive material, noise, and to some extent the placement of installations and pipelines on the sea bed. (http://www.ospar.org/documents?v=7154)

[50] OECD, The Ocean Economy in 2030, 2016. Available at: www.keepeek.com/Digital-Asset-Management/oecd/economics/the-ocean-economy-in-2030_9789264251724-en

4 Extraction of aggregates

4.1 B 08.11 Quarrying of ornamental and building stone, limestone, gypsum, chalk and slate

B 08.12 Operation of gravel and sand pits; mining of clays and kaolin

B 08.99 Other mining and quarrying n.e.c.

B 09.90 Support services for other mining and quarrying

Description: The aggregates sector is by far the largest amongst the non-energy extractive industries. In the 2014, 2.15% of total EU aggregates production was represented by marine-dredged aggregates (Source: UEPG).

The sector is made up of 4 NACE classes that include extraction and dredging of industrial sand, sand for construction and gravel; breaking and crushing of gravel; quarrying of sand; mining of clays, refractory clays and kaolin. Granular products are used most notably in construction (e.g. sands, stones etc.), manufacture of materials (e.g. clay, gypsum, calcium etc.), manufacture of chemicals etc. Support services are also included.

Source: Eurostat SBS (sbs_na_ind_r2) and UEPG.

Maritime proportion: The maritime proportion can be calculated based on production data that distinguish between onshore and offshore production. The data are made available on UEPG's website at http://www.uepg.eu/statistics/estimates-of-production-data.

A minor production, not reported by the UEPG, is carried out in the Estonia, Finland, Greece, Latvia, Lithuania, Italy, Poland, Portugal, Spain, and Sweden (Source: ICES, F. Velegrakis et al., 2010). It is proposed not to include these countries in the database, because their production is negligible and too difficult to estimate.

Growth potential: In the past 4 years, marine aggregates production in the EU decreased less (-9.2%) than total aggregates production (-11.6%). However, by comparing 2014 production estimates with 2008, total marine aggregates production experienced significant downsizing, and decreased by 70.4%, from 92 million tonnes to 54.

The growth potential seems to be limited and strictly related to the construction industry trends and to the availability, quality, and cost of alternatives such as land-based sand and gravel, crushed rock, and recycled/secondary material. However, an increasing demand for beach replenishment material in the face of coastal erosion and planned projects of coastal infrastructures (e.g. offshore concrete gravity-base foundations used for offshore wind turbines) could sustain the production in the future.

Environmental considerations: Marine aggregates are finite, being a non-renewable resource. Extraction activities undertaken in an inappropriate way may cause significant harm to the marine and coastal environment. Effects can be short- or long-term and/or cumulative (e.g. modifications of the topography of the seabed, changing in the sediment substrate, reduction of the abundance, diversity, and biomass of the macro-benthic community, increase of suspended sediment, disturbance of mobile animal species etc.). For these reasons their exploitation is regulated by national and international mineral policies, subject to environmental safeguards. In the last few years, environmental regulation and control have continued to

increase, with controls in the EU particularly influenced by EC Directives (e.g. the EIA 85/337/EEC, and Habitats 92/43/EEC Directives).

On the other hand, extraction of marine aggregates has also some advantages in terms of beach nourishment, and in view of the decrease of land-based aggregates sources. Furthermore, it may be argued that the carbon footprint associated with the extraction and transport of marine aggregate is significantly lower than that associated with land-based extraction activities.

5 Extraction of salt

EuSalt (www.eusalt.com) has been involved in the study to develop a method for estimating the maritime proportion of this activity. EuSalt has pointed out that salt (including sea salt) is primarily used by the chemical industry (approx. 70%), then for de-icing purposes (20-25%), then for food and feed purposes (5%), and then for pharmaceuticals etc.

The NACE code (B 0893 Extraction of salt) does not distinguish the source of salt. Sea salt is only a part of salt extraction. EuSalt suggested combining NACE with CPA Rev. 1 codes, the latter being 'Rock salt', 'Sea salt', 'Vacuum salt', 'Salt in brine' and 'Others. The main problem is that, despite specific CPA codes exist, data is not available for most countries.

However, EuSalt is also working on an internal study that will make available data through which it should be possible to know how much salt is extracted offshore. At the time of writing, these data have not yet been made available, but the new study is due in February 2017. No data on salt extraction are reported for the moment, but they could be added in the next updates of the database.

6 Seabed mining

Being an emerging activity, seabed mining is not recorded in the statistical classification system. Enquiries with private information providers, however, have revealed that the value added generated in Europe is close to zero, as no extraction takes place in EU waters, although there are 9 vessels that carry out research and exploration activities. Considering the size of the market, it is thus proposed to exclude the activity for the time being.

Three main types of deposits are being explored for their metal contents. These are:

- polymetallic sulphides (also known as sea floor massive sulphides)
- polymetallic nodules
- polymetallic (cobalt-rich) crusts

EU companies are providers of technology and services for exploration projects (for all three types of deposit) outside European waters. As regards areas under the coastal state jurisdiction of European countries, three applications for exploration projects are currently pending: one in Italy, one in Norway and one in Portugal.

In the future, should new data become available, seabed mining includes the following NACE codes:

- B 07.10 Mining of iron ores
    - mining of ores valued chiefly for iron content
    - beneficiation and agglomeration of iron ores
- B 07.21 Mining of uranium and thorium ores

- mining of ores chiefly valued for uranium and thorium content: pitchblende etc.
- concentration of such ores
- manufacture of yellowcake

- B 07.29 Mining of other non-ferrous metal ores
  - mining and preparation of ores chiefly valued for non-ferrous metal content: aluminium (bauxite), copper, lead, zinc, tin, manganese, chrome, nickel, cobalt, molybdenum, tantalum, vanadium etc.; precious metals: gold, silver, platinum
- B 09.90 Support services to other mining and quarrying
  - support services on a fee or contract basis, required for mining activities of divisions 05, 07 and 08; exploration services, e.g. traditional prospecting methods, such as taking core samples and making geological observations at prospective sites; draining and pumping services, on a fee or contract basis; test drilling and test hole boring

Growth potential: it was estimated that a maximum of 2-4% of global production of minerals could be sourced from the deep sea by 2050. Despite this slower progress, it is likely that the sector, which is heavily research- and innovation-driven, will be able to increase its turnover via the sales of research vessels and specialised equipment. It is also likely that an increasing number of private enterprises would be involved in one or more stages of deep-sea mining. Growth in employment would very much depend on the number of projects taking place at the same time.

Since the EEZ of EU Member States, apart from the Azores islands, will unlikely be exploited for deep-sea mining due to the lack of mineral reserves, the role of EU stakeholders in the sector can be two-fold. On the one hand, the EU Commission and Member States individually are expected to remain important players in financing research and innovation in exploration, extraction and monitoring devices that may be used for seabed mining. On the other hand, EU private enterprises are likely to continue their involvement as technology and service providers.

Source: 'Study to investigate the state of knowledge of deep-sea mining' (Ecorys, 2014).

The OECD's report on ocean economy[51] deep-sea mining among the activities with significant long-term potential but not operating at a commercial scale for some time to come. The extent of the potential is expected to be huge, although it is admittedly difficult to gauge.

Environmental considerations: Deep-sea mining is a pioneering activity which interacts with flora and fauna on the seafloor and water column.

It is important to note that there are differences in impacts depending on the deposit type as well as the geomorphological setting, physical conditions, the scale of operations, and therefore also depending on the technology used for extraction.

The extraction phase is supposed is expected to impact the environment more than others, because of the interferences with the seafloor habitat. Disaggregation, lifting and dewatering are the extraction processes that are expected to have the most notable environmental impacts

If deep-sea mining is developed, environmental policies will need to be adjusted as new information, technologies and working practices emerge. This will require an on-going, collaborative approach involving industry representatives, policy makers, field scientists and subject matter experts, environmental managers, government authorities, international agencies, civil society and the general public. As deep-sea mining activities will, for the most part, be carried out in remote locations which may make independent observation difficult, transparency will need to be a key consideration in developing such approaches.

[51] OECD, The Ocean Economy in 2030, 2016. Available at: www.keepeek.com/Digital-Asset-Management/oecd/economics/the-ocean-economy-in-2030_9789264251724-en

Source: Ecorys, 2014.

7 Desalination

Desalination is another activity which is not captured in the classification system of economic activites. Enquiries have been made with Desaldata, a private information provider. They sell a yearly report with market information on desalination worldwide. However, the data are not in line with the objectives of this study, as they do not include information such as turnover and value added. Desaldata have pointed out that in Europe there is a market for desalination only in Spain, Italy and Cyprus, among which only Spain's has an appreciable dimension.

Desalination is included in the list of maritime activities in case new data are made available in the future.

8 Maritime transport

8.1 H 50.10 Sea and coastal passenger water transport

Description: This class includes:

- transport of passengers over sea and coastal waters, whether scheduled or not:
- operation of excursion, cruise or sightseeing boats
- operation of ferries, water taxis etc.
- renting of pleasure boats with crew for sea and coastal water transport (e.g. for fishing cruises)

Source: Eurostat SBS (na_1a_se_r2).

Maritime proportion: The activity is considered fully maritime and data can be imported into the database without further calculation.

Growth potential: The shipping industry is a significant economic activity for the EU economy due to the multiple economic benefits. The European controlled fleet comprises 450 million gross tonnes and 23,000 vessels currently represents around 40% of world's gross tonnage.EU fleet has shown a significant increase of almost 70% during the last five years in terms of capacity. Greece controls the majority of the European fleet (36%) followed by Germany (21%). In terms of economic impact in 2012 EU shipping contributed 56 billion euros to EU GD and employed 590 thousand people. Totally the industry contributed more than 145 billion euros in the European economy. The growth potential of the sector is directly linked to the GDP growth rates. Predictions for 2016 are modest, however the demand coming from emerging markets is expected to balance sector performance. Shipping activity is a mature industry, nevertheless specific sub-sector present positive growth potentials. SSS constitutes almost 60% of the total EU-28 maritime transport carrying 1,7 billion tonnes of freight[52].

The OECD's report on ocean economy[53] classifies shipping among the activities with high long-term growth of business and employment. In the report, it is noted that generally a 1% increase in real GDP corresponds to a 1,1% growth in seaborne trade. For this reason, the whole shipping industry is expected to grow by 4,3% in 2016, 4,1% per year over the period 2017-2019, 40% per annum on average over 2020-2029, and 3,3% between 2030 and 2040.

[52] Figures from, Oxford Economics, The economic value of the EU shipping industry, 2014. Available online at http://llsa.lt/images/articles/naudinga_info/2014-04-01%20Oxford%20Economics%20Shipping%20value.pdf

[53] OECD, The Ocean Economy in 2030, 2016. Available at: www.keepeek.com/Digital-Asset-Management/oecd/economics/the-ocean-economy-in-2030_9789264251724-en

Environmental considerations: Shipping is considered an environmentally friendly transport mode. However, based on the study of IMO, shipping is responsible for 2,5% of the global greenhouse emissions, while future predictions suggest that there will be an increase between 50% and 250% until 2050. In this context, the EU has set specific CO_2 reduction specifics. For the shipping industry, this includes the reduction of CO_2 emissions from maritime bunker fuels by 40% until 2050. Apart from the various regulations imposed to the ships – especially the ones concerning the establishment of sulphur emission control areas (SECA) and the use of cleaner fuels – the sector of short-sea shipping can contribute to achieving EU environmental goals. This is why in 2011 White Paper on Transport the EC suggests that 30% of road freight over 300 km should shift to other modes such as rail or waterborne transport by 2030, and more than 50% by 2050. To that extent, this shift can be supported by SSS and this is why the EU has taken initiatives (Motorways of the Sea program, promotion of Short Sea Shipping, Blue Belt) to support maritime transport and thus aid in the modal shift. The Athens Declaration in 2014 reissued the necessity to strengthen SSS.

8.2 H 50.20 Sea and coastal freight water transport

Description: This class includes:

- transport of freight overseas and coastal waters, whether scheduled or not
- transport by towing or pushing of barges, oil rigs etc.
- This class also includes:
- renting of vessels with crew for sea and coastal freight water transport

Source: Eurostat SBS (na_1a_se_r2).

Maritime proportion: The activity is considered fully maritime and data can be imported into the database without further calculation.**Type of market**: see § 8.1

Growth potential: see § 8.1

Environmental considerations: see § 8.1

8.3 H 50.40 Inland freight water transport

Description: This class includes:

- transport of freight via rivers, canals, lakes and other inland waterways, including inside harbours and ports
- renting of vessels with crew for inland freight water transport

Source: Eurostat SBS (na_1a_se_r2).

Maritime proportion: The activity is not to be considered maritime according to the definition developed for this study. However, it has been decided to include it in the database, as it may be important for some countries, in which a great part of inland freight transport originates from maritime transport.

Growth potential: see § 8.1

Environmental considerations: see § 8.1

Assessment of data availability and sources: see § 8.1

8.4 H 50.30 Inland passenger water transport

Description: This class includes:

- transport of passenger via rivers, canals, lakes and other inland waterways, including inside harbours and ports

This class also includes:

- - renting of pleasure boats with crew for inland water transport

Source: Eurostat SBS (na_1a_se_r2).

Maritime proportion: The activity is not to be considered maritime according to the definition developed for this study. However, it has been decided to include it in the database, as it may be important for some countries, in which a great part of inland freight transport originates from maritime transport.

Growth potential: see § 8.1

Environmental considerations: see § 8.1

Assessment of data availability and sources: see § 8.1

8.5 H 52.29 Other transportation support activities

Description: This class includes:

- forwarding of freight
- arranging or organising of transport operations by rail, road, sea or air
- organisation of group and individual consignments (including pickup and delivery of goods and grouping of
- consignments)
- issue and procurement of transport documents and waybills
- activities of customs agents
- activities of sea-freight forwarders and air-cargo agents- brokerage for ship and aircraft space
- goods-handling operations, e.g. temporary crating for the sole purpose of protecting the goods during transit,
- uncrating, sampling, weighing of goods

Source: Eurostat SBS (na_1a_se_r2) and Eurostat naio_10_cp

Maritime proportion: It has been assumed that the maritime proportion is the same as Warehousing and storage services.

Growth potential: see § 8.1

Environmental considerations: see § 8.1

Assessment of data availability and sources: see § 8.1

8.6 K 65.12 Non-life insurance

Description: This class includes:

- provision of insurance services other than life insurance

- accident and fire insurance
- health insurance
- travel insurance
- property insurance
- motor, marine, aviation and transport insurance
- pecuniary loss and liability insurance

Source: Eurostat SBS (na_1a_se_r2) and Eurostat naio_10_cp

Maritime proportion: A proxy of the maritime proportion can be calculated by using the input-output tables of each MS to estimate the amount class K 65 'Insurance, reinsurance and pension funding services, except compulsory social security' gives for the production of class H 50 Water transport divided with the total of the intermediated consumption of class K 65.

Growth potential: see § 8.1

Environmental considerations: see § 8.1

Assessment of data availability and sources: see § 8.1

8.7 K 65.20 Reinsurance

Description: This class includes:

- activities of assuming all or part of the risk associated with existing insurance policies originally underwritten by other insurance carriers

Source: Eurostat SBS (na_1a_se_r2) and Eurostat naio_10_cp

Maritime proportion: A proxy of the maritime proportion can be calculated by using the input-output tables of each MS to estimate the amount class K 65 'Insurance, reinsurance and pension funding services, except compulsory social security' gives for the production of class H 50 Water transport divided with the total of the intermediated consumption of class K 65.**Type of market**: B2B

Environmental considerations: see § 8.1

Assessment of data availability and sources: see § 8.1

8.8 N 77.34 Rental and leasing services of water transport equipment

Description: This class includes renting and operational leasing of water-transport equipment without operator: commercial boats and ships

Source: Eurostat SBS (na_1a_se_r2)

Maritime proportion: the class can be considered entirely maritime and data can be imported into the database without further calculations.

Growth potential: see § 8.1

Environmental considerations: see § 8.1

Assessment of data availability and sources: see § 8.1

9 Ports (including dredging

9.1 F 42.91 Construction of water projects

Description: This class includes:

- construction of:
    - waterways, harbour and river works, pleasure ports (marinas), locks, etc.
    - dams and dykes
- dredging of waterways

Source: Eurostat SBS (sbs_na_con_r2)

Maritime proportion: the activity can be considered entirely maritime, although it also includes construction of dams and dykes and dredging of waterways. Harbour and ports may be located on rivers or lakes, but as long as inland navigation is included in the list of maritime activities, there should not be any problem.

Notes: this class also includes dredging, which is an important economic activity, especially in certain countries of northern Europe. It is extremely difficult to separate 'dredging' from the rest of the activity under the class. During the study, several contacts were sought with the European Dredging Association to enquire whether they could have any useful data. However, no reply was received.

9.2 H 52.10 Warehousing and storage services

Description: This class includes:

- operation of storage and warehouse facilities for all kinds of goods:
- operation of grain silos, general merchandise warehouses, refrigerated warehouses, storage tanks etc.
- storage of goods in foreign trade zones
- blast freezing

Source: Eurostat SBS (na_1a_se_r2) and Eurostat naio_10_cp

Maritime proportion: This is a partially maritime activity. A proxy of the maritime proportion can be calculated by using the input-output tables of each MS to estimate the amount class H 52 Warehousing and support services for transportation gives for the production of class H 50 Water transport divided with the total of the intermediated consumption of class H 52. When available, warehousing and storage services can also be estimated from supply and use tables for water transport.

Growth potential: see § 8.1

Environmental considerations: see § 8.1

Assessment of data availability and sources: see § 8.1

9.3 H 52.22 Service activities incidental to water transportation

Description: this class includes:

- activities related to water transport of passengers, animals or freight:
- operation of terminal facilities such as harbours and piers
- operation of waterway locks etc.
- navigation, pilotage and berthing activities
- lighterage, salvage activities
- lighthouse activities

Source: Eurostat SBS (na_1a_se_r2).

Maritime proportion: since inland transport is included in the list of maritime activities, this class can be considered 100% maritime and data can be imported into the database without further calculations.

Growth potential: see § 8.1

Environmental considerations: see § 8.1

Assessment of data availability and sources: see § 8.1

9.4 H 52.24 Cargo handling

Description: This class includes:

- loading and unloading of goods or passengers' luggage irrespective of the mode of transport used for transportation
- stevedoring
- loading and unloading of freight railway cars

Source: Eurostat SBS (na_1a_se_r2) and Eurostat naio_10_cp

Maritime proportion: it is assumed that the maritime proportion is the same as warehousing and storage services.

Growth potential: see § 8.1

Environmental considerations: see § 8.1

Assessment of data availability and sources: see § 8.1

10 Shipbuilding

10.1 C 28.11 Engines and turbines, except aircraft, vehicle and cycle engines

Description: This class includes:

- manufacture of internal combustion piston engines, except motor vehicle, aircraft and cycle propulsion
- engines:
- marine engines
- railway engines

- manufacture of pistons, piston rings, carburettors and such for all internal combustion engines, diesel engines etc.
- manufacture of inlet and exhaust valves of internal combustion engines
- manufacture of turbines and parts thereof:
- steam turbines and other vapour turbines
- hydraulic turbines, waterwheels and regulators thereof
- wind turbines
- gas turbines, except turbojets or turbo propellers for aircraft propulsion
- manufacture of boiler-turbine sets
- manufacture of turbine-generator sets
- manufacture of engines for industrial application

Maritime proportion: Partially maritime. The maritime proportion is estimated based on production data available through PRODCOM.

Croatia: 19,29%

Denmark: 0,19%

Finland: 12,89%

France: 2,03%

Germany: 6,36%

Italy: 0,05%

UK: 0,81%

Type of market: Companies in this industry manufacture parts for internal combustions engines. These include pistons, piston rings, carburettors and inlet and exhaust valves. The manufacture of wind turbines is also included within this industry. The industry excludes the manufacture of engines for aircraft, vehicle and cycles.

Geographic distribution: the activity does not necessarily take place in the marine environment or in coastal areas.

Type of provider: private

Growth potential: The European marine equipment industry is a world leader for a wide range of products ranging from propulsion systems, large diesel engines, environmental, and safety systems, to cargo handling and electronics. Mobility industries comprise activities that provide products and services which aim to optimise the mobility of goods and people by combining or connecting different means and modes of transport (notably car/road, train/rail, airplane/air and ship/water), by optimising the effectiveness and resource-efficiency or reducing the cost or environmental impact of mobility, for example through the use of new materials, new energy sources and grids (e.g. new technologies and devices such as GPS, Galileo for electric vehicles).

Mobility industries build upon competences in transport and logistics on the one side and/or IT and mobile services on the other, but may also cut into other sectors such as mobile navigation services, tourism, retail and financial services. The activities of this emerging industry add value by providing, for instance, integrated, smart, clean, service-oriented and/or user-focused mobility services and related products. They provide new services to the particular needs of both businesses (B2B) and customers (B2C). This includes the provision of different forms of facilitation and mediation services such as tracking and management services and related products as well as the organisation of specific service offers, such as deliveries or car-sharing in relation to other forms of transport.

As specifically regards marine engines, it should be noted that the shipping industry has increasingly focussed on reducing fossil fuel consumption by developing electric motors which also help increase energy efficiency. This process has also been prompted by more stringent MARPOL regulation, which often require lower emission levels for ships sailing in certain areas (e.g. Sulphur Control Emission Area in the Baltic since January 2015). With the advancement in technology and increasing awareness pertaining to environmental conservation, development of propulsion systems that run on alternate fuels (including LNG) and with minimal emissions may offer growth opportunities for this industry.

The classification method for emerging industries assigned the NACE codes to the mobility industries, including C 28.11. http://www.emergingindustries.eu/methodologies/definitions/mobility-industries.aspx

Environmental considerations: see § 8.1

10.2 C 30.11 Building of ships and floating structures

Description: This class includes the building of ships, except vessels for sports or recreation, and the construction of floating structures:

This class includes:

- building of commercial vessels:
- passenger vessels, ferry boats, cargo ships, tankers, tugs etc.
- building of warships
- building of fishing boats and fish-processing factory vessels
- building of hovercraft (except recreation-type hovercraft)
- construction of drilling platforms, floating or submersible
- construction of floating structures:
- floating docks, pontoons, coffer-dams, floating landing stages, buoys, floating tanks, barges, lighters, floating
- cranes, non-recreational inflatable rafts etc.
- manufacture of sections for ships and floating structures

Source: Eurostat SBS (sbs_na_ind_r2)

Maritime proportion: the activity can be considered entirely maritime and data can be imported into the database without further calculations.

Growth potential: The European shipbuilding industry is a dynamic and competitive sector. It is important from both an economic and social perspective. It is also linked to other sectors including transport, security, energy, research, and the environment.

There are about 150 large shipyards in Europe. Around 40 of them are active in the global market for large seagoing commercial vessels;

Some 120 000 people are employed by shipyards (civil and naval, new building, and repair yards) in the EU;

With a market share of around 6% in terms of tonnage and 35% for marine equipment, Europe is a major player in the global shipbuilding industry (total turnover of EUR 60 billion in 2012);

Shipbuilding is an important and strategic industry in a number of EU countries. Shipyards contribute significantly to regional industrial infrastructure and national security interests (military shipbuilding).

The European shipbuilding industry is the global leader in the construction of complex vessels, such as cruise ships, ferries, mega-yachts, and dredgers. It also has a strong position in the building of submarines and other naval vessels.

Under the EU Framework on state aid to Shipbuilding (2011/C 364/06), the EC may authorise aid to the shipbuilding sector. Three areas for state aid are identified in the framework:

1) Regional aid. Specific measures related to regions which benefit from Cohesion policy (Objective 1), where state aid may not exceed 22.5% of gross grant equivalent. Horizontal guidelines for regional aid will be reviewed in 2013. The aid is linked to upgrading or modernizing existing yard(s);

2) Innovation aid. In the case of innovation support, aid may be provided up to a maximum of 20% of investments. Under the Shipbuilding Framework, the provision on aid to research, development and innovation justifies aid for innovation in existing shipbuilding, ship repair or ship conversion yards, provided that it relates to the industrial application of innovative products and processes, i.e. technologically new or substantially improved products and processes compared to the state of the art existing in this industry in the Community, which carry a risk of technological or industrial failure. The guidelines explicitly refer to improvement in the environmental field including optimised fuel consumption, emissions from engines, and waste. When products or processes are introduced at least one year before the introduction of more strict EU environmental regulation or in case there is no EU regulation but the products and processes contribute to a higher environmental standard, the maximum aid can be raised up to 30%;

3)Export credits. State-supported credit facilities may be granted to ship owners for newbuilding or conversion of vessels. It does not include any specific green criteria.

The OECD's report on ocean economy[54] classifies shipbuilding among the activities with high long-term growth of business and employment. The significant long-term growth expected in seaborne trade is projected to be reflected in shipbuilding, which – to a lesser extent – can also benefit from strong linkages with the offshore oil and gas industry, offshore wind energy, cruise tourism and fisheries.

Environmental considerations: Shipbuilding is considered a comparatively clean industry and maritime freight is considered among the cleanest modes of transport in terms of CO_2 per tonne/km. Nevertheless, given the total number of global ship movements and the increasing dependency of global trade on shipped goods, attention is now focused on reducing general emissions from ships.

The increased number of operational ships requires higher safety standards to avoid environmentally hazardous accidents. Shipbuilders and maritime equipment suppliers are part of the solution to the challenge of reducing emissions from ships. For instance, INTERSHIP aims to increase competitiveness of EU shipbuilders by better integrating tools and methods for design and manufacturing of complex one-of-a-kind vessels. The IP will enable shipyard engineers to consider leading edge knowledge in environmental aspects, safety, comfort and cost efficiency in simultaneous engineering, thus making sure, that optimum solutions can be obtained for the total life-cycle of complex ships.

10.3 C 30.12 Building of pleasure and sporting boats

Description: This class includes:

- manufacture of inflatable boats and rafts
- building of sailboats with or without auxiliary motor
- building of motor boats
- building of recreation-type hovercraft

[54] OECD, The Ocean Economy in 2030, 2016. Available at: www.keepeek.com/Digital-Asset-Management/oecd/economics/the-ocean-economy-in-2030_9789264251724-en

- manufacture of personal watercraft
- manufacture of other pleasure and sporting boats:
- canoes, kayaks, rowing boats, skiffs

Source: Eurostat SBS (sbs_na_ind_r2)

Maritime proportion: the activity can be considered entirely maritime and data can be imported into the database without further calculations.

Growth potential: The overall production value in the EU of recreational crafts peaked in 2008 (and 2010) and decreased after the 2008 crisis with 12%. In 2013 the overall production value for the EU28 was approximately € 6.5 billion. In 2013 the main boat producing countries in the EU were IT, NL, GE, UK and FR. The Baltic States and Poland are gaining market share due to the shift of production activities from Scandinavia. In 2012 approximately 4,500 manufacturing enterprises were present in the EU-28. Compared to 2008 this is a decrease of 4%. Approximately 95% of the companies in the manufacturing sector are SMEs. The high-end of the market is dominated by a small group of major serial boat manufactures

Environmental considerations: see § 10.2

Assessment of data availability and sources: Data generally available through Eurostat SBS.

10.4 C 28.11 Engines and turbines, except aircraft, vehicle and cycle engines

Description: This class includes:

- manufacture of internal combustion piston engines, except motor vehicle, aircraft and cycle propulsion
- engines:
- marine engines
- railway engines
- manufacture of pistons, piston rings, carburettors and such for all internal combustion engines, diesel engines etc.
- manufacture of inlet and exhaust valves of internal combustion engines
- manufacture of turbines and parts thereof:
- steam turbines and other vapour turbines
- hydraulic turbines, waterwheels and regulators thereof
- wind turbines
- gas turbines, except turbojets or turbo propellers for aircraft propulsion
- manufacture of boiler-turbine sets
- manufacture of turbine-generator sets
- manufacture of engines for industrial application

Source: Eurostat SBS (sbs_na_ind_r2) and PRODCOM (DS-066341)

Maritime proportion: this class includes a variety of engines. To single out marine engines, it is necessary to look at PRODCOM data. There is a full list of products for NACE C 28.11 on PRODCOM. The production value (PRODVAL is the name of the indicator) of 'Outboard motors for marine propulsion' (28111100), 'Spark ignition reciprocating or rotary internal combustion piston engines for marine propulsion (excluding

outboard motors) and for other use' (28111200), 'Marine propulsion compression-ignition internal combustion piston engines (diesel or semi-diesel) of a power <=¿200 kW' (28111311), 'Marine propulsion compression-ignition internal combustion piston engines (diesel or semi-diesel) of a power > 200 kW but <=¿1¿000 kW' (28111315) and 'Marine propulsion compression-ignition internal combustion piston engines (diesel or semi-diesel) of a power > 1¿000 kW' (28111319) should be divided by the total production value of the 28.11 class. The resulting ratio can be used as the maritime proportion.

Growth potential: The European marine equipment industry is a world leader for a wide range of products ranging from propulsion systems, large diesel engines, environmental, and safety systems, to cargo handling and electronics. Mobility industries comprise activities that provide products and services which aim to optimise the mobility of goods and people by combining or connecting different means and modes of transport (notably car/road, train/rail, airplane/air and ship/water), by optimising the effectiveness and resource-efficiency or reducing the cost or environmental impact of mobility, for example through the use of new materials, new energy sources and grids (e.g. new technologies and devices such as GPS, Galileo for electric vehicles).

Mobility industries build upon competences in transport and logistics on the one side and/or IT and mobile services on the other, but may also cut into other sectors such as mobile navigation services, tourism, retail and financial services. The activities of this emerging industry add value by providing, for instance, integrated, smart, clean, service-oriented and/or user-focused mobility services and related products. They provide new services to the particular needs of both businesses (B2B) and customers (B2C). This includes the provision of different forms of facilitation and mediation services such as tracking and management services and related products as well as the organisation of specific service offers, such as deliveries or car-sharing in relation to other forms of transport.

As specifically regards marine engines, it should be noted that the shipping industry has increasingly focussed on reducing fossil fuel consumption by developing electric motors which also help increase energy efficiency. This process has also been prompted by more stringent MARPOL regulation, which often require lower emission levels for ships sailing in certain areas (e.g. Sulphur Control Emission Area in the Baltic since January 2015). With the advancement in technology and increasing awareness pertaining to environmental conservation, development of propulsion systems that run on alternate fuels (including LNG) and with minimal emissions may offer growth opportunities for this industry.

The classification method for emerging industries assigned the NACE codes to the mobility industries, including C 28.11. http://www.emergingindustries.eu/methodologies/definitions/mobility-industries.aspx

Environmental considerations: see § 8.1

10.5 C 32.30 Sports goods

Description: This class includes the manufacture of sporting and athletic goods (except apparel and footwear). This class includes:

manufacture of articles and equipment for sports, outdoor and indoor games, of any material:

- hard, soft and inflatable balls
- rackets, bats and clubs
- skis, bindings and poles
- ski-boots
- sailboards and surfboards
- requisites for sport fishing, including landing nets
- requisites for hunting, mountain climbing etc.

- leather sports gloves and sports headgear
- basins for swimming and padding pools etc.
- ice skates, roller skates etc.
- bows and crossbows
- gymnasium, fitness centre or athletic equipment

Source: Eurostat SBS (sbs_na_ind_r2) and PRODCOM (DS-066341)

Maritime proportion: this class includes goods that are manufactured for a variety of sports, not necessarily linked to the maritime economy. To single out 'maritime sports goods', it is necessary to look at PRODCOM data. There is a full list of products for NACE C 32.30 on PRODCOM. The production value (PRODVAL is the name of the indicator) of 'Water-skis, surfboards, sailboards and other water-sport equipment' (32301300) and 'Fishing rods, other line fishing tackle; articles for hunting or fishing n.e.c.' (32301600), should be divided by the total production value of the 10.89 class. The resulting ratio can be used as the maritime proportion.

Growth potential: the growth potential of this activity is closely linked with coastal tourism.

Environmental considerations: no particular considerations to put forward.

11 Ship repair

This sector includes the following activities:

- C 33.15 Repair and maintenance of ships and boats
- E 38.31 Dismantling of wrecks

The activities are to be considered 100% maritime, although in principle they offer they services also to the inland shipping industry. Data are generally available through Eurostat SBS, and the same considerations related to shipbuilding also apply here.

12 Coastal tourism

Description: "Tourism is defined as the activities of persons travelling to and staying in places outside their usual environment for not more than one consecutive year for leisure, business and other purposes not related to the exercise of an activity remunerated from within the place visited". (Tourism Satellite Account: Recommended Methodological Framework, Eurostat, OECD, WTO, UNSD, 2001, paras 1.1and 2.1).

Contrary to other maritime activities tourism is not associated with any NACE codes. Its size is measured based on tourist expenditure by category (accommodation, restaurants and cafés, transport, durables and valuable goods, other expenditure), multiplied by the number of nights spent at tourist accommodation establishments in coastal areas.

Method: the method for tourism is inherently different from the other maritime activities:

EU_{28}	is set of 28 EU countries
EU_{oth}	is set of EU countries excluding the holiday destinatin
M	Is set of all modes of transport – air, train, car, etc.
O	is set of all outbound destinations for tourists from j
$n_j^{o,a}$	is number of nights spent by tourists from j in accommodation type a as recorded in origin [1]

$n_{i,j}^{o}$	is number of nights spent by tourists from *j* in *I* in all types of accommodation (rented and non-rented) as recorded in origin [2]
$n_{i,j}^{d,a}$	is number of nights spent by tourists from *j* in *i* in accommodation type *a* as recorded in destination [3]
$s_{i,j}^{a}$	is spending of tourists from *j* in *i* in accommodation type *a* as recorded in origin [4]
$s_{i,j}^{t}$	is spending of tourists from *j* in *i* on transport [5]
$s_{i,j}^{t,m}, s_{O,j}^{t,m}$	is annual spending of tourists from *j* on transport by mode *m* to destination on domestic or outbound trips [6]
$s_{j,j}^{o}, s_{O}^{j}$	is spending of tourists on categories other than transport or accommodation for domestic or outbound trips respectively [7]

The number of nights spent in each type of accommodation used (rented, non-rented, hotel, campsite etc.) is available on Eurostat from the tourism survey. For outbound destinations, we assume that nights spent in each type of accommodation are in the same proportion, whatever the destination.

$$n_{i\neq j,j}^{o,a} = n_{i\neq j,j}^{o,all} \frac{n_{j}^{o,a}}{\sum^{a} n_{j}^{o,a}}$$

where $i \neq j$ is the sum of all types of accommodation.

The spending of non-EU residents in paid accommodation in country i is not known because the spending numbers are taken from the country of origin. We estimate this from the average spending of non-resident tourists from EU28 in destination country i in paid accommodation. We know the number of non-EU visitors in paid accommodation from the hotel survey. So, we can estimate the spending as:

$$s_{i,non\ EU_{28}}^{a} = n_{i,non\ EU_{28}}^{d,a_p} \frac{\sum_j s_{i,j}^{a_p}}{\sum_j n_{i,j}^{o,a_p}}$$

Where $j \in EU$, $j \neq i$ and a_p is is paid accommodation. We do not have data for non-EU residents staying in unpaid accommodation.

Ion most, but not all, countries, the survey of tourists suggests a higher number of nights than the survey of accommodation establishments. Discrepancies are significant in a small number of countries, for instance for the number of Polish residents staying within their own country, but, on the whole, agreement is reasonable.

We have the spending of transport $s_{i,j}^{t}$ of tourists from *j* in *i* and the division of spending of transport between the various modes (plane, car, etc.) for tourists from country *j* split between those staying in their own country $s_{j,j}^{t,m}$ and those who travel abroad $s_{O,j}^{t,m}$ where $m \in M$

$$s_{i,j}^{t,m} = \begin{cases} s_{j,j}^{t,m} & domestic \\ s_{O,j}^{t,m} \dfrac{s_{i,j}^{t}}{\sum_{i\neq j} s_{i,j}^{t}} & outbound \end{cases}$$

The survey of tourist spending provides separate indications of expenditure on ‘durables’, ‘restaurants’, ‘other’ for trips inside their country of residence and outside it. We then assume that the expenditure on these items in a given country is proportional to the number of nights spent in that country.

$$s_{i,j}^{o} = \begin{cases} s_{j,j}^{o} & domestic \\ s_{O,j}^{o} \dfrac{n_{i,j}^{o}}{\sum_{i\neq j} n_{i,j}^{o}} & outbound \end{cases}$$

This gives the spending on goods and services by residents of EU countries. We then estimate the spending of tourists resident outside the EU in country *i* assuming the same spending per night as EU tourists not resident in country *i*. So for transport we assume:

$$s^{t,m}_{i,non\ EU} = s^{t,m}_{i,EU_{oth}} \frac{n^{a}_{i,non\ EU}}{n^{a}_{i,EU_{oth}}}$$

and a similar estimate can be made for 'other' expenses. We now have the spending of residents of each EU country *j* and the sum of spending by all non-EU residents in country i. The fraction in each country that is coastal can then be estimated from the fraction of nights spent at the coast in that particular country for that particular type of accommodation *a*, and we can assume the spending on transport and other goods and services is in the same proportion. The number of nights spent in coastal areas is available on Eurostat [8].

Lastly, we need to attribute the spending of tourist for *j* in country *i* to activity in each particular country. Here we assume that all expenditure is at the destination except for transport. For transport, we assume that half is spent in the country of residence and half in the destination country.

Eurostat datasets used:

[1] tour dem tnac

[2] tour dem tnw

[3] tour occ ninraw

[4] tour dem exacw

[5] tour dem extrw

[6] tour dem extr

[7] tour dem exexp

[8] tour occ ninatc

Geographic distribution: For the purpose of this study, 'coastal tourism' is defined as tourism in coastal areas. Coastal areas are defined as municipalities (LAU-2) that either border on the sea or have 50% of their surface within a distance of 10 km from the sea).

Growth potential: In the period 2012-2014 the number of nights spent at tourist accommodation establishments in coastal area grew by 3% a year in the EU-28. The Netherlands, Greece, Latvia and Portugal recorded the highest growth rates. The number of bed places in coastal areas, on the other hand, remained steady in the same period (+1% a year). There might be potential for further growth in Southern Mediterranean countries as a result of political turmoil in Arab countries.

In the future, there may be increasing demand for sustainable tourism services, as well as for emerging destinations as a result of increasingly affordable airline tickets.

The OECD's report on ocean economy[55] classifies tourism among the activities with high long-term growth of business and employment, with tourist arrivals worldwide expected to increase by 3,3% a year from 2010 to 2030.

Environmental considerations: As noted in a report by Ecorys[56] (2013), there is wide consensus on the high pressure on environment of current mainstream models of summer mass-tourism. Peaks of high fresh

[55] OECD, The Ocean Economy in 2030, 2016. Available at: www.keepeek.com/Digital-Asset-Management/oecd/economics/the-ocean-economy-in-2030_9789264251724-en

[56] Study in support of policy measures for maritime and coastal tourism at EU level, available at http://ec.europa.eu/maritimeaffairs/documentation/studies/documents/study-maritime-and-coastal-tourism_en.pdf

water consumption, waste production and need for infrastructural access and accommodation stress the capacity of local infrastructures and ultimately results in negative impacts on the environment. The situation is even more critical in those regions where local infrastructures are traditionally poor and, built to respond to the needs of a few thousand people, cannot sustain the high pressure of a growing number of visits by tourists over the summer period. At the same time, greater attention paid to environmental sustainability by local enterprises, hotels, service providers and tour operators, could trigger the interest of a growing target of sustainable visitors and therefore increase economic gains, whilst reducing environmental costs.

Note: there are many gaps in Eurostats tourism datasets that would make it impossible to make the calculations described above. When the gap regards the number of nights spent in a given country, it can be assumed that this has not varied since the previous year, or has varied to the same extent of the EU average. When data on tourist spending is missing, the EU average can be used.

13 Cruise tourism

13.1 H 50.10 Sea and coastal passenger water transport

Description: This class includes:

- transport of passengers over sea and coastal waters, whether scheduled or not:
- -operation of excursion, cruise or sightseeing boats
- -operation of ferries, water taxis etc
- renting of pleasure boats with crew for sea and coastal water transport (e.g. for fishing cruises)

Maritime proportion: This is a maritime activity dedicated to passenger shipping services, including both coastal shipping and cruise shipping. The estimation of the maritime proportion is possible by calculating the share of the class corresponding to the coastal shipping by calculating the class amount * number of coastal passengers (passengers l (excluding cruise passengers) mar_mp_am_cft)/ country level passengers embarked and disembarked in all ports [mar_mp_aa_cph].

Type of provider: Private. The cruise shipping product is provided by private companies only. At EU level, in 2014 there were 42 cruise lines operating, 123 cruise ships, plus further 18 non-European lines active in the EU market. With respect to the activities incidental to water transport based on the activity this can be provided both from the private and public sector. Specifically, all the activities related to the lighthouse activities, safety and pilotage are in most European countries a public service while the operations of terminals, piers etc., based on the port system of each country can be public, private or follow a mixed scheme. For example in Italy municipalities participate in concessionary companies dealing with the operation of cruise terminals (Genoa, Venice etc).

Growth potential: Over the last few years, the EU industry has experienced high growth rates. Since 2009 – which however was a crisis year – there has been an increase estimated at almost 30% in terms of cruise passengers (6,39 million of EU pax) and 21% in terms of embarkation. In 2014-2015, the European cruise industry recorded a decline both in embarkations and passengers' figures. Nevertheless, based on the data available from CLIA during the last five years, the economic contribution generated by the industry shows an increasing trend. The shipbuilding activity has significantly benefitted from cruise shipping, with an estimated amount of almost 17 million euro in investments for the period 2015-2018. The sector has not yet reached its maturity and there is potential for further development. Worldwide the annual passenger growth rate is estimated at 6,55% (1990-2019).

Environmental considerations: In the last few years, there has been an interesting debate about the effects of cruise shipping on environmental aspects such as air and water quality. However, Sweeting and Wayne (2006) suggest that cruise shipping has minor environmental impacts compared with the total shipping activity. Air emissions are a challenge exacerbated by the gigantism of the cruise ships. Based on a study of

Policy Research Corporation (2009), the cruise industry emitted 7.168.331 tonnes of CO_2 emissions. According to the same study, the in-port emissions are comparable lower in ports than in the sea due to the compliance of the ships with the EU Directive 2005/33/EC. In this context, cruise ships are considered to be the most innovative in applying various abatement technologies such as shore power connection, exhaust gas cleaning systems, hull optimization design, energy efficiency equipment, advanced wastewater treatment systems, recycling, packaging reducing etc. In this context, cruise industry can contribute to the objectives of the EU for reducing air emissions coming from the shipping industry.

14 Wind energy

14.1 D 35.11 Production of electricity

Description: This activity includes:

- operation of generation facilities that produce electric energy; including thermal, nuclear, hydroelectric, gas turbine, diesel and renewable.

The production of electricity by wind turbines offshore and the transmission of the electricity produced to land. The offshore wind figures are expected to include marine 'transmission'. There is transmission within the wind farm array to sub-stations and then transmission to shore. Separating this out is not possible.

Sources: WindEurope, Study for the Offshore Renewable Energy Catapult, 2014 (Strathclyde University, available online at https://ore.catapult.org.uk/press-release/offshore-renewable-energy-set-to-drive-uk-economic-growth-but-by-how-much/), The Impact of Offshore Wind Parks in the UK (Oxford Economics, available online at http://www.oxfordeconomics.com/my-oxford/projects/129065), Global Wind Energy Outlook.

Method to calculate the data: no useful data can be found on Eurostat SBS, therefore the method used for wind energy is quite different from the ones used for other activities and requires several assumptions:

Given that the future update process will be inevitably data-limited, it is important to define the different categories of data that are needed, and match these needs to the likely availability of data. This analysis is presented below:

Determining parameters

Economic impacts of offshore wind are principally determined by the installed capacity of offshore wind-farms and the rate of construction of new wind-farms:

- Installed capacity (GW) mainly determines the amount of expenditure on operations and maintenance, subject to the trends listed below. It also allows the annual electricity production (GWh) to be estimated, based on estimates of capacity factor;
- Construction of new capacity (GW/year) mainly determines the spend on procurement for building and installing the capacity, subject to the trends listed below. The data on new capacity is generally calculated based on the year when that capacity starts feeding power into the grid. The actual economic activity to build the new capacity is spread over a number of prior years. Although the construction time line varies between projects, it is a reasonable to estimate that half the spend occurs in the year before start-up and half in the year before that. Although some activities (e.g. surveying, engineering design) take place in previous years, around 95% takes place in the two years before start-up. Note that this estimate does not affect the total amount of economic activity, only its distribution over time.

This data (cumulative GW capacity and annual GW/year new capacity) is relatively easy to get (WindEurope), on a country-by-country basis, and should be updated on an annual basis.

Trending parameters

As time passes, the construction of offshore wind farms changes as new technologies come on stream, and as the 'easy' offshore locations are taken up. There are two major trends that are well documented in technical journals:

- Wind turbines are getting larger, so that fewer turbines are needed to achieve a given level of installed capacity. This means that fewer foundations and associated services are needed, but at the same time, the unit cost of both turbines and foundations increases as the turbine size increases.

  The optimal size of turbine for a given wind farm is not obvious, and depends on multiple other factors such as seabed conditions. Cost information on an individual field basis is also not widely available on a regular basis, as cost data is generally confidential to the developer.

  Ideally, the data needed to capture this trend would be time trends of average costs (€M capital and €M/year operating) per GW of installed capacity. This is a relatively long-term trend, given the time-scale of new turbine development, and periodic analysis (e.g. every 5 years) would be sufficient to capture this trend. Given the international nature of this market, these cost factors are unlikely to vary significantly between Member States.

- Wind farms are getting further offshore, so that in general water depths and export cable lengths are increasing. Increasing water depth currently translates into (greatly) increased foundation cost. Increasing offset from shore translates into increased seabed cabling cost and also increased O&M cost due to the transit time for support vessels. Furthermore, a breakpoint is reached where it becomes more cost-effective to locate operations and maintenance personnel on an offshore accommodation platform, rather than ferry them from shore for each intervention.

  The breakpoint is subject to many variables, and equally the cost implications (shifting expenditure from OPEX to CAPEX) are also difficult to obtain. Since only one windfarm has been built so far in Europe with an offshore accommodation platform, there is insufficient data to include this factor in the analysis.

  In general terms, as windfarms move further offshore, OPEX and CAPEX costs (€M/yr and €M per GW installed capacity) will increase, and these changes will be captured in the above overall trends in cost per GW installed capacity. In parallel, capacity factor will also increase to compensate for the increased costs.

In conclusion, trending parameters do, by definition, change over time, but relatively slowly given the timescale of offshore wind farm developments. Therefore, it would be valid to extract data on European average €M/GW (CAPEX) and €M/GW/year (OPEX) from reports and studies carried out from time to time, and not necessarily on a systematic, annual basis.

Quasi-static parameters

The cost figures quoted for windfarm construction are the direct costs to the developer. In aggregate, these represent direct turnover. Part of these direct developer expenditures will be sub-contracted out through the supply chain, so that the value-add created by the windfarm will only be a fraction of the total expenditure. Equally, however, the development activities will require expenditure on a wide range of related activities, resulting in additional indirect expenditures. These factors need to be taken into account in quantifying the economic impact from the offshore wind sector.

There are two key multipliers to represent these factors:

- The value add multiplier (<1) which estimates the value add due to a unit of turnover;
- The indirect multiplier (>1) which estimates the total value add due to a unit of direct value add.

These multipliers have been subjected to extensive economic analysis, across multiple sectors. Their size depends upon the sector concerned (e.g. service sectors tend to have relatively high value add multipliers because most of their costs are in-house labour) but they only change slowly over time, being functions of industrial structure.

Although there are no systematically available multiplier figures specifically for the offshore wind sector, figures are available for comparable sectors. These have been assumed to be:

- Shipbuilding as a surrogate for the construction phase, since this should reflect quite accurately the major cost centres (foundation and turbine fabrication, installation/assembly)
- Port operations as a surrogate for the operation phase, since this should reflect quite accurately the major cost centres (vessel operations, shore-side facilities).

It is proposed, therefore, to apply these multipliers to the raw expenditure data for offshore windfarm construction and operation. Some analyses also take into account induced value added, which is the economic activity caused generally by growth in the economy, but not linked to the specific development project. Induced value add has not been included in the present analysis, as the induced activities will almost entirely be non-marine.

Employment within the offshore wind sector can be treated in a similar way to value added, outlined above. Various analyses of employment on specific projects have produced figures for the amount of GVA generated per full time equivalent (FTE) person employed on contracting or operating an offshore windfarm. However, the variation of GVA/FTE is wider than the multipliers described above. Therefore, this aspect of the analysis should be reviewed.

The GVA/FTE metric could also be subject to more rapid change than the other metrics, as investment in high productivity allows production levels to be expanded without a correspondingly large increase in employment.

Indirect employment multipliers also apply, in the same way as for GVA. Type 1 employment multipliers describe the additional indirect employment, without allowing for induced employment. Based on methodology applied by the Scottish government in analysis of the economic impact of their offshore wind industry, type 1 multipliers have been applied in this analysis, based on figures derived for defence fabrication (as a surrogate for windfarm construction) and for ferry operations (as a surrogate for offshore windfarm operation).

For the construction phase, an economic impact study conducted by Strathclyde University for the Offshore Renewable Energy Catapult in 2014 showed a GVA/FTE multiplier across UK offshore wind (and a small amount of tidal) developments of around £46.000/capita. At an exchange rate of 1,25 €/£ this amounts to just under €60k/capita.

For the operational phase, a Vestas study conducted by Oxford Economics in 2010 indicated that 280 direct jobs are created in the UK per GW of installed capacity, and a further 34 jobs are created overseas; it is reasonable to assume that all these 34 jobs are located within the EU. This makes a total of 314 direct jobs within the EU per GW of EU installed capacity. Applying the Type 1 multiplier for ferry operations (1,55) gives a total (direct + indirect) employment impact of 487 jobs per GW.

By way of comparison, the Global Wind Energy Outlook for 2014 gives figures of 14 person-years for construction of 1MW capacity, and 330 persons for operation of 1 GW capacity, over all wind energy capacity. These figures would be dominated by onshore wind developments, where construction and especially operation require significantly fewer personnel. Taking the average procurement spend of €1.250/kW from the same report, and a GVA/TO multiplier of 0,43, gives a GVA/FTE metric of €77.000/FTE. A slightly higher GVA/capita figure for onshore wind seems logical, given that an offshore windfarm has proportionally more expenditure on lower-value items such as foundations and marine operations. A 30% lower OPEX employment for onshore wind also seems logical, given the increased intervention rate and cost of access to offshore capacity.

Growth potential: rapidly growing sector with more capacity coming on stream each year. The OECD's report on ocean economy[57] classifies wind energy among the activities with high long-term growth of business and employment. In the more optimistic scenarios, it is predicted that there could be almost 400 GW of offshore wind capacity installed by 2030 and approximately 900 GW by 2050.

Environmental considerations: 'Green energy': significant resource use in construction (e.g. steel), but reduced emissions compared to electricity production from oil & gas fossil. Renewable.

15 Other renewable energy

15.1 D 35.11 Production of electricity

Description: The operation of generation facilities that produce electric energy; including thermal, nuclear, hydroelectric, gas turbine, diesel and renewable.

Source: Eurostat SBS (sbs_na_serv) and DG Energy Country Datasheets (https://ec.europa.eu/energy/en/data-analysis/country)

Maritime proportion: NACE code D 35.11 includes data on turnover, value added and employment if production of electricity from any source. DG Energy have data on the energy mix of each EU country and make it possible to calculate the share of offshore renewable energy.

Growth potential: This sector has not a relevant growth rate yet, although the number of test projects (available on EMODnet Human Activities) suggests that there is increasing potential for this sector.

The OECD's report on ocean economy[58] classifies ocean renewable energy among the activities with significant long-term potential but not operating at commercial scale for some time to come. The report states that there is potential worldwide to develop 337 GW of wave and tidal energy by 2050, and possibly as much again from ocean thermal energy conversion.

Environmental considerations: Just as wind energy, this sector has reduced emissions compared to electricity production from oil & gas fossil.

Assessment of data availability and sources:

- EUROSTAT energy statistics - preliminary data up to 2014 (February 2016) Updated
- EUROSTAT RES survey 2014 - final data (last update Feb 2016) Updated
- EEA UNFCCC-GHG inventory up to 2013 (last update November 2015) Updated
- ECFIN/AMECO and EUROSTAT macro-economic data (extracted in February 2016) Updated
- EUROSTAT electricity and gas markets survey 2013 (Feb 2015 update)
- EUROSTAT CHP survey 2013 - final data (June2015 update)

[57] OECD, The Ocean Economy in 2030, 2016. Available at: www.keepeek.com/Digital-Asset-Management/oecd/economics/the-ocean-economy-in-2030_9789264251724-en

[58] OECD, The Ocean Economy in 2030, 2016. Available at: www.keepeek.com/Digital-Asset-Management/oecd/economics/the-ocean-economy-in-2030_9789264251724-en

15.2 D 35.12 Transmission services of electricity

Description: The operation of transmission systems that convey the electricity from the generation facility to the distribution system.

Source: Eurostat SBS (sbs_na_serv) and DG Energy Country Datasheets (https://ec.europa.eu/energy/en/data-analysis/country)

Maritime proportion: NACE code D 35.11 includes data on turnover, value added and employment if transmission of electricity from any source. DG Energy have data on the energy mix of each EU country and make it possible to calculate the share of offshore renewable energy.

Environmental considerations: see §16.1.

Assessment of data availability and sources: see §16.1.

16 Public activities

Data from the 4 common indicators of activities E3812 (Collection of hazardous waste) and E3900 (Remediation activities and other waste management services) have been used. The other 4 activities assigned to this group (08411, 08422, 08424 and 08426) refer to public services. For these activities, "Total general government expenditure" (data sourced from Eurostat (COFOG) for groups GF01, GF02, GF03 and GF05, respectively) are reported as 'public expenditure' in the database.

In the public sector database, there are no data on number of employees, so we need to estimate is as follows:

A) We have taken workforce data from Eurostat, for "Public administration and defense; compulsory social security" (lfsq_egan2).

B) For the variable "compensation of employees" we have collected data from indicators GF01 to GFO5 (GF01= General public service; GF02=Defence; GF03= Public order and safety; GF04= Economic affairs; GF05= Environmental protection).

C) Values of "compensation of employees" from GF01 to GF05 are added.

D) Result from C) is divided by result from A) in order to obtain average public wage (D). We assume that the average wage is the same for all subsectors of public Administrations (GF01 a GF05).

E) Number of employees = Compensation of employees (of each subsector, each GF) divided by the average public wage (D).

In particular, for 08422 "Defence activities", we use the European Defence Agency (EDA)[59] as a source, which gives the percentage of marine employees over the total of Defence personnel (see table below). This percentage is used to estimate the share of Navy on military expenses in the 23 costal Member States, both in terms of "public expenditure" and "employees".

Share of navy personnel on total European Defence

2008	2009	2010	2011	2012	2013	2014
12%	13%	13%	13%	14%	13%	13%

[59] DEFENCE DATA 2014. European Defence Agency, 2016. ISBN: 978-92-95075-28-3

For the remaining public activities, we have consulted several general budgets of EU countries (Spain, Italy, Portugal and France) to obtain a proxy. In order to estimate the maritime proportion of the remaining 5 activities, the set of representative countries has been taken as a reference (table below). The standard deviation of figures analysed shows no dramatic differences between countries.

Average Maritime proportion for the Public Services

GF/ Year	2008	2009	2010	2011	2012	2013	2014
GF01= General public service	**0,12%**	**0,11%**	**0,10%**	**0,73%**	**0,78%**	**0,12%**	**0,12%**
Standard deviation	-	-	-	*0,90%*	*1,01%*	*0,05%*	*0,05%*
GF02= Defence	**12%**	**13%**	**13%**	**13%**	**14%**	**13%**	**13%**
Standard deviation	-	-	-	-	-	-	-
GF03= Public order and safety	**2,46%**	**1,64%**	**1,47%**	**1,15%**	**1,11%**	**1,49%**	**1,47%**
Standar deviation	-	-	-	*1,15%*	*1,19%*	*1,29%*	*1,34%*
GF04= Economic affairs	**0,42%**	**0,43%**	**0,37%**	**1,27%**	**0,56%**	**0,94%**	**0,94%**
Standar deviation	-	-	-	*1,18%*	*0,74%*	*1,00%*	*0,88%*
GF05= Environmetal protection	-	-	-	**1,42%**	**0,82%**	**0,97%**	**1,18%**
Standar deviation	-	-	-	*0,79%*	*0,04%*	*0,27%*	*0,52%*

Estimating the maritime proportion of activities in group 7 is very complex. Different sources and general budgets for some countries have been consulted. Generally speaking, information is not homogenous across Member States, i.e. it is not always assignable to the same activity, and the activities are also linked to other sectors not necessarily maritime. Therefore, a clear identification of the maritime budgetary items is very limited, and the proxies elaborated should come with a number of caveats.

Spain

GF	Budget items
GF01= General public service	* 467E: Oceanography and fisheries research
GF02= Defence	
GF03= Public order and safety	* 454M: Security and maritime traffic and coastal monitoring * 456D: Coastal actions
GF04= Economic affairs	*415B: Improvements in structures and fisheries markets *441N: Subventions and support to maritime transport
GF05= Environmetal protection	* 497M: Rescue and fight against maritime pollution

GF/ Year	2008	2009	2010	2011	2012	2013	2014
GF01= General public service	0,12%	0,11%	0,10%	0,09%	0,08%	0,08%	0,08%
GF02= Defence							
GF03= Public order and safety	2,46%	1,64%	1,47%	0,94%	0,74%	0,58%	0,52
GF04= Economic affairs	0,42%	0,43%	0,37%	0,30%	0,14%	0,23%	0,31%
GF05= Environmetal protection	-	-	-	-	-	1,16%	1,55%

Italy

GF	Budget items
GF01= General public service	*Institutional and general service of public administration. Environment and protections of land and sea * Resumption Fund. Environement protections of land and sea * Maritime Services Society (Finmare). * Maritime Sector Mutua Fund (FGICLP)
GF02= Defence	
GF03= Public order and safety	* Security and Sea, Ports and coastal control.
GF04= Economic affairs	* Portuary System. * Development and security of navigation, maritime transport and inland waters. * Incentives to modify inland transport to maritime. * Development and security of navigation and maritime transport in inland waters.
GF05= Environmetal protection	* Maritime Environment Research. * Research in godos and activities related to cultural activity of the sea * Protection and conservation of the marine environment, biodiversity and ecosystem.

GF/ Year	2011	2012	2013	2014
GF01= General public service	0,18%	0,14%	0,15%	0,15%
GF02= Defence				
GF03= Public order and safety	2,39%	2,44%	2,40%	2,42%
GF04= Economic affairs	2,41%	1,66%	1,65%	1,56%
GF05= Environmetal protection	1,98%	0,85%	0,78%	0,81%

France

GF	Budget items
GF01= General public service	* Maritime Commercial Fleet * Ministerial actions on the sea * Aupport to maritime programmes * Retirement pension of sea workers * Social Security of sea workers
GF02= Defence	
GF03= Public order and safety	* Maritime security and protection * Matirime agents and training
GF04= Economic affairs	* River, ports and aeroports Infraestructures * Management and control in the inland, sand and maritime waters
GF05= Environmetal protection	* Persone costl of the programme security and maritime matters

GF/ Year	2008	2009	2010	2011	2012	2013	2014

GF01= General public service				0,63%	0,66%		
GF02= Defence							
GF03= Public order and safety				0,11%	0,15%		
GF04= Economic affairs				0,19%	0,15%		
GF05= Environmetal protection				0,86%	0,79%		

Portugal

GF	Budget items
GF01= General public service	* General Directorate of Sea Policy * General Directorate of Natural Resources, Security and Maritime Services * Portuguese Institute of the Sea and the Atmosphere * Management Action in integrative services * Support General Services, coordination and control * Regional coordination services of agricultura and sea * SS. Of research * Projects * Management Actions * IMAR- Institute of the sea
GF02	
GF03	
GF04= Economic affairs	* Institutute for funding agricultura and sea * Fisheries * Maritime and inland waters transport
GF05	*

GF/ Año	2008	2009	2010	2011	2012	2013	2014
GF01= General public service				2,03%	2,24%		
GF02= Defence							
GF03= Public order and safety							
GF04= Economic affairs				2,16%	0,29%		
GF05= Environmetal protection							

Annex II – Blue biotechnology

Blue biotechnology is still an emerging area. As a whole, it is science-rich and cost-heavy, not product-rich and profitable. Dedicated companies tend to be SMEs and even micro-enterprises, and the outputs go into general sectors (chemicals, pharmaceuticals, food, materials, etc.) where the exact origin may go unidentified in data or discussion of inputs and outputs. The conventional indicators that work well enough for established market sectors can be expected not to work well, may be irrelevant, or produce misleading information if incautiously used, or are not sub-divided to refer specifically to activities in this sector. Estimates based on macro-sectors such as 'biotechnology research' or 'chemicals' remain difficult to produce and inherently not robust. The NACE category M7211 is too high-level to be of use without intensive surveys of industries and specific companies.

Unless the marine origin of organisms, tools, techniques or molecules is stressed as a vital economic indicator, so that data can be collected at the same time as major conventional industrial and economic indicators are being collected, this sector is likely to remain under-represented in robust economic measurements, and under-valued. The challenge is what kind of indicator framework to use and how to institute this as a routine. The simplest additional recording element is needed, for example a sub-code selection in an on-line input matrix. The suggested sub-divisions of NACE codes would thus have a unique sub-point. This could be added to R&D, services, manufacturing, production codes to indicate activities dependent on marine bio-resources and bio-processes. UN SIC and regional (eg NAICS) agreement would need to be secured in any further revision round, NAICS has already rejected sub-division of biotechnology (2007).

Governmental and industry collaboration are vital for this activity

How to express any proportion of activities remains a difficulty. Regular surveys/interviews may need to be instituted to gain a panoramic profile of the sector, on a 2-3 yearly basis, even though this clashes with the concept of sustainable data sources. Avoiding double-counting is an important task and challenge – input companies (those involved in generating the inputs to end-users) would be identified by a single NACE code/sub-code, so that double-counting should not be a problem. The activities of end-users, who represent a very important part of GVA for the outputs of marine biotechnology, will be almost impossible to capture without a means by which they provide an estimate of their marine biotechnology purchases and the proportion of their turnover that can be related to these. A pilot study is indicated to test how feasible this would be. This could be carried out with the collaboration of specific end-user industry organisations. For the originator companies, producing marine biotechnology products that then go up the value chain, there is no guarantee that these belong to any specific industry grouping (eg biotechnology associations or regional clusters/Pôles), so some means needs to be found to identify them better and capture their economic indicators. Incentivised self-reporting may be needed, for example.

The context and definition of blue biotechnology

Marine or Blue Biotechnology is one of the sub-divisions of biotechnology in general. It has been interpreted as both "the use of marine-origin bioresources for biotechnology purposes" and "the use of biotechnologies in the marine environment"[60]. Bioresources are generally interpreted as microorganisms or multicellular invertebrates but not vertebrate organisms such as fish or mammals. A typical use of marine-origin bioresources for biotechnology purposes would be ***marine bioprospecting of sponges or planktonic bacteria and algae*** and typical uses of biotechnologies in the marine environment would be ***in situ bioremediation***, ***genomics in aquaculture*** or ***bio-based sensors*** for eg marine algal toxins in shellfish beds. Marine biotechnology is often hidden inside the broader category of industrial biotechnology. In practice, any activity involving non-traditional use of marine bio-resources appears to be classified as 'blue biotech',

[60] Various bodies adopt this or similar definitions, including the Marine Board Ireland, the CSA MarineBiotech and the European Marine Board.

such as microbial processing of seaweeds to generate new sources of energy or extracts for chemical, pharmaceutical or nutritional sectors. This is of course broader than a traditional definition focused on gene technologies.

A ***dedicated biotechnology firm*** **i**s defined as a biotechnology active firm whose predominant activity involves the application of biotechnology techniques to produce goods or services and/or the performance of biotechnology R&D[61.] In this context, then, a dedicated marine biotechnology firm is one whose goods, services and R&D depend on marine bio-resources, or are devoted to biotechnology in the marine and maritime context.

Challenges in identifying and analysing the socioeconomic contribution of marine biotechnology

Biotechnology activities may be incorporated within the overall category of life sciences, interpreted mainly as the biopharmaceutical sector. All biotechnology research & development activity is aggregated in NSO data within the NACE category M7211.

The difficulties of disentangling marine biotech activities from broader categorisation can be seen well in data from Austria. The biotechnology sector is mainly included in pharma: Life Sciences Austria (LISA) reports 336 biotechnology and pharma companies in 2014, with turnover of €11,65B. Of these, 116 were classed as dedicated biotechnology companies (35%). 75 companies belonged to the so-called "Research, development and manufacturing companies", which consist of "dedicated biotechnology companies", "other biotechnology active" and "pharma companies". 77 of 116 dedicated biotech companies (66.4%) are in medical biotechnology. Almost €87M was reported to have reached this conglomerated sector, including funds from venture capitalists, institutional and private investors, grants, loans and other contributions[62]. However, a known marine biotechnology company, SeaLife Pharma, is described on LISA's web-site as a human health biotech; it isolates and validates active pharmaceuticals from aquatic organisms[63]. The marine linkage is simply not expressed. The profile for another company Marinomed, which depends completely on algal-origin molecules for its prime technology, omits any mention of the marine biomass usage[64].

For another example that shows the difficulties of developing robust information for Blue Biotechnology, there is the analysis of Portugal's maritime economy 2010-2013 produced for this report. There is the category 'Novos usos e recursos do mar' (New uses and resources of the ocean), and it may be that marine biotechnology and bioprospecting is included in this. The data, or estimate, of the value of this category in 2013 is €22,8M out of €58.738M for the total maritime economy, a vanishingly small percentage (actually, about 0,04%), but estimated at about 2,5 times more than in 2012. On the other hand, employment was estimated in 2013 at about 100, with a total remuneration of €1,9M. This was a fall in personnel employed of >25% and in remuneration of 50% since 2010. GVA for this category was estimated at €14,4M, 0,3% of a total of €4714,7M, in 2013. No estimate of the proportion associated with blue biotechnology can be made.

The linkage, or even blurring of boundaries, between marine ("blue") and industrial biotechnology (platform processes, [bio]refineries, bioenergy) also makes it difficult to work out the socioeconomic contributions of marine biotechnology *per se*. Applications of marine biotechnology may also be classified primarily as environmental biotechnology, interpreted mainly as bioremediation and possibly *in situ* monitoring.

The difficulties of monitoring maritime economic activities in general have been recognised by the Maritime Alliance Foundation, which has called for proposals to go into the 2017 revision of the

[61] *A Framework for Biotechnology Statistics* OECD 2005: Chapter 2 Basic Concepts and Definitions
[62] *Life Science Report Austria 2015* Austria Wirtschaftsservice GmbH 2015
[63] personal knowledge, M Lloyd-Evans
[64] http://www.lifesciencesdirectory.at

US/Canada/Mexico NAICS (North American Industry Classification System) codes and for demand-side codes clarifying the types of products, via revision of the NAPCS (North American Product Classification System)[65]. However, the body responsible for maintaining NAICS in the USA, the ECPC (Economic Classification Policy Committee), rejected a proposal for the 2007 revision to establish separate codes for activities in food and agriculture biotechnology, medical biotechnology and industrial biotechnology, arguing that they were not distinct enough from existing code-bearing categories (eg agriculture, chemical industry, food manufacturing). ECPC did however recommend a new category and code for industry involved in Biotechnology Research and Development, which harmonises with the UN's ISIC (and thus with the NACE category M7211)[66]. This step made it possible to evaluate companies researching, developing and using biotechnology processes for products, but does not allow quantification of marine biotechnology activities.

It is noticeable that all recent studies of socioeconomic data in blue growth areas of interest have noted the impossibility of deriving even crude estimates of marine biotechnology activities and impacts without direct information-gathering from as many companies as can be identified and interviewed. Public data is not available for marine biotechnology at the level of consistency, accuracy, depth and breadth that is needed to underpin reliable policy or understanding of the dynamics of the activities.

Ecorys regard blue biotechnology as in the pre-development stage, i.e. when financial flow is mainly inwards, therefore as "investing in jobs for tomorrow" but also see it as an enabling activity feeding into and supporting other maritime sectors[67]. The European Marine Board in 2015 concurred that the marine biotechnology sector is "currently more of a scientific than an economic sector"[68]. In that case, the parameters used by Ecorys (2012) are realistic, as they bridge the strictly academic and the potential commercial – patent applications/patents; patent assignees; publications[69] – plus available data on public research and innovation funding.

Many of the difficulties are outlined in a recent paper that profiled the blue biotech sector, in the context of the RITMARE project in Italy[70]. The authors scanned a very wide range of literature and other sources to create a list of companies interested and involved in the use and exploitation of marine bioresources, including publications, membership association lists, trade fair and conference attendees, databases of marine-origin drugs in clinical pipelines, and commercial partners in multi-partner projects such as those of EU FP6 and FP7. They identified 465 companies in 39 countries, of which 226 were in the EU and 162 in USA, and included 13 acquired by other companies and 40 others that were no longer active. The work clearly identified large and multinational corporations involved in the area, to the extent of joint ventures, collaborations and acquisitions, as well as a number of small and start-up companies. The headline descriptors for the large companies did not however include the term 'marine biotechnology', ie the prime industry code would miss this involvement altogether. In terms of applicability to development of indicators for socioeconomic mapping, the work is most useful in clarifying definition of company activities (products and services offered and markets served) and quantifying patents and patent applications. Data such as turnover and employee numbers was not collected.

A recent report on the global marine biotechnology market mentions companies such as BASF, CP Kelco, Cyanotech Corp, Jazz Pharmaceuticals, Lonza, New England Biolabs, PharmaMar, ProLume and DSM, some of which are clearly identifiable as marine biotech companies and others who are users, in whose business

[65] *Updating the NAICS codes – what one needs to know* The Maritime Alliance Foundation 24 March 2014
[66] Appendix D of *Updating the NAICS codes*
[67] Ecorys *Blue Growth: Scenarios and drivers for sustainable growth from the oceans, seas and coasts* 2012
[68] *Delving Deeper: Critical challenges for 21st century deep-sea research* European Marine Board Position Paper 22 EMB September 2015
[69] Ecorys *Blue Growth: Scenarios and drivers for sustainable growth from the oceans, seas and coasts – Maritime Sub-Function Profile Report Blue Biotechnology (4.2)* 2012
[70] Greco GR and Cinquegrani M (2016) *Firms Plunge into the sea. Marine Biotechnology Industry, a first investigation* Frontiers Mar Sci 2 Art 124 doi: 10.3389/fmars.2015.00124

codes marine biotech is buried[71]. The report authors interviewed 84 companies, but the split between providers and users is not clear.

Standard DOTS (Development Outcome Tracking System) indicators as used in World Bank projects involving Manufacturing Agribusiness Services[72] may be relevant in measuring impacts of marine biotechnology activities. For Health & Education, in addition to ROIC (return on invested capital), project costs, direct employment, wages, payments to Government and indirect employment, this includes the number of students enrolled.

For Europe, the number of specific marine biotechnology courses on offer in a country and the number of students might provide some useful data; in this case, the number of students should include undergraduates, master's, doctoral, and could include post-docs if these are not included in R&D. For Life Sciences industry-focused projects, there are specific indicators include output of relevant products (tonnes and value), number of new products launched in period, number of new dedicated manufacturing plants, and perhaps number of end-users reached.

However, DOTS indicators are generally applied on a project-by-project basis, and global systems are therefore not available at country level to aggregate and understand the impacts of an entire active sector.

The Ecorys study identified a number of OECD indicators that could be directly relevant to blue biotech (adapted from Table 3.2, Applicability of indicators to estimate industry size) and points out that "The Blue Biotechnology sector is not an independent statistical sector and up until now no official statistics have been released on the number of companies, GVA or employment figures for the sector" [73]. The estimate for employment in the European Blue Biotechnology sector is approx. 11.000-40.000, the wide range reflecting the absence of reliable robust data. However, even if the number of employees working in biotechnology, the pharmaceutical industry, cosmetics and aquaculture can be estimated, there is no way of being precise about the proportion involved in blue biotechnology-related activities (see Table 3.4 and associated text pp 19-20 of report). The data on which Ecorys's estimates are based is indeed not publicly-available as primary material, but is taken from industry or sector reports and can be assumed to be secondary or even itself based on estimates.

The EU's Maritime Forum holds some data on the blue economy for the 28 EU MSs and the EU as a whole, including turnover, average wages, employment numbers, indirect employment, average annual growth, but none of this information allows us to discern the contribution of blue biotechnology to the sectors included (petroleum & gas, aquaculture & fisheries, salt extraction, renewables, shipbuilding, shipping and tourism). The category M72, scientific and research development services, is the closest identifier, but is still too general and, in any case, includes no translational development, innovation development or commercial activities[74]. For the EU28, the estimate of headcount provided is 13,043, but these are accounted for almost wholly by research services for petroleum & gas and fisheries & aquaculture[75].

EASME has reported on the early outcomes of implementation of the EU SME Instrument[76]. Among the 13 thematic topics under which SMEs could apply for innovation support, Blue growth, Food and Industrial Biotechnology seem most relevant to marine biotechnology. Total indicative budgets for 2014 & 2015 were €9M, €27M and €6.2M respectively. It is not possible to disentangle blue biotechnology or identify marine biotechnology SMEs from this report, but the NACE code identifier M72 was used by the 2nd highest proportion of SMEs responding to the Blue Growth topic, after fishing and aquaculture, and was top-equal

[71] *Marine Biotechnology. A Global Strategic Business Report* Global Industry Analysts Jan 2015
[72] www.oifc.org, MAS aspects
[73] Ecorys (2014) *Study in support of Impact Assessment work on Blue Biotechnology Revised Final Report FWC MARE/2012/06 – SC C1/2013/03*
[74] NACE Rev. 2 (Eurostat 2008 ISBN 978-92-79-04741-1) in any case does not include research and development involving marine biotechnology or bioprospecting as examples within the explanation of category 72.11
[75] https://webgate.ec.europa.eu/maritimeforum/sites/maritimeforum/files/output.htm
[76] *Catalysing European Innovation: EASME's report of the first two years of implementation of the SME Instrument 2014-2015* EASME 2016

for industrial biotechnology SMEs. In terms of target market, Blue growth SMEs gave Biotechnology & Medical Research as 3rd of 5, after engineering and digital sectors.

Existing estimates of the economic impacts of marine biotechnology

These are unitary figures with simple growth projections. The Table below shows a range published from 2005 onwards. The OECD's Global Forum on Marine Biotechnology, 2012, set out the position with respect to the known socioeconomic contributions at the time[77]. The global estimate provided is secondary or even tertiary, of €2.8B in 2010, with a 4%-5% CAGR[78], and specific examples of marketed products are given. Other sources describe "By 2020, [employment in the marine and maritime economy] should increase to 7 million and [total gross value added to] nearly 600 billion euros"[79] or the "World market for Marine Biotechnology is projected to reach US$4.6 billion by the year 2017."[80]

Another figure for the global market for marine biotechnology products is US$4,8B by 2020, with Japan identified as the highest-growth market[81]. The Blue Growth Opportunities communication of 2012[82] proposes an estimate of GVA of €0.8B with low employment in the sector at the time of the report, growing to a niche market of high-value products, mid-sized by 2020. No reference for the figure is given in the document. These figures are not very helpful in trying to determine the socioeconomic impacts of marine biotechnology in the setting of European Blue Growth. Ecorys and team estimated that marine biotechnology firms would constitute 2%-5% of the total complement of biotechnology companies, i.e. at least 36-90 of an estimated total of 1399 in 2013; in the event, 97 companies (73% of which were SMEs) were identified by survey.

The Bio-based Industries Consortium (BIC) reports a turnover of €2.1Tr and 18.3 million jobs in the European Bioeconomy. The relevant end-user sectors (chemicals and plastics, pharmaceuticals, paper and paper products, forest-based industries, textile sector, biofuels and bioenergy) contribute c. €600B, 29% of the total. Primary biomass production (agriculture, forestry & fisheries) is the largest contributor to employment (58%)[83]. This gives a vision of the overall space into which marine biotechnology outputs will flow, but no concept of the size of the contributions. This is based on a recent report *European Bioeconomy in Figures*[84]. This used EUROSTAT data and estimated the bio-based proportion of target sector activities. It identifies fishery as a primary source of biomass, without definition or analysis, and there is no mention of marine biomass or biotechnology as a contributor or user, so that a percentage contribution of marine bio activities cannot be estimated at all.

[77] *Marine Biotechnology – Enabling solutions for ocean productivity & sustainability* Vancouver, 30th-31st May 2012, OECD

[78] derived from *Marine Biotechnology: A Global Strategic Business Report* Global Industry Analysts Jan 2015

[79] *Blue Growth: Commission presents prospects for sustainable growth from marine and maritime sectors* 13 Sept 2012 http://europa.eu/rapid/press-release_IP-12-955_en.htm

[80] *Marine Biotechnology: A Global Strategic Business Report* Global Industry Analysts Jan 2015

[81] *Marine Biotechnology. A Global Strategic Business Report* Global Industry Analysts Jan 2015

[82] *Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions* COM(2012) 494 final European Commission 13.9.2012

[83] *European Bioeconomy in Figures* nova-Institut for Ecology and Innovation, March 2016

[84] Piotrowski S, Carus M and Carrez D (2016) *European Bioeconomy in Figures* for the Bio-based Industries Consortium

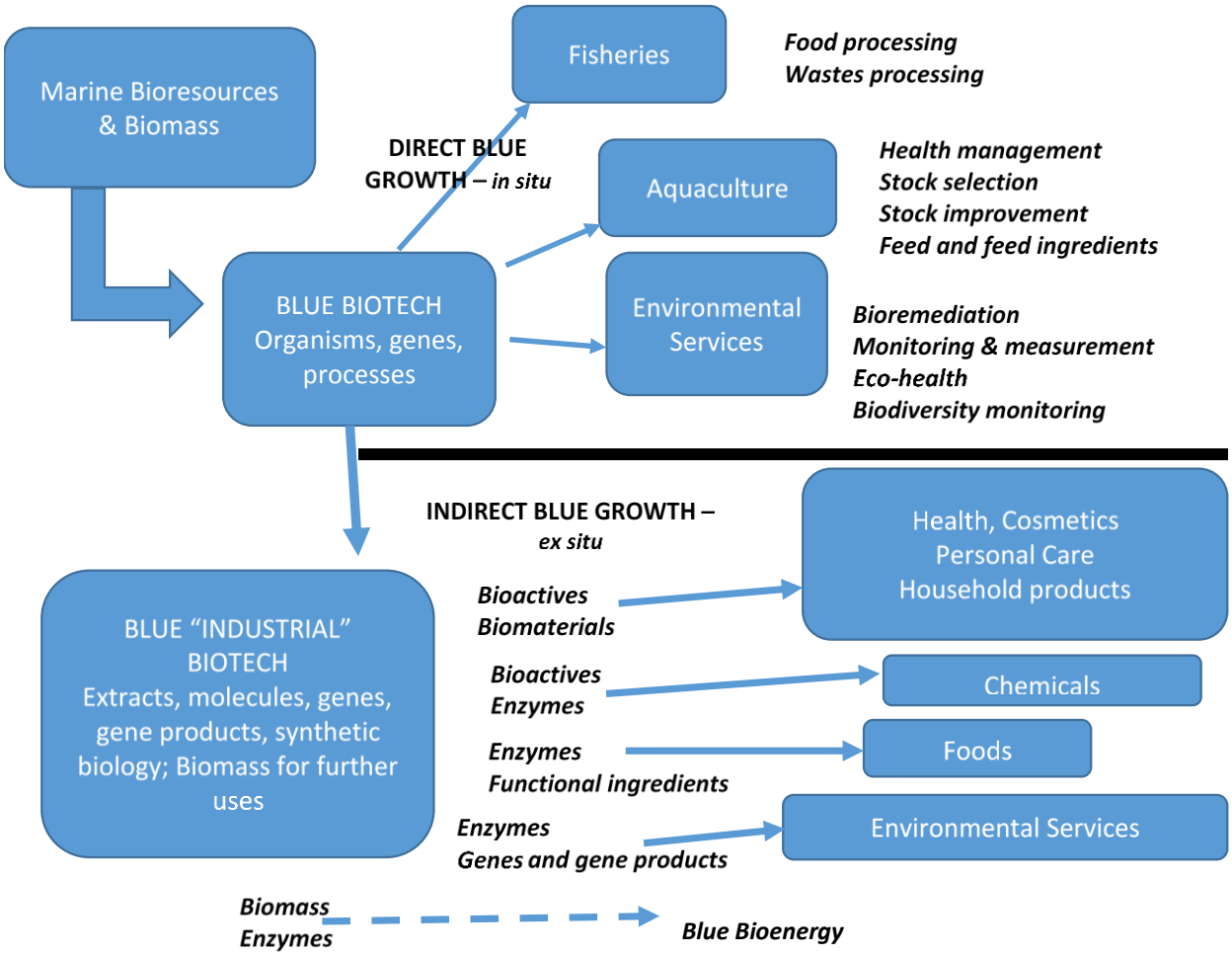
Table 6 - Estimates and projections of Maritime sectors, biotechnology, and Marine biotechnology contributions to Blue Growth 1999-2025

Region/Sector	Market size	Date range	Source
World potential for UK MBt	£0,5B to £1,5B £2,0B-£2,6B	1999 to 2004	UK Fore*sight* Marine Panel Westwood D (2000) *UK Marine Industries World export market potential* ISBN 1-902536-38-X, quoted in Lloyd-Evans LPM *A Study into the prospects for marine biotechnology development in the UK* (2005)
World Blue biotechnology	$2,4B 6% CAGR	2002 1999-2007	BCC Research Inc. Report RC-184R *Biomaterials from Marine Sources* 2003, quoted in Lloyd-Evans LPM *A Study into the prospects for marine biotechnology development in the UK* (2005) and used in Ecorys (21012)
Ireland Blue biotechnology	€9M to €18M TO Direct GVA 2007 €8,7M; Direct + Indirect GVA €14,6 >€61M	2003 to 2007 Proj. to 2020	Morrissey K, Hines S et al. (2010) *Ireland's Ocean Economy 2010* SEMRU NUI Galway, using NACE code data plus company interviews. *Our Ocean Wealth Development Task Force Report to the Inter-Departmental Marine Coordination Committee* Dept of Food, Agriculture and the Marine, Ireland 2015, based on SEMRU 2010
EU Blue biotechnology	€0,8B Employment <0,5K	2008/2012	Ecorys *Blue Growth: Scenarios and drivers for sustainable growth from the oceans, seas and coasts* (2012), based on Lloyd-Evans LPM (2005) and Ecorys assumptions
World Blue biotechnology	$2.8B 4%-5% CAGR	2010	ESF Marine Board Position Paper 15 *Marine Biotechnology: a new vision and strategy for Europe* Sept 2010 (origin not referenced)
World carotenoids	€77B	2010	*Ibid.*
World microalgae	€1,25B (=5M Kg)	2010 [?]	*Ibid.*
World Marine-origin drugs	c. €4,8B to €8,6B 12,5% CAGR	2011 to 2016 2011-2016	BCC Research Inc *Global Markets for Marine-derived Pharmaceuticals*, quoted in Greco GR and Cinquegrani M (2016)
EU total maritime economy	€485B GVA	2012	Ecorys *Blue Growth: Scenarios and drivers for sustainable growth from the oceans, seas and coasts* (2012)
EU total Biotechnology	€15B	2012	Ernst & Young *Beyond Borders - matters of evidence Biotechnology Industry report 2013*, quoted in Ecorys *Study in support of impact assessment work on blue biotechnology* (2014)
EU Blue biotechnology	€754M to €1B	2014-2019	Ecorys *Study in support of impact assessment work on blue biotechnology* 2014, quoted in Hurst D, Børresen T *et al*. (2016) *Marine Biotechnology Strategic Research and Innovation Roadmap: insights to the future direction of European marine biotechnology* Marine Biotechnology ERA-NET ISBN 978-94-92043-27-6
World Nutraceuticals	32% marine-origin, of total €250B	2018	BioMarine *About marine biotechnology* (2012) and KPMG International *Nutraceuticals: The future of intelligent food – Where food and pharmaceuticals converge* (2015), quoted in Hurst D, Børresen T *et al.* (2016)
World Blue biotechnology	€3,5B ($4,9B) 4-5% CAGR	2018 2013-2018	Global Industry Analysts *Marine Biotechnology- a global strategic business report* (2015), quoted in Ecorys (2014) & Greco GR and Cinquegrani M (2016)
World Blue biotechnology	$4,8B to $6,4B	2020 to 2025	Smithers Group *The Future of Marine Biotechnology for Industrial Applications to 2025* (2015), quoted in Hurst D, Børresen T *et al.* (2016)
World Omega-3 PUFA	$19B	2020	Marketsandmarkets.com *Omega-3 PUFA Market by Type, Application, Source, Sub-source, & Region - Global Forecasts to 2020* (2016), quoted in Hurst D, Børresen T *et al.* (2016)

Nevertheless, the maritime sector does already contribute to Europe's industrial biotechnology, as found by a recent survey of almost 450 experts involved in biobased research, industry and governance[85]. Industry respondents were asked about the source of their feedstock and 7% reported using marine biomass, including microalgae and macroalgae. In 2010, ESF's Marine Board noted a world production of macroalgae of 5M Kg dry matter, total value about €1,25B, for example[86].

However, there is little or no distinction in economic analysis so far between the direct applications of marine biotechnology, actual or potential, *in situ* in fisheries, aquaculture and the aquatic environment, and the indirect applications – see figure. Theoretically, the direct uses should be easier to measure than the indirect uses.

Figure 21 - Blue Biotechnology – Direct and Indirect applications for Blue Growth



[85] Hodgson E, Ruiz-Molina ME *et al*. (2016) *Horizon scanning the European bio-based economy: a novel approach to the identification of barriers and key policy interventions from stakeholders in multiple sectors and regions* Biofuels, Bioprod, Bioref 10: 508-522 doi: 10.1002/bbb.1665

[86] Querellou J, Børresen T *et al*. (2010) *Marine Biotechnology: A new vision and strategy for Europe* Marine-Board ESF Position Paper 15

Current and recent work that is aiming to provide descriptors or data

There is at least one report providing much more specific and apparently robust data, from Europôle Mer in France. The west of France has a substantial focus on marine biotechnology, with Biogenouest network of facilities for life sciences including marine, Capbiotek[87], an industry-wide initiative, and Europôle Mer, a kind of umbrella. Europôle Mer regards marine biotechnology as having "massive potential". However, the specific actions it proposes for the sector are mainly upstream and regard it as not very mature, ranging from further support for fundamental research to enhancing technology transfer and establishing demonstrators[88]. Within western France are four competitiveness clusters, of which three deal with marine bioresources (Pôle Mer Bretagne Atlantique) and their applications (Valorial for food and nutraceutical ingredients and Atlanpole Biotherapies for health). Europôle Mer's report provides excellent data of the type needed for analysis, such as 303 scientists working in Bretagne and Pays de la Loire; marine biotechnology scientific projects worth about €171M (2009-2013); 125 companies, identified in 2014 by direct survey, that are involved in using marine bioresources, producing products from marine biomass, or providing marine bio-related services; and about 380 marine bio-related patents filed from the region in 2000-2011. Nevertheless, it is not possible to generalise this data across France (though the report provides a comparison between western France and France as a whole, for marine bio-related patents) and certainly very unwise to use it to produce estimates across Europe.

The Harvest Atlantic project[89], an EU-funded project involving Ireland, Portugal, Spain and Scotland, included marine biotechnology as part of the blue economy. The project identified the NACE-coded sectors in which marine biotechnology might be involved as aquaculture, manufacture of prepared animal feeds, research and experimental development on natural sciences and engineering, research and experimental development on biotechnology, and manufacture of pharmaceutical products and preparations[90]. As expectable, a survey of companies was required to derive estimates of marine biotechnology activities in these 5 sectors, but it's not clear from the figures given in the publication (see Table below) whether they are the specific contribution of marine biotechnology companies to total corporate/industrial activity in each sector or the distribution of identified marine biotechnology companies across the sectors concerned. In any case, neither horizontal nor vertical sets of figures add up to 100%, and there is no information on the missing balances.

Figure 22 - Summary of Marine Biotechnology Figures at a European Level. Percentages of Companies in EU countries involved in the following sub-sector

	Aquaculture %	Manufacture of Animal Feed %	Natural Sciences and Engineering R&D %	Biotechnology R&D %	Manufacture of Pharmaceutical Products %
Ireland	38,3	6,2	14,8	12,3	6,2
Portugal	5,1	2,6	5,1	3,8	0
Scotland	11,4	0	0	5,6	2,8
Spain	27,1	20,8	0	12,5	0

Source: HARVEST Survey, HARVEST Atlantic Report (2014

[87] http://www.capbiotek.fr/index.php/en/about-capbiotek/the-cluster
[88] Boyen C and Jaouen P (2015) Marine Biotechnology in western France, Europôle Mer
[89] http://www.harvestatlantic.eu
[90] Corcoran J, O'Shea H and McGlynn H (2014) *Harvest Atlantic Project – Sectorial analysis of marine biotechnology in the Atlantic area* J Maritime Res XI (I): 81-85

A recent EU-funded project, Maribe (Marine Investment for the Blue Economy[91]), reviewed opportunities in marine integrated activities, such as combined aquaculture and off-shore wind-farming, to define the investment and business development requirements. Possibilities involving marine biotechnology did not reach the inclusion score for the short list of study cases, because of a combination of factors including stage of development, prospects and likely time for economic returns[92].

The Baltic Region is highly active in biosciences and life science development. The most notable regional blue biotechnology initiatives in the EU are the SUBMARINER Network[93] and the Baltic Blue Technology Alliance project[94], an Interreg-funded project managed by GEOMAR, Germany. Both of these have grown out of the regional science and business network ScanBalt and are centred on countries bordering the Baltic Sea, but include broader marine biotechnology interests, such as Norway, UK and Portugal. The SUBMARINER network envisages marine biotechnology as part of its roadmap, but recognises that it is still "at a nascent stage even on a global scale"[95]. SUBMARINER has estimated that marine biotechnology activity has a market size of €0,5B-€3,3B, a recent growth of 4%-6% pa, and a potential of 5/6 (where windpower gains 6/6)[96]. Nevertheless, EUNETMAR (2013) was able to pinpoint blue biotechnology as a definite promising maritime economic activity for Germany alone, amongst the Baltic, northern European and Scandinavian countries included in the work[97].

The MARNET project[98] may offer a foundation for the work required in this project. The Marine Strategy Framework Directive MSFD and the Integrated Maritime Policy IMP both envisage a much stronger and more comprehensive data-gathering system. Marine Knowledge 2020 and EMODNet represent actions towards this. However, the data-collection exercises undertaken for the MSFD assessment and to establish status of GES include only the uses of marine waters and the cost of degradation of the marine environment as their targets for analysis. MARNET set out to develop a methodology for collecting broader-based marine socio-economic data and demonstrated this successfully in the national partners. MARNET's work used NUTS and concentrated on coastal states. It also accepted the use of proxies when the technology under focus contributed only partly to an industrial sector, as would be the case for the discovery and development of industrial enzymes from marine bioresources, and their application in the food or chemical industries, for example.

[91] https://maribe.eu/

[92] *pers comm* Dr G Dalton, Maribe Project Co-ordinator, September 2016

[93] http://www.submariner-network.eu/

[94] https://www.interreg-baltic.eu/fileadmin/user_upload/about_programme/Cooperation_priorities/P2_Natural_resources/R021_Baltic_blue_biotechnology_alliance.pdf

[95] http://www.submariner-network.eu/index.php/submariner-roadmap/topics/blue-biotechnology

[96] SUBMARINER Compendium *An Assessment of Innovative and Sustainable uses of Baltic marine resources* University of Gdansk, Poland 2012

[97] *Study on Blue Growth , Maritime Policy and the EU Strategy for the Baltic Sea region – Final Report* EUNETMAR 2013

[98] http://marnetproject.eu/

Funded by ERDF, INTER-REG Atlantic, 2007-2013, it involved establishing a framework for socio-economic definition of the marine-related economy in the countries participating in the project, Ireland, UK, Portugal, France and Spain, based on a system used in USA by the National Ocean Economics Program and for the European Atlantic Area[99]. Unfortunately, for emerging sectors such as marine biotechnology, data was not available and it was necessary to survey companies[100]. This methodology may be one that is appropriate for future data-gathering in marine biotechnology, given the emerging nature and absence of serial data. For Ireland alone, the contribution of ICT and biotechnology in the total marine and maritime sectors was not expected to reach much above €60M of a total of €6,4B, by 2020[101]. The analysis established in the MARNET project was used to estimate turnover, employment and gross value-added in emerging sectors including marine biotechnology and bioproducts. The analysis used in this report put marine biotechnology and bioproducts at 3rd of 4 emergent sectors for turnover ad gross value-added, and 2nd in employment numbers. The next report on the Irish Ocean Economy is expected in 2016.

Cogea led a study on the Baltic Region, as part of EUNETMAR, for DG MARE[102]. In the course of this study, it was identified for Denmark that "so far, there is no socio-economic impact of [marine biotechnology]", though a development strategy document had been produced by the Danish Government in 2010. Of the 7 other countries investigated in this study, Germany was the only one where blue biotechnology was identified as one of the most promising MEAs, mainly on the basis of innovation, impact, policy aspects and sustainability – employment was scored as 0.

EUNETMAR also carried out a study for the Mediterranean and Black Sea countries[103]; for Albania, Bosnia-Herzegovina, Bulgaria, Croatia, Montenegro, Romania, no marine biotechnology industrial activity could be found. In Greece, Italy, there was some evidence of activity but it was minimal and no indicators could be found.

The European Regional Research and Innovation Network, ERRIN, has an active Blue Growth working group, including the Pomorskie region of Poland, Brittany and Emilia Romagna, and also identifies North Norway and Galicia as being relevant Blue Growth regions[104]. However, the working group is not working on socioeconomic indicators for marine biotechnology[105].

Tools and projects to be considered for their potential synergies in establishing data systems:

- The OECD has established a project The Future of the Ocean Economy[106]. Amongst other aspects, this will examine the investment needs, contribution to green growth and necessary policy options for supporting long-term prospects of emerging sectors such as blue biotechnology.
- Activities of the EMB's working group on valuing marine ecoservices will involve development of a data capture, aggregation and reportage system that may provide a model for valuing more direct marine biotechnology activities[107].

[99] Foley NS, Corless R *et al*. (2014) *Developing a Comparative Marine Socio-Economic Framework for the European Atlantic Area* Journal of Ocean and Coastal Economics, vol. 2014 (Article 3)

[100] Vega A *Measuring Ireland's Ocean Economy: Methods and Trends*, Galway 2015, see http://www.atlanticstrategy.eu/sites/all/themes/clean_theme/doc/events/ireland/galway/opening-session/amaya-vega-measuring-irelands-ocean-economy-methods-and-trends.pdf accessed Aug 1 2016

[101] Vega A, Corless R and Hynes S (2010) *Ireland's Ocean Economy: reference year 2010* NUI Galway

[102] *Study on Blue Growth, Maritime Policy and EU Strategy for the Baltic Sea Region* Contract No. MARE/2012/07 Ref 1, reported 2013-2014.

[103] *Studies to support the development of sea basin cooperation in the Mediterranean, Adriatic and Ionian, and Black Sea* Contract No. MARE/2012/07 Ref 2, reported 2013-2014.

[104] www.errin.eu and *pers. comm.* R Tuffs, ERRIN Director, 2016

[105] *Pers. comm.* J Millins, S Skwara 2016

[106] http://www.oecd.org/futures/oceaneconomy.htm

[107] *pers comm* Dr N McDonough, Executive Secretary of the EMB, September 2016

Potential sources of information for specific parameters

Parameter	Source for class data	Sources for factorisation
Percentage of biotechnology R&D (NACE Rev2 M 72.11)	Government data for R&D support National biotechnology associations	Government data
Number of national institutes working on marine biotechnology; % of total	Government department[s] responsible for national R&D institutes	Annual reports of each institute or direct contact
No of researchers involved in marine biosciences	Review of staff sections of web-sites for each institute/HEI Potentially a single point such as European Science Foundation	The same
Public funding of research in MBt	Departments responsible for funding R&D, industry-academic joint D&I and economic development projects	Government and agency annual reports
Number of publications		Global publication analytical software
Patent applications/granted patents	Public and commercial patent databases [challenge of key words]	Espacenet
Translational companies based on marine bioresources	Industry associations, web-searches for CROs, SMEs, interviews	
Private funding	Venture Capital Associations	Almost impossible to scan all sources

There is much work to do in implementing smart keyword-based internet searches, and in considering and recommending what types of data can be instituted as national programmes of data-gathering that can then be aggregated into a DG MARE-sponsored EUROSTAT database or EUROMONITOR-type of report.

Usable proxies:

It isn't immediately apparent what might be usable robust proxies to use for assessment of marine biotechnology activities and evolution of estimates, apart from public funding of innovation, published papers and patenting activities. This aspect still requires further thought.

Though there may be need to check again on the validity of the information, contextual aspects of the MARNET and Ecorys projects are helpful and they may form a basis for further determinative work.

Atlantic Country	Shipping and Maritime Transport	Sea Fisheries and Aquaculture	Seafood Processing	Oil and Gas Exploration and Production	Marine Manufacturing
			Gross Value Added (GVA) (millions Euro), 2010		
France	2.834	1.335	738	393	1.557
Ireland	422	227	89	61	9,5
Portugal	43	251	200	100	85
Spain	2.659	913	1.662	-	1.391
UK	4.805	553	759	29.802	2.030

Source: MARNET report

Indicators	Applicability to reflect socio-economic data	Data
Number of marine biotechnology firms – field/sector	+	This data is not available through official statistics such as Eurostat or national statistical offices. However, estimations can be made based on the database compiled for the Ecorys study and on further surveys.
Products – in development and on the market	+	The number and value of products can serve as a good indication on the value of the sector and future growth potential. Distinction is needed between products from MBt companies and products from companies using these as inputs to their products and processes
Value of Blue Biotechnology market	+	The gross value added of the sector is one of the key socio-economic indicators, signalling market and investment value.
Venture capital investment	+	Venture capital investment is a good indication of current socio-economic sectoral position signalling investment trust and quick revenue/turnaround
Employment in marine biotechnology sector – marine biotech employment as a percentage of total employment	+	Employment in the sector is an important socio-economic indicator signalling sector size.
Funding and manpower devoted to marine biotechnology R&D	+/-	Research and development potential is no solid indication of actual commercial product value. A number of factors might hinder commercialisation postponing or even discontinuing research.
Total business marine biotech R&D expenditures - as a share of total business sector expenditures in R&D– intensity of business investment in marine biotechnology - investment in (marine) biotechnology is strongly related to the underlying industrial structure	-/+	Business expenditures into RDI can be a good indication of private investment potential complimenting venture capital or more short-tem/high-risk investment sources. However alone this indicator will not provide solid figures regarding socio-economic outlook.

Indicators	Applicability to reflect socio-economic data	Data
Patents – applications and granted, share of WO patents (protected in 184 countries)	-/+	Patents can give some indication on the value of upcoming products. However, in the case of Blue Biotechnology a number of external factors limit the accuracy of establishing market value figures (prolonged clinical trials, investor confidence etc.)
Public R&D expenditures in biotech as a percentage of total public expenditures on R&D - gives us an idea of how much targeting might be going on.	-	Public R&D expenditures are a good indication of national commitment and policy support. However, they are no direct indication of the actual market -, product value, investment or employment potential.
Distribution of total business R&D in biotechnology by application	-	Distribution of R&D by application is a good indicator of market expectations towards certain sub-sectors and their future development potential but alone it might not provide an indication of current market size and value.
Publications and citations – share of worldwide	-	Publications and citation are indicative of baseline research and development trends but will not provide a direct link to sector size and market value.
Trends in clinical trials (or other trials) of marine biotechnology products (closer to the market than patents)	-	Trends in clinical trials are more of an indirect indication on future development potential especially with regards to product commercialisation. However, shortening trial periods might not necessarily lead to a sectoral boom. External and exogenous factors such as access to raw materials, competition etc. can still slow down the pace of development.
Education in marine biotechnology i.e. number of university degree courses	-	Number of students or courses in marine biotechnology are an indirect indication of future development potential and available skilled labour.

Source: Ecorys report

The Scottish Government commissioned a report on Aquaculture Science & Research Strategy published in 2014[108]. Marine Scotland's Science & Research Working Group included Blue Biotechnology & Growth as one of the 9 research topics under review, which also included several where blue biotechnology might play a part, such as nutrition, health and welfare, stock improvement and food safety.

[108] *Aquaculture Science & Research Strategy*, The Scottish Government, May 2014, available at www.gov.scot/Resource/0045/00456584.pdf

An aquaculture research database was used to derive estimates of the numbers and value of research projects in the whole field. This database is the result of a sustained effort by the Scottish Aquaculture Research Forum, covering research from 1994 onwards in the UK and other countries, with national and EU funding included. The database is not complete, though it contained 841 entries at a research value of just over £350M at the time of the report, and certainly does not include all industrial R&D. About 6% of projects were classified as Blue Biotech, and they took about 25% of the total cost, a much greater proportion compared with the other topics, though stock improvement and technology & engineering projects appeared slightly more expensive pro rata than the other topics. Specific blue biotech projects were first recorded in 2007 in this database.

The report identifies topics within marine biotechnology – exploitation (of marine bioresources) and associated skills and bioengineering; health; environmental and ecological applications; nutritional value of food and marine-derived ingredients (including selection and health of stock); and energy from algae. It is clear from the topic descriptions that the concept of blue biotech has been extended to include non-traditional technological approaches such as better biomass production and processing, and classical biotechnology (gene manipulation and engineering) is only one part of this.

Aquaculture research databases are available elsewhere, for example the Aquaculture Association of Canada's Salmon research database[109] or the marine biotechnology sub-set of the FAO's excellent Aquatic Sciences and Fisheries Abstracts[110], but they are publication-based and give no clue to value of funding. The EU-funded CSA MarineBiotech and the follow-on ERA-Net in Marine Biotechnology operate a project database with a broader focus than aquaculture alone, but this does not contain all relevant projects (only 70 to-date) or note their value[111].

Where do we want to be?

The development of accessible economic Indicators for Blue biotechnology needs historic and current data as well as the establishment of prospective frameworks. Specific data is not consistently available and all studies reviewed so far in this sector have resorted to interview programmes to identify and collect this information.

The types of data needed:

- Companies explicitly involved in marine bioresources valorisation: e.g. bioprospecting companies, biomass-harvesting and conversion companies – total number, employment, capitalisation, turnover, value-added, number of products, number of research projects, extent of public funding;
- Academic and research institutions devoted to blue biotech – specific employment, specific public funding levels, numbers of specific graduates, PhD students, post-graduates and Masters' students;
- Specific marine bioresources valorisation projects: numbers, funding, national or regional (EU);
- Blue biotechnology publications: number, number of authors, countries involved, number of citations;
- Blue biotechnology patents and patent applications: number, authors;
- Marketed products: number, types, turnover (if possible but very unlikely).

[109] http://www.aquacultureassociation.ca/slmndb/database/salmon
[110] http://www.fao.org/fishery/asfa/en - access by subscription
[111] http://www.marinebiotech.eu/projects?module=project

Total analysis of the sector, and analysis or estimation of its productivity are less-accessible:

- Total numbers, employment levels, sector turnover (due to incomplete sampling even in a large interview programme);
- Companies partly involved in marine bioresources valorisation: eg fisheries companies processing by-products or wastes for their outputs; enzyme companies with product range including marine enzymes; environmental bioremediation some of which may use marine organisms (due to incomplete sampling and 'burying' of information in the generic NACE codes for company activity);
- Companies using blue biotechnology outputs as inputs to their activities; eg green chemistry companies; biocatalysis companies; diagnostic companies; pharmaceutical companies; mixed-substrate bioenergy companies (due to 'burying' of information in the generic NACE codes for company activity).

The Preliminary Results, Methodological Note produced for this report[112] used a 5-character sector code to assist in analysing the data and estimates used. For marine biotechnology 01.04, some, very incomplete, data was found only for categories 01.04.2, national institutes working in the area; 01.04.4, amount of public funding; 01.04.5, number of publications; and 01.04.6 granted patents and patent applications. Data is available for many countries in parameters Turnover, GVA, Employment numbers and Average personnel costs for the aggregated category M7211 biotechnology R&D.

There is a potential for interface with aquaculture and blue energy that can be recognised, with aquaculture via selection of broodstock, monitoring for health, detection of disease, management of environmental impacts and GM technology for productivity and efficiency improvements (second type of activity referred to above); and with blue energy via bioenergy eg seaweeds for AD-CHP or microalgae for algal fuels.

There are no obvious interfaces with maritime coastal and cruise tourism or marine mineral resources except the areas of education/dissemination of information, and environmental protection and valorisation respectively.

[112] *Preliminary Results Methodological Note: Study on the Establishment of a Framework for Processing and Analysing Maritime Economic Data in Europe* Cogea June 2016