European Commission

Sustainable BLUE ECONOMY productive seas and oceans

Research & Innovation Projects for Policy

Research and Innovation

SUSTAINABLE BLUE ECONOMY - productive seas and oceans

European Commission
Directorate-General for Research and Innovation
Directorate F — Bioeconomy
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2017 Directorate-General for Research and Innovation

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EXECUTIVE SUMMARY

There is no doubt that the Earth's survival will depend on the protection and sustainable management of our seas and oceans and the resources they provide. This is recognised by the Joint Communication on International Ocean Governance, which is an integral part of the EU's response to the United Nations' 2030 Agenda for Sustainable Development, and in particular to the targets set out by Sustainable Development Goal 14 (SDG 14) to "conserve and sustainably use the oceans, seas and marine resources".

This report demonstrates how the results of recent research and innovation (R&I) projects funded by the European Union contribute to four areas of policy challenges related to the EU's Blue Economy:

- international cooperation on the Atlantic Ocean;
- effective use of maritime space;
- sustainable and safe marine food production/ feeding the world;
- healthy marine and coastal environments.

The EU's Seventh Framework Programme for Research and Development (FP7) and Horizon 2020 have funded over 1200 Blue-Economy-related projects, over 40 of which were analysed in the context of the four selected policy challenges. Based on their results, **seven key policy recommendations for a strong European Blue Economy are proposed.**

SEVEN KEY POLICY RECOMMENDATIONS FOR A STRONG EUROPEAN BLUE ECONOMY

↗ Unlock and treasure the Atlantic's potential from Antarctica to the Arctic through research with international partners.

↗ Implement effective framework conditions to facilitate coexisting sustainable marine and maritime activities.

↗ Combine latest scientific developments to ensure a substantial and sustainable food supply is unlocked while preserving the health and productivity of the oceans and seas.

↗ Introduce genetic tracking to ensure the origin and the safety of sea food and to track illegal fishing and correctly assess fish stocks.

↗ Ensure discoverability of, open access to and interoperability of data.

↗ Establish a well-integrated and performing global ocean-observing system with improved forecasting capabilities.

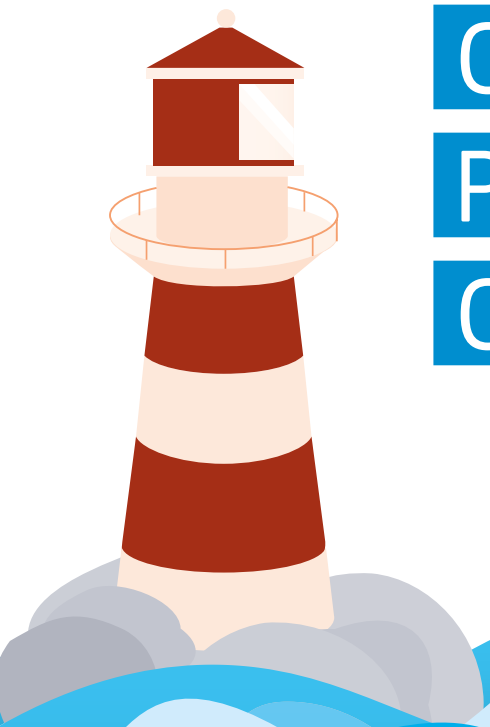
↗ Implement the circular economy approach and use the plastics strategy to reduce marine litter and micro-plastics throughout the life span of products.

DID YOU KNOW THAT

- Our oceans and seas account for 71 % of the world's surface, but only about 10 % of it has been explored[1].
- Our oceans and seas are the world's single largest ecosystem and every second breath we take comes from the oceans, which have absorbed most of global extra heat+ and around 30% of carbon dioxide produced by humans, buffering the impacts of global warming.
- Oceans serve as the world's largest source of protein, with more than 3 billion people depending on the oceans as their primary source of protein.
- Marine fisheries directly or indirectly employ over 200 million people.
- As much as 40% of the world oceans are heavily affected by human activities, including pollution, depleted fisheries, and loss of coastal habitats[2].
- Over the period 1901 to 2010, global mean sea level rose by 0.19 [0.17 to 0.21] m. The rate of sea-level rise since the mid-19th century has been larger than the mean rate during the previous two millennia[3].
- There is likely to be an increase in mean global ocean temperature of 1-4° C by 2100. There are many regional unbalances. The greatest ocean warming overall is occurring in the Southern Hemisphere and is contributing to the subsurface melting of Antarctic ice shelves. Since the 1990s the atmosphere in the Polar Regions has been warming at about twice the average rate of global warming[4].

1 National Geographic Society, 2016
2 Global Facts and Figures highlighted under the UN Sustainable Global Development Goal 14 (UN, 2016).
3 IPCC: AR5, 2014
4 International Union for Conservation of Nature and Natural Resources: Explaining Ocean Warming: Causes, scale, effects and consequences, 2016.

SELECTED CURRENT POLICY CHALLENGES

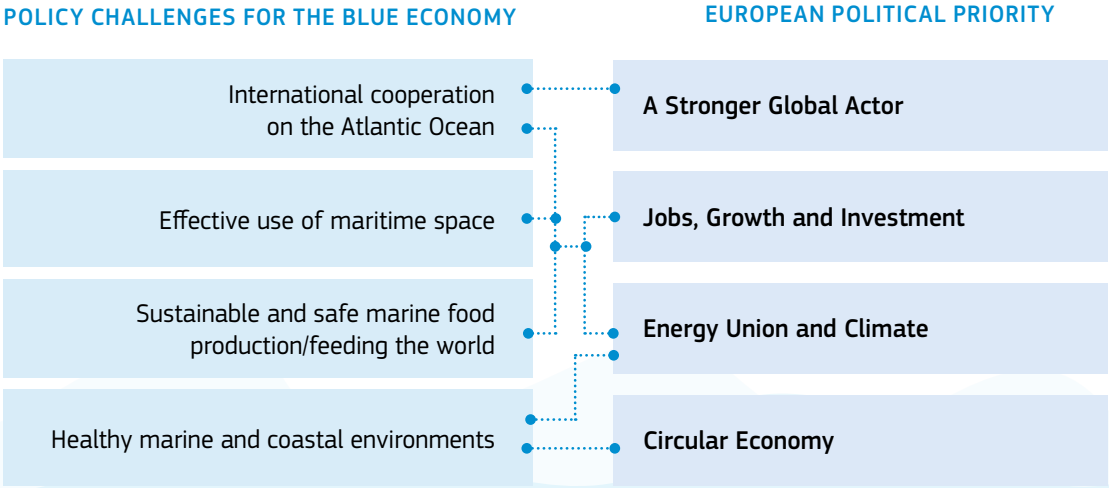


The European Union Member States' Exclusive Economic Zone (EEZ)[5] is the largest in the world, covering over 20 million km². It is a large but finite reservoir of resources (biotech, pharma, energy, food, feed, minerals, etc.) which is already stressed. The oceans and seas produce food and energy, absorb CO_2, provide half of the world's oxygen and impact climate and weather patterns. The ocean floor is a rich source of both resources and hazards, yet only a small percentage of the world's oceans and seas are accurately mapped.

The survival of the Earth will depend on the ocean, which means that the protection and sustainable management of ocean resources are crucial. This has been recognised in the Joint Communication on International Ocean Governance[6], which is an integral part of the EU's response to the United Nations' 2030 Agenda for Sustainable Development, in particular Sustainable Development Goal 14 (SDG14) and its targets[7] to "Conserve and sustainably use the oceans, seas and marine resources".

This report demonstrates how results of recent research and innovation projects funded by the European Union contribute to four areas of policy challenges related to the EU's Blue Economy. These policy challenges were selected as they are of high relevance to the challenges faced today, and are already addressed by current EU or international policies. All policy challenges have clear links to the European Commission's political priorities[8], as shown below.

In addition to the political priorities, these challenges are directly linked to the EU Bioeconomy Strategy[9] and Food 2030: Research and Innovation for Food and Nutrition Security[10].



5 https://stats.oecd.org/glossary/detail.asp?ID=884
6 https://ec.europa.eu/maritimeaffairs/policy/ocean-governance_en
7 http://www.un.org/sustainabledevelopment/development-agenda/
8 https://ec.europa.eu/priorities/index_en
9 http://ec.europa.eu/research/bioeconomy/index.cfm?pg=policy&lib=strategy
10 http://ec.europa.eu/research/conferences/2016/food2030/index.cfm

1. INTERNATIONAL COOPERATION ON THE ATLANTIC OCEAN

The Atlantic Ocean is the second largest of the wold's oceanic divisions, covering approximately one-fifth of the Earth's surface. Because of the long-standing cultural and historic ties among nations along the Atlantic Rim, they have the potential – if they cooperate towards a shared purpose – to become global role models in developing approaches for the sustainable exploitation of shared resources. As the Atlantic is a shared resource, it comes with a collective responsibility. We rely on it to support life, to regulate climate and weather. We exploit its mineral and living resources. But the more we learn about its environmental importance and its socio-economic potential, the more we realise the extent to which we still lack the capacity to understand and predict its major phenomena, as well as the changes and risks linked to human activities and climate change.

The EU's Integrated Maritime Policy[11] (IMP) aims to adopt a more coherent European approach to maritime issues in order to contribute to the creation of sustainable growth and jobs from sea-related activities. It encompasses the EU Atlantic Strategy[12] which takes stock of existing initiatives that can support growth and job creation. This Strategy identifies five major challenges and opportunities facing the Atlantic Ocean area: 1) implementing the ecosystem approach; 2) reducing Europe's carbon footprint; 3) the sustainable exploitation of the Atlantic seafloor's natural resources; 4) responding to threats and emergencies; and 5) socially inclusive growth.

The international dimension of the Strategy and its associated Action Plan[13] is represented by the Atlantic Ocean Research Alliance between the EU, USA and Canada. It was launched by the Galway Statement[14] with the aim of enhancing knowledge of the Atlantic Ocean and its dynamic systems, including interlinks with the part of the Arctic region that borders the Atlantic. The Southern Atlantic dimension of this cooperation is currently being developed, in close cooperation with the EU Member States, Brazil and South Africa.

As is true for all seas and oceans, many different and potentially conflicting activities take place in Atlantic waters, such as transport, fisheries, aquaculture, research, energy production and leisure. This can lead to tensions and conflicts, especially in areas close to land where these activities often coexist. The challenges to be addressed require joint efforts through enhanced international cooperation.

11 https://ec.europa.eu/maritimeaffairs/policy_en
12 http://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX:52011DC0782
13 http://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1395674057421&uri=CELEX:52013DC0279
14 http://ec.europa.eu/research/iscp/pdf/galway_statement_atlantic_ocean_cooperation.pdf

2. COORDINATING THE USE OF MARITIME SPACES

With a rapidly increasing demand for maritime space for new activities in addition to those mentioned above – ranging from renewable energy to aquaculture installations – better and coherent planning is needed. The seas and oceans are important drivers of economic growth as they provide natural resources, access to trade and transport, and opportunities for leisure activities. The EU's Blue Economy represents roughly 5.4 million jobs and generates a gross added value of almost EUR 500 billion a year[15], with potential for further growth. However, as maritime activities increase, so does the competition for space as coastal and maritime areas become over-crowded.

In July 2014, the European Parliament and European Council endorsed a Directive for maritime spatial planning (MSP)[16] which aimed to help Member States develop plans to better coordinate the various activities that take place at sea, ensuring they are as efficient and sustainable as possible. In coastal and maritime areas, many activities compete for the same space and resources: fishing grounds, aquaculture farms and marine protected areas exist alongside maritime infrastructures such as cables, pipelines, shipping lanes and energy installations. This Directive will help to avoid potential conflicts between such diverse uses and create a stable environment which is attractive to investors, thereby contributing to sustainable growth.

MSP is indeed a challenge in itself. The EU Directive on MSP seeks to facilitate the multi-use of busy marine waters to prevent conflicts between different marine users. In addition, the Directive requires that other EU and international regulations, such as the EU Birds Directive[17] or the EU Waste Directive[18] are taken into account. The development of the MSP faces additional constraints, in particular the incompatibility of certain national or local regulations, notably for different sectors.

All these issues have to be addressed and backed up by sound scientific knowledge which supports the development of strategic, forward-looking plans for the regulation, zoning, management, protection and sustainability of the marine environment, and its exploitations.

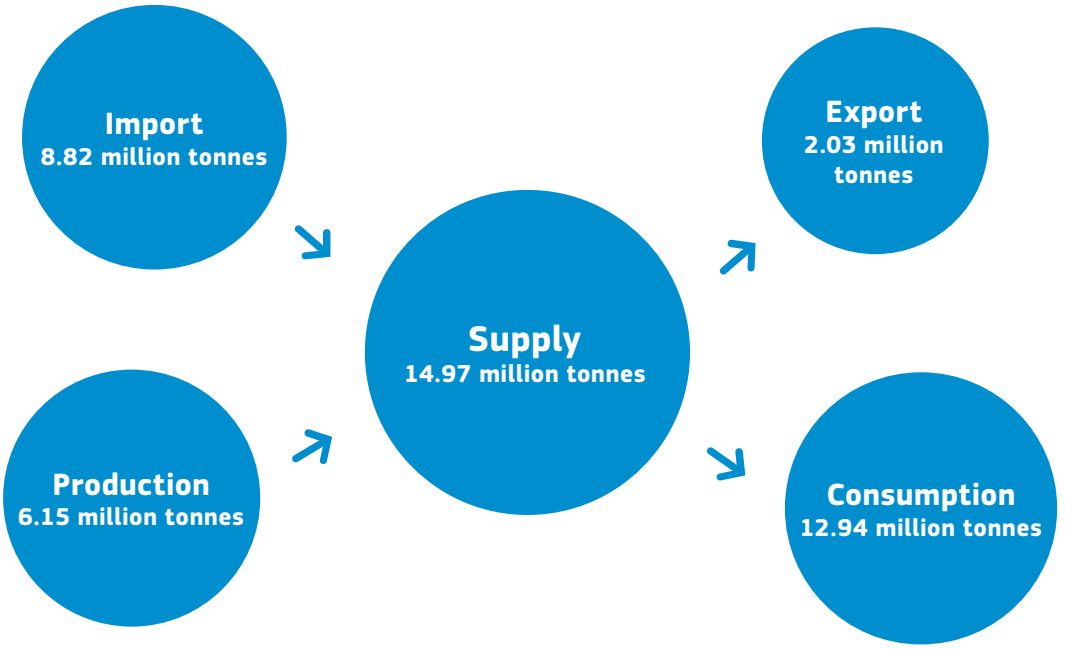
3. FEEDING THE WORLD

With the world population set to approach over 9 billion by 2050[19], societies will soon have to face the challenge of finite natural resources for food and feed. Currently, only 5 % of the economic activities and a fraction of our food come from the seas and oceans, although they cover 71 % of the Earth's surface. This challenge concerns both food security and food safety and must be addressed by a combination of actions: ensuring healthy and productive seas and oceans, sustainability of fisheries, sustainable exploitation of new seafood resources (different trophic levels) and sustainable aquaculture[20].

In 2015, the EU consumers spent 54 billion euro for buying fisheries and aquaculture products, reaching the highest amount ever recorded. However, the European seafood market is currently very dependent on imports, with 60 % of the seafood consumed in the EU being imported (see figure 1 outlining the EU seafood market overview 2014). European aquaculture

15 http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52012DC0494&from=EN
16 http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv:OJ.L_.2014.257.01.0135.01.ENG
17 http://ec.europa.eu/environment/nature/natura2000/sites_birds/index_en.htm
18 http://ec.europa.eu/environment/waste/legislation/a.htm
19 http://www.fao.org/fileadmin/templates/wsfs/docs/expert_paper/How_to_Feed_the_World_in_2050.pdf
20 This is in line with a question Commissioner Vella addressed to the Scientific Advice Mechanism on how more food and biomass can be obtained from the oceans in a way that does not deprive future generations of their benefits.

FIGURE 1 The EU seafood market overview 2014[21]



needs to sustainably increase its production by tapping into the main barriers that are hindering its production potential.

The EU Bioeconomy Strategy[22] and the EU Common Fisheries Policy (CFP)[23] address aspects of food security and food safety.

The EU Bioeconomy Strategy addresses the production of renewable biological resources (including aquatic) and their conversion into vital products and focuses on proposing solutions to four key challenges: a growing population that must be fed; depletion of natural resources; the impact of ever-increasing environmental pressures; and climate change.

The current EU CFP (2014) has four main policy areas: fisheries management[24] international policy[25], market and trade policy[26] and policy funding (EFF 2007-2013 and EMFF 2014-2020)[27]. The EU CFP aims to conserve fish stocks and reduce overfishing in order to provide EU citizens with a long-term stable, secure and healthy food supply. It also intends to boost the aquaculture sector through a so-called 'open method of coordination' which includes the Strategic Guidelines[28] for the sustainable development of the EU aquaculture, the Multiannual National Aquaculture plans and the creation of a European Aquaculture Advisory Council (AAC)[29].

21 European Market Observatory for Fisheries and Aquaculture Products (EUMOFA). The EU Fish market. 2016 edition.
22 http://ec.europa.eu/research/bioeconomy/index.cfm?pg=policy&lib=strategy
23 http://ec.europa.eu/fisheries/cfp_en
24 http://ec.europa.eu/fisheries/cfp/fishing_rules_en
25 http://ec.europa.eu/fisheries/cfp/international_en
26 http://ec.europa.eu/fisheries/cfp/market_en
27 http://ec.europa.eu/fisheries/cfp/emff_en
28 http://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1477555805378&uri=CELEX:52013DC0229
29 https://ec.europa.eu/fisheries/cfp/aquaculture/aquaculture-advisory-council_en

The issues of more food and less pollution require a lot of attention if we want to provide sufficient seafood in the future, notably because fish stocks have already been significantly depleted.

Therefore, research efforts are needed both to implement the EU CFP and to be able to acquire more food from the seas and oceans in a sustainable way, either through novel foods or food via aquaculture or fisheries. Special attention must be paid to developing ways to calculate the 'maximum sustainable yield' (MSY), i.e. how much fish can be taken out without depleting stocks. The determination of MSY is challenging since MSY for one species may have a negative impact on another stock that feeds on this species, while the overall ecosystem of natural resources impacted by human activities must also be taken into consideration.

4. HEALTHY MARINE AND COASTAL ENVIRONMENTS

Ensuring healthy and productive oceans, well-functioning ecosystems, safe and secure food supply and clean bathing waters requires remedying actions to protect and restore the marine environment rather than taking corrective actions after the damage has been done.

The EU Marine Strategy Framework Directive (MSFD)[30] has been put in place to protect the marine ecosystem, including the biodiversity upon which our health and marine-related economic and social activities depend. To help Member States achieve a good environmental status (GES)[31], the Directive sets out 11 illustrative qualitative descriptors[32], and the Commission Communication on International Ocean Governance[33] proposes concrete actions at international level, for example to address environmental, fisheries and climate issues. As underlined in the Commission Decision on GES, more research is needed to better define the descriptors. Furthermore, research already shows that additional actions will be needed, too (see DEVOTES[34]).

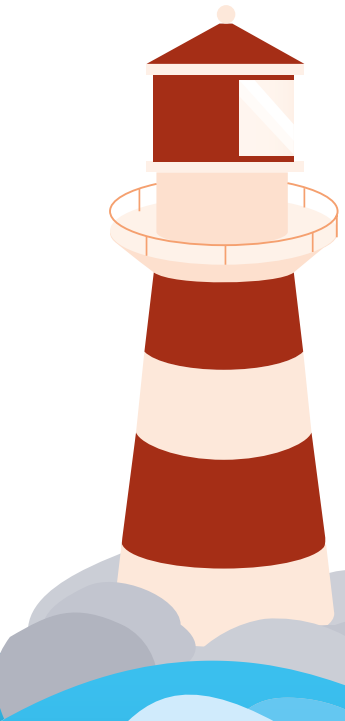
One of the major challenges is the negative impact from marine litter: animals and plants can get entangled in marine litter; litter and the adsorbed toxins can be ingested by marine species and eventually by humans; alteration, damage and degradation of benthic habitats; reduced recreational, aesthetic and educational value of marine areas; and economic harm resulting from marine litter interfering with aquaculture, fishing, transport, tourism and leisure, and power generation. Microparticles in marine habitats, which often originate from plastic materials, are seen as a major global threat to marine life. Since the first step in reducing marine litter is to prevent it from entering the oceans and seas, the need for proper and efficient waste management, which is widely recognised internationally as an issue, must be addressed worldwide and must be dealt with urgently. Furthermore, public awareness of the impact of litter on the oceans and seas must be increased if we do not want to aggravate the situation substantially.

Furthermore, the EU is actively participating and contributing substantially to international efforts to prevent and reduce marine litter and to mitigate its impact through biodiversity conventions, such as Rio+20[35].

A new international legally binding instrument under the United Nations Convention on the Law of the Sea[36] on the conservation and sustainable use of marine biological diversity in areas beyond national jurisdiction is currently being prepared.

30 http://ec.europa.eu/environment/marine/eu-coast-and-marine-policy/marine-strategy-framework-directive/index_en.htm
31 http://ec.europa.eu/environment/marine/good-environmental-status/index_en.htm
32 http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32008L0056
33 https://ec.europa.eu/maritimeaffairs/policy/ocean-governance_en
34 Borja, A., Grand Challenges in marine ecosystem ecology, in 'Frontiers in marine science', 12 February 2014, pp10-15.
35 http://www.unep.org/esm/Waterecosystems/PolicyFrameworks/TheRIO20MarineOutcomes/tabid/129791/Default.aspx
36 http://www.un.org/depts/los/convention_agreements/convention_overview_convention.htm

PORTFOLIO OF RECENT EU-FUNDED R&I PROJECTS



In both the EU Seventh Framework Programme (FP7) and Horizon 2020 Framework Programme for Research and Innovation, nearly all the themes contribute to marine and maritime research, technological development and innovation. This chapter focuses on the project portfolio analysis of the FP7 projects dealing with marine or maritime research and contributing to the Blue Economy. The selection was made by searching titles and abstracts using a set of key words before the final list was quality checked manually. This section proposes recommendations for addressing selected current policy challenges based on the results from recent R&I projects funded under EU Framework Programmes for research and innovation.

FIVE KEY FACTS CONCERNING THE PROJECT PORTFOLIO

A large part of EU FP7 support to marine and maritime R&I projects concerned fisheries; addressing the ecosystem-based approach in fisheries management; sustainability and in particular the MSY concept and optimal involvement of stakeholders, in support of the EU CFP.

EU-funded marine and maritime research covers a broad portfolio of Blue Economy sectors and the marine environment across the following EU FP7 themes: environment, KBBE, transport, Marie-Curie Actions, energy, ERC, space, SME, infrastructures, security, ICT, NMP and research potential.

Under EU FP7 projects dealing with marine or maritime research, 22.1% of project participants were SMEs.

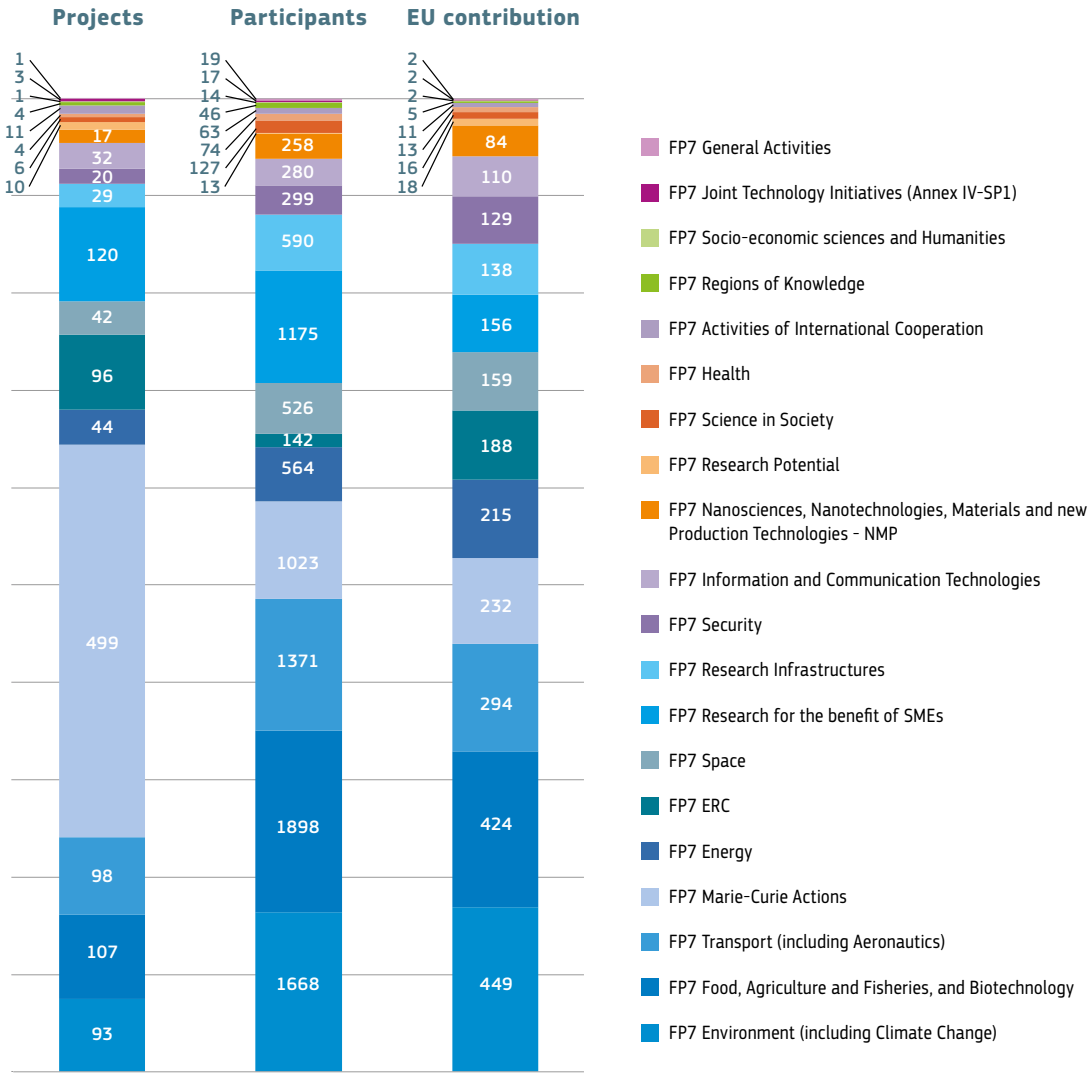
Under EU FP7, over 1200 marine and maritime R&I projects were funded, with a total EU contribution exceeding EUR 2.600 million (an average EUR 2.2 million per project).

Marine research is contributing to solving many global societal challenges we face today, such as food security and safety, environmental protection, energy security, maritime security, etc.

1. PROGRAMME AREAS WITH CONTRIBUTIONS TO THE BLUE ECONOMY

Although there have been dedicated Blue Growth calls under the Ocean of Tomorrow initiative, a number of relevant marine and maritime projects were funded under all the other FP7 themes: Environment, KBBE, Transport, Marie-Curie Actions, Energy, ERC, Space, SME, Infrastructures, Security, ICT, NMP and Research Potential. The highest participations were in marine projects in KBBE and in Environment with 1898 and 1668 participants respectively, as illustrated in the Figure 2.

FIGURE 2 Breakdown of EU FP7 projects dealing with marine or maritime research



2. PORTFOLIO OF PROJECTS AND TOPICS COVERED

Like many marine and maritime activities, research in this area is multi-disciplinary and cross-cutting in nature. The topics covered range from environment and food to space, transport and information and communication technologies. EU financial support to R&I in the Blue Economy sector has steadily increased over time.

In the EU FP7, a total of 136 000 eligible project proposals were submitted to calls for proposals covering all areas, of which 25 000 projects were funded. Of these, over 1200 concerned the seas and oceans or maritime activities with a total budget of EUR 2600 million. Horizon 2020 is still running. Based on the calls from recent years, it may be concluded that well over 200 marine projects are funded annually (over EUR 260 million per year), from all three programme pillars: Excellent Science, Societal Challenges and Industrial Leadership.

All marine topics are covered in the presented portfolio. In FP7, about 100 projects concern the Atlantic Ocean[37]; around 130 projects are relevant to the healthy marine and coastal environment, while 10 projects deal with the use of marine spaces. There are an estimated 190 projects relating to fisheries, addressing the ecosystem-based approach in fisheries management, sustainability and in particular the MSY concept (maximum sustainable yield) and the optimal involvement of stakeholders, while approximately 160 projects relate to aquaculture.

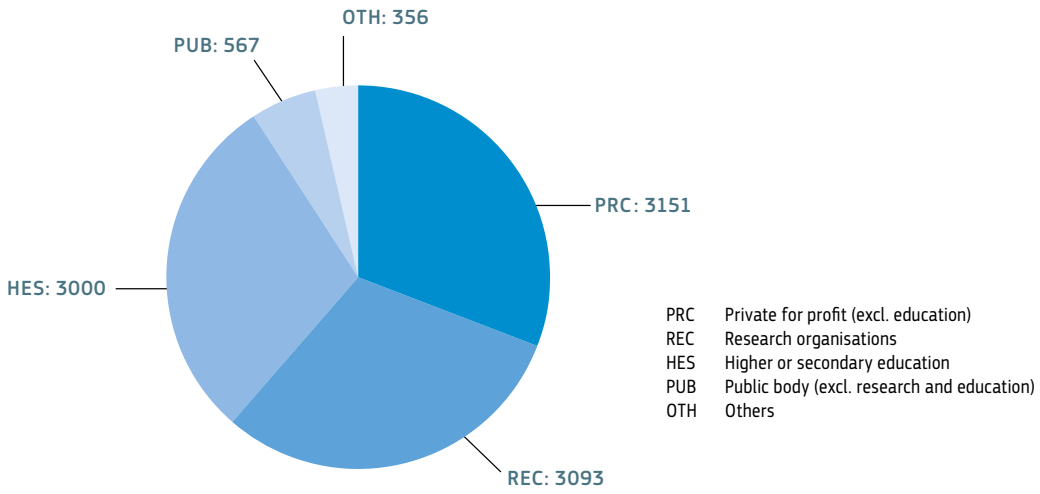
One special case is the Ocean of Tomorrow initiative: the four FP7 Ocean of Tomorrow calls (2010-2013) introduced multi-disciplinary approaches, with integrated cross-fertilisation between various scientific disciplines and economic sectors on key cross-cutting marine and maritime challenges. The calls spanned four broad themes: ecosystems; the use of maritime space; the environment (MSFD); and technologies supporting existing EU policies. Under these calls, 31 projects were selected for a total EU contribution of EUR 195.6 million for 2010-2013. The Ocean of Tomorrow calls paved the way for new challenge-driven approaches under Horizon 2020. These calls also enabled the funding of quite complex research projects to underpin EU marine and maritime policies.

3. PORTFOLIO OF BENEFICIARIES

Analysis of the 1200 selected projects shows that the project portfolio encompasses various partners from all over Europe. Furthermore, clustering of EU FP7 project participants demonstrates that a high percentage of marine research is concentrated in the maritime nations, such as France, Spain and the UK.

If taken as one group, most beneficiaries came from research institutes and higher education institutes, followed by private commercial companies. The SMEs participate in 22.1 % of the projects in this portfolio, which reflects the dynamism of the Blue Economy and its potential to create jobs and ensure the future of its sectors.

FIGURE 3 Breakdown of project participation by type



37 All the projects which are particularly relevant to the Atlantic Ocean are also relevant for other regional sea basins.

FIGURE 4 Number of beneficiaries by country.in the analysed project portfolio

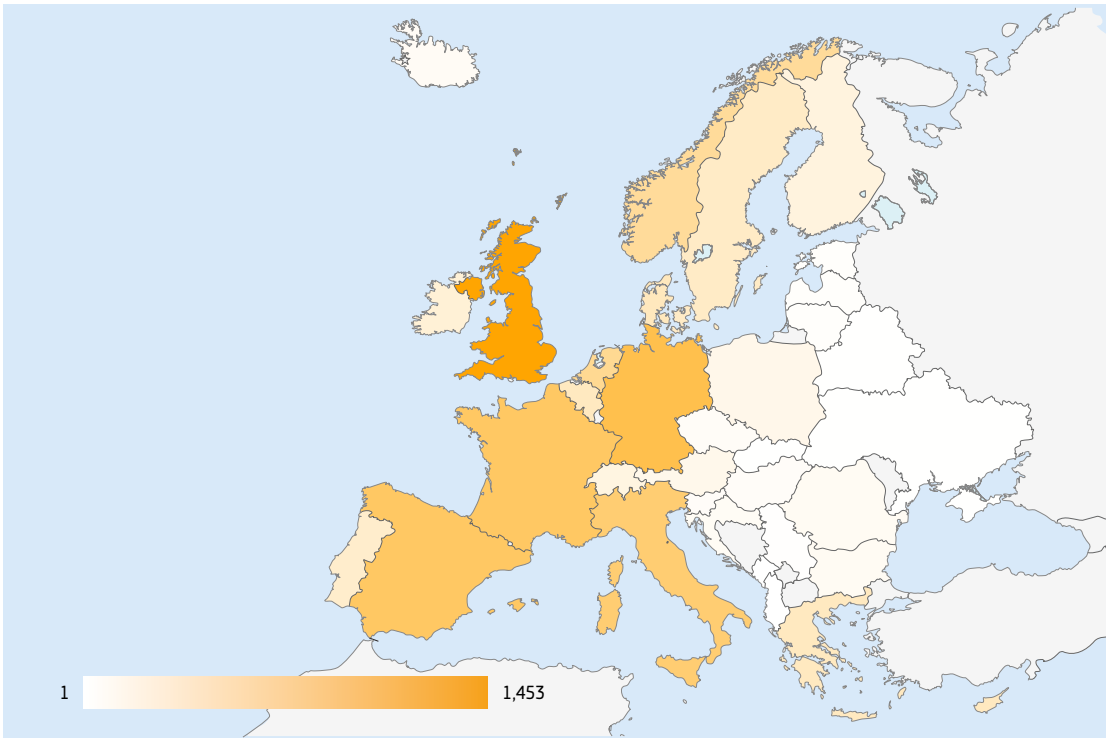
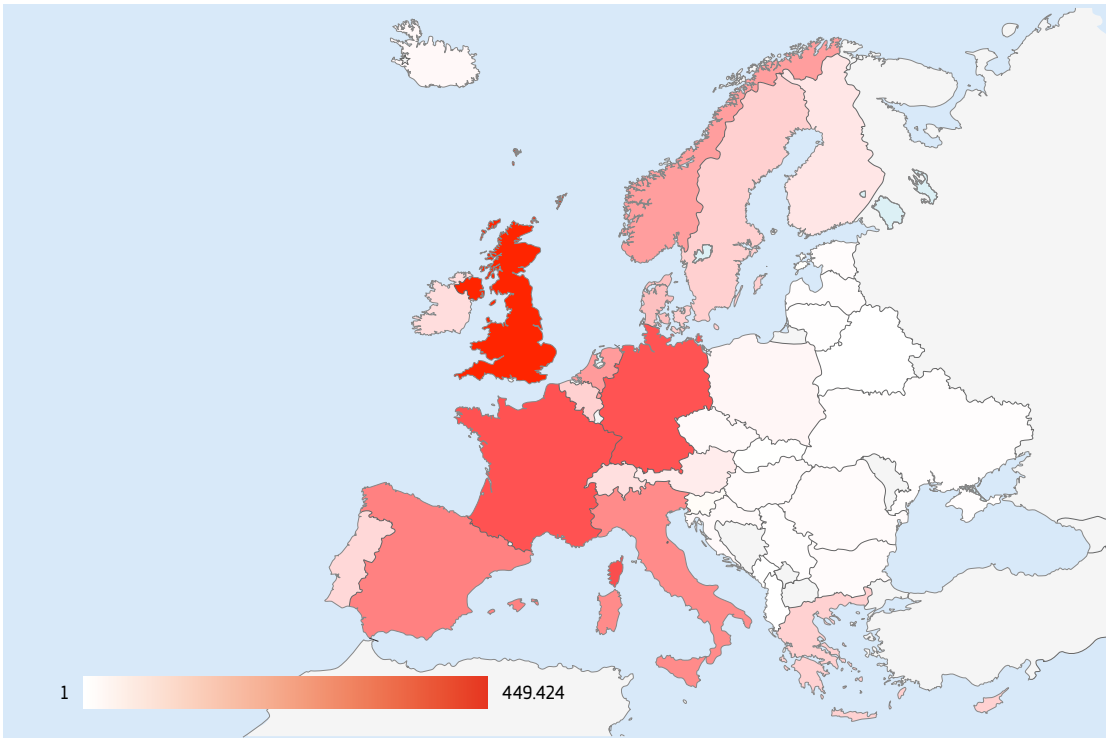
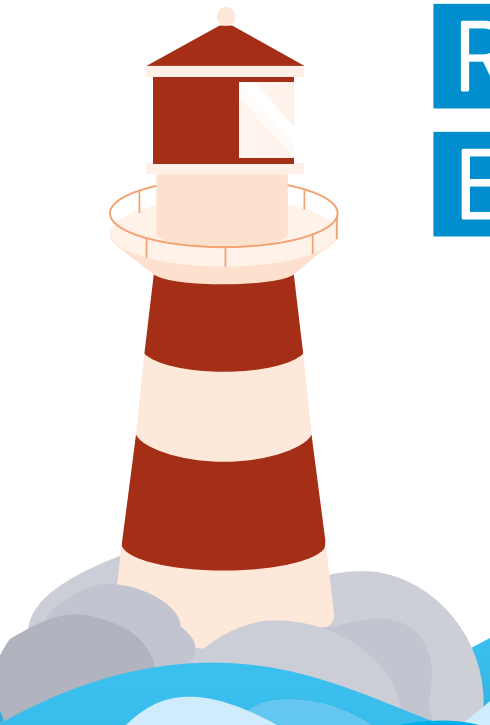


FIGURE 5 EU financial contribution by country for the analysed project portfolio



IMPACT AND RESULTS OF EU FUNDING



1. ADDED VALUE OF EU-LEVEL R&I INVESTMENT

In general, conducting marine and maritime research can be very expensive and highly risky: the area of ocean and seas (350 million km^2), the harsh environment, such as water depth, temperature, corrosion and biofouling, and the need for appropriate technologies increase the cost associated with marine research projects.

Therefore, the need for European-level marine R&I cooperation is crucial:

- EU-level R&I investments in the Blue Economy bring many countries, organisations and the private sector together to cooperate. Current and future societal challenges to be tackled include, among others, climate change, feeding a growing population, and preserving marine biodiversity. These cooperative activities also encourage the sharing of data and infrastructures, including research vessels, satellites and observation systems. They also attract the brightest minds and highly skilled people to work together for joint purposes;
- EU R&I funding provides opportunities to test, share risks and costs, demonstrate innovative marine technologies, new business concepts (e.g. the multi-use offshore platforms) and contributes to the technological leadership of some Blue Economy sectors (e.g. marine renewable energies);
- EU R&I funding is crucial for supporting participation of European research organisations involved in international marine and maritime cooperation; it supports and enables European participants to make use of internationally shared resources, infrastructures and knowledge and provides excellent opportunities for training the next generation of blue researchers and entrepreneurs as well as a blue workforce;
- Last, but not least, EU-funded marine and maritime R&I projects often have a strong social innovation element, as project results tackle environmental concerns, for example, and therefore suggest new behaviour models for society (e.g. awareness-raising on marine litter, or choosing sustainably harvested and farmed fish and seafood, etc.).

2. R&I ACHIEVEMENTS

This section provides examples of EU R&I projects which have contributed to addressing the policy challenges described in the first chapter of this report. They are directly related to the EU CFP, the EU MSFD, the EU Atlantic Strategy and its associated Action Plan, and the wider EU Integrated Maritime Policy.

Several EU-funded projects have provided results for one of the key challenges of the EU CFP – estimating the MSY (maximum sustainable yield). For example, The MyFish project developed decision support tables for the correct estimation of MSY, while respecting the ecological, economic and social sustainability.

The analysis developed in the ECOKNOWS project can be used to calculate fish mortality with greater accuracy than standard methods, and to inform stock assessment of another stock or species. In addition, information from the FACTS project was used to estimate the total allowable catch for herring and sprat in the Baltic, and the maximum sustainable fishing mortality for cod, herring, sprat and other species.

Several other projects addressed the ecosystem-based approach in fisheries management. Specifically, MEFEPO provided a synthesis and review of progress towards this approach while DeepFishMan developed a comprehensive framework for the evaluation of management plans for deep-water fisheries, including ecosystem and socio-economic criteria.

The MADE project developed a good practice guide for EU vessels fishing in the tropical open seas. Also, building on the responsive fisheries management system developed by EcoFishMan, fishers, national authorities and researchers in Algarve/Portugal worked to identify commonly agreed measures that can feed into a management plan for small-scale octopus fisheries.

The interaction between aquaculture and the marine environment and the resulting competition for space has been addressed in the COEXIST project. Similarly, PERSEUS helped to foster and strengthen cooperation and paved the way to advance the work with international partners in the Mediterranean, within the BLUEMED initiative, and also in the Black Sea. In addition, DEVOTES provided recommendations for implementation of the EU MSFD all over Europe for the descriptors related to biodiversity; and STAGES reviewed the existing knowledge on all 11 descriptors, identified knowledge gaps and proposed a roadmap for the science-policy interface.

Several infrastructure projects contributed to improving ocean observations, such as:

- EMSO, a seafloor laboratory;
- EuroARGO, the European part of the global ARGO floats infrastructure;
- SeaDataNet, a standardised system for managing data sets collected by oceanographic fleets and automatic observations;
- EuroFleets2 which is developing services and providing access to modern research vessels and equipment.

In addition, climate-related marine research has been addressed by several projects..MEDSEA, VECTORS and MEECE covered issues such as the effects of climate change on marine ecosystems and human activities in the Mediterranean Sea, the Atlantic Ocean, the Baltic Sea and the Black Sea.

All of these projects also have directly contributed to the UN Consultative Process on Oceans and the Law of the Sea, while most of them not only contribute to policy implementation but also have a direct impact on the environment.

3. IMPACTS FOR SOCIETY AND INDUSTRY

EU-funded marine and maritime research, technological development and innovation projects, as well as better ocean observations have led to many innovations in policies and technologies. These address a number of societal challenges, such as climate change and its impact, food security, and the exploitation of ecosystem and mineral resources.

Results of EU-funded projects have brought concrete benefits for EU citizens, ranging from better forecasting of sea conditions and weather, mitigation of climate change impact, to ensuring a sufficient and safe food supply for a growing and more demanding world population.

The ECsafeSEAFOOD project has developed new tools to assess the links between the level of contaminants in water sources and levels of environmental contaminants in seafood products. It has tested the toxicological impact of previously identified contaminants in selected seafood products. It has also assessed the influence of these contaminants on humans so as to enhance seafood risk management and spread public awareness.

Numerous projects have contributed to the sustainable development of Europe's fish farms which are heavily dependent on the availability of feed.

The ARRAINA project has helped to develop new alternative feeds tailored to meet the nutrient requirements of key target fish species, while reducing the fishmeal and fish-oil content of fish feed. For example, rainbow trout have been grown on a totally plant-based diet without any marine ingredients from first feeding through to adult without compromising growth; similarly, diets containing less than 7.5 % of marine ingredients supported rapid growth in sea bream.

The TARGETFISH project made progress with the development of existing and new prototype vaccines against viral or bacterial pathogens in key target fish species. In particular, the project has improved the vaccination of rainbow trout against enteric redmouth disease and developed prototype machines for vaccination by injection of small and flatfish.

Furthermore, the FP7 project ACCESS has addressed the Arctic Climate Change Economy and how it could affect society.

GAP2 promoted stakeholder participation in the debate on and development of research knowledge relevant to emerging policy on fisheries.

4. IMPACTS FOR POLICIES

Marine projects are contributing to and supporting relevant EU marine policies, be it the MSFD, the CFP or the Integrated Maritime Policy as well as the EU Bioeconomy Strategy or the Communication on International Ocean Governance.

For example, under the Oceans of Tomorrow initiative, the Commission explicitly published calls to support the implementation of the MSFD. In the 2012 call (10 projects were selected for an EU contribution of almost EUR 44 million), the focus was on research gaps in the definition and monitoring of the GES of EU waters to be achieved by 2020. Furthermore, projects relevant to GES and secure food supply will contribute to several of the UN Sustainable Development Goals, notably SDG 14 (targets1, 2, 4 and 7) and SDG 2 (targets 1, 2 and 4).

The International Council for the Exploration of the Sea (ICES)[38] is one of the users of the results coming from EU Framework Programme projects. Among others, ICES advises the European Commission (DG MARE and DG ENV), other international organisations (e.g. OSPAR, HELCOM) and its member countries on fisheries and aquaculture management.

For example, information from the FACTS project was used by ICES to estimate the total allowable catch for herring and sprat in the Baltic, and the maximum sustainable fishing mortality for cod, herring and sprat. Information on how much herring, Norway pout, sandeel and sprat is consumed by predatory fish species, seabirds and seals in the North Sea was integrated into models that were used by ICES to advise the Commission on total allowable catches for these species, and on reference points for GES in the North Sea.

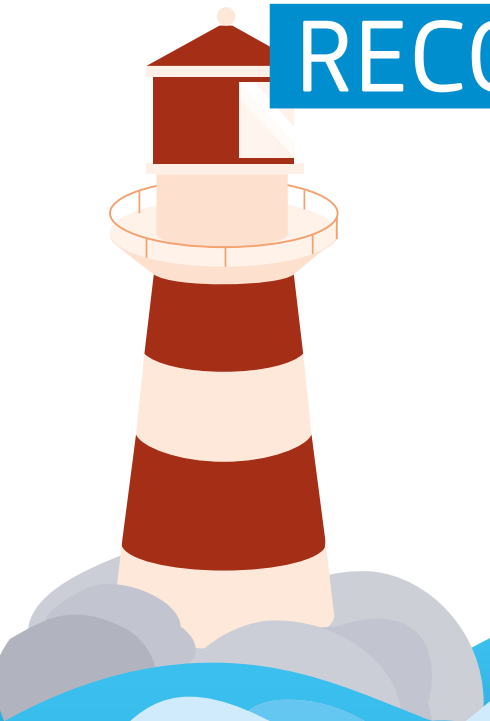
The FP7 Seas-ERA and EURO-BASIN laid the foundations for greater scientific cooperation across the Atlantic and the joint development of a solid scientific basis to sustainably exploit the Atlantic Ocean. This also contributed to strengthening the activities in the context of bilateral EU-US and EU-Canada science and technology agreements, and the process initiated by the Galway Statement (signed in 2013 between the EU, the USA and Canada). It linked science to policy and triggered a new way of effective international cooperation based on political commitment, dialogue, constant stakeholder engagement and concrete projects, which is now developing in a new partnership model for Atlantic Ocean Research Cooperation.

A number of ongoing Horizon 2020 projects are currently contributing and supporting many of the above mentioned policies. The two H2020 projects on eliminating discards – DiscardLess and MINOUW – are developing strategies to avoid unwanted catches. The elimination of discards is an important element of the EU CFP and has also been highlighted in a recent report by the EU Court of Auditors[39]. The ongoing AQUASPACE project is aiming to identify key spatial constraints on developing aquaculture. ATLANTOS project is contributing to climate-related ocean observations and the INTAROS project is extending its observations to the Arctic Ocean. Furthermore, projects CERES and ClimeFish are addressing the threats and opportunities facing the aquatic primary production sector, and are developing adaptation strategies related to climate change.

38 www.ices.dk

39 European Court of Auditors (2016) Combating Food Waste: an opportunity for the EU to improve the resource-efficiency of the food supply chain. Special report 34

POLICY RECOMMENDATIONS



This section proposes recommendations for addressing selected current policy challenges based on the results from recent R&I projects funded under EU Framework Programmes for research and innovation. With the help of the European Commission project officers, approximately 45 projects with the most relevant results have been selected and used as the basis for policy recommendations in this report. More information on the evidence and concrete results underlying the recommendations can be found on the project websites. All projects mentioned in this report are listed in the Annex II.

SEVEN KEY POLICY RECOMMENDATIONS FOR A STRONG EUROPEAN BLUE ECONOMY

↗ Unlock and treasure the Atlantic's potential from Antarctica to the Arctic through **research with international partners**.

↗ Implement **effective framework conditions** to facilitate coexisting sustainable marine and maritime activities.

↗ **Combine latest scientific developments** to ensure a substantial and sustainable food supply is unlocked while preserving the health and productivity of the oceans and seas.

↗ Introduce **genetic tracking** to ensure the origin and the safety of sea food and to track illegal fishing and correctly assess fish stocks.

↗ Ensure discoverability of, **open access** to and interoperability of data.

↗ Establish a well-integrated and performing global **ocean-observing** system with improved forecasting capabilities.

↗ Implement the **circular economy** approach and use the plastics strategy to reduce marine litter and micro-plastics throughout the life span of products.

1. UNLOCK AND TREASURE THE ATLANTIC'S POTENTIAL FROM ANTARCTICA TO THE ARCTIC THROUGH RESEARCH WITH INTERNATIONAL PARTNERS

Based on the results of the projects on the challenges and opportunities of the Atlantic Ocean as a system (notably Seas-ERA and EURO-BASIN, EMSO, Euro-ARGO and SeaDataNet, and including the ongoing Horizon 2020 projects AtlantOS, ATLAS and SponGES), the EU and its Member States should step up cooperation on marine R&I with countries bordering the South Atlantic Ocean, including in areas relating to observations, data sharing and capacity building.

This cooperation will prove beneficial in many different areas, such as driving climate and resource policy agendas, improving the forecasting of climate change and its impacts, and in helping to assess resources or forecasts for navigation and security.

2. IMPLEMENT EFFECTIVE FRAMEWORK CONDITIONS TO FACILITATE COEXISTING SUSTAINABLE MARINE AND MARITIME ACTIVITIES

Although the seas and oceans are vast, many different activities coexist in limited areas, especially in coastal zones and in the Exclusive Economic Zones. This limits certain activities, for example aquaculture or energy production, because the space is already being used for other activities. One possible solution would be to carry out several different activities in the same location.

The projects TROPOS, H2Ocean and MERMAID have shown that although this is technically feasible, regulations often hamper this. In addition, the Horizon 2020 project MARIBE has confirmed that a common regulatory framework would greatly facilitate the growth of the Blue Economy sectors. Therefore, existing regulations should be revised and innovative ways to use the marine space should be facilitated. Such an approach must include a clear definition of administrative and legal proceedings related to the implementation of offshore projects, and must be compatible across sectors and national borders. However, it should be noted that since the MSP Directive was only adopted in 2014[40], any new policy recommendations must take into account that this Directive is yet to be fully implemented and that new elements may arise shortly.

40 https://ec.europa.eu/maritimeaffairs/policy/maritime_spatial_planning_en

3. COMBINE LATEST SCIENTIFIC DEVELOPMENTS TO ENSURE A SUBSTANTIAL AND SUSTAINABLE FOOD SUPPLY IS UNLOCKED WHILE PRESERVING THE HEALTH AND PRODUCTIVITY OF THE OCEANS AND SEAS

The main issue here is to ensure enough and safe food for the generations to come, in other words "how can more food and biomass be obtained from the oceans in a way that does not deprive future generations of their benefits", as Commissioner Karmenu Vella asked in his request to the EU's Scientific Advice Mechanism (SAM)[41].

Marine protected areas (MPAs) may provide essential fish habitats, where juveniles or spawning aggregations are abundant. Following design guidelines for MPAs (MESMA), it is possible to set up an effective network of MPAs which could favour the recovery of certain fish stocks, leading to a greater biomass of those stocks outside the MPAs, too. Thus, the suggestion is that these guidelines be used to create a coherent network of MPAs (in a given region), taking into account the need to provide food for over 9 billion people in 2050.

The MyFish project demonstrated and recommended that when deciding on MSY, social and ecosystem objectives should be taken into consideration regarding biomass or economic optimisation. It is possible to take these objectives into account by using the ranges of fishing mortality that correspond to MSY rather than point values. The project concluded that it is important to develop these ranges to allow for the flexibility recommended by the CFP.

4. INTRODUCE GENETIC TRACKING TO ENSURE THE ORIGIN AND SAFETY OF SEAFOOD, TO TRACK ILLEGAL FISHING, AND TO CORRECTLY ASSESS FISH STOCKS

European citizens must have access to safe food of the highest standard, as well as consumer protection. This requires the support of a stringent traceability concept to ensure that the origin of marketed fish is known[42]. In addition, fisheries management includes banning the fishing of certain species in specific areas and seasons. This creates the need to trace the origin of fish in European markets. The genomic tools developed by the project FishPopTrace for origin assignment of the commercially highly important Atlantic cod, common sole, Atlantic herring and European hake enable individual marine fish to be traced back to the population of origin with unprecedented high levels of precision. Food and fisheries control organisations should use this genomic method for their control mission[43] to avoid illegal fishing, estimating fish stocks correctly, and also as a first step to ensure that the seafood is safe.

41 https://ec.europa.eu/research/sam/index.cfm?pg=hlg

42 Regulation (EC) 178/2002

43 Article 13 of Regulation (EU) 1224/2009 explicitly mentions genetics as a powerful means that should be taken into account to support traceability.

5. IMPLEMENT THE CIRCULAR ECONOMY APPROACH AND USE THE PLASTICS STRATEGY TO REDUCE MARINE LITTER AND MICRO-PLASTICS THROUGHOUT THE LIFESPAN OF PRODUCTS

The recommendations below mainly concern environmental policies and target different levels of authorities. For example, the Directorate-General for Environment leads environmental policy on behalf of the European Commission, but EU Member States are responsible for the implementation of the EU MSFD, the main legislative EU instrument for the protection of the marine environment, while local authorities deal with waste management.

The following recommendations are most relevant:

- Take all measures to ensure stability of climate-related ocean ecosystem services and incorporate climate change considerations in the revision of the EU MSFD to take account of changing baselines due to altered temperature regime-species redistribution and coastal hydrodynamics (DEVOTES)[44];
- Reduce marine litter across all stages of the waste hierarchy and product lifespan; more specifically, national and local authorities need to effectively reduce marine litter at source (PERSEUS, in line with the Circular Economy Package[45]) and implement a circular economy approach, also taking account of the bioeconomy strategy and the plastics strategy[46], which aims to reduce leakages of plastic to the environment;
- Combine legislation with a wide range of 'soft' mechanisms, working from global to local scales, in which organisations and individuals are encouraged to play their part, building on commitments made in the G7 Action Plan[47] to combat marine litter (MARLISCO);
- Member States and regions should implement the best-ranked measures and practices per region in terms of (potential) effectiveness and per litter item to target the main drivers, sources and impacts of the most abundant marine litter in each of the four EU seas (CleanSea).

Furthermore, a number of policy recommendations for better implementation of the EU MSFD have been made by several FP7-funded projects, such as:

- Define, with the help of scientists, MSFD terminology and global agreements, and clarify in particular the terminology used in the indicative list of characteristics (habitat types and biological features), pressures and impacts (Annex III of the EU MSFD) (CleanSea);
- Address legal and political barriers to achieving Good Environmental Status (MARLISCO);
- Intervene in the current product–to-waste cycles 'design and production' and 'use and consumption' across all regional seas (CleanSea);
- Member States should undertake a rigorous risk assessment and establish a risk management framework linked to marine management, for example by using the Driver-Pressures-State-Impact-Response (DPSIR) conceptual framework which provides an accepted framework for addressing complex issues (DEVOTES).

44 The evidence base can be traced back to the project references given in parenthesis.
45 http://ec.europa.eu/environment/circular-economy/index_en.ht
46 http://ec.europa.eu/environment/waste/plastic_waste.htm
47 https://www.bundesregierung.de/Content/EN/_Anlagen/G7/2015-06-08-g7-abschluss-annex-eng_en.pdf?__blob=publicationFile&v=2

6. ESTABLISH A WELL-INTEGRATED AND PERFORMING GLOBAL OCEAN-OBSERVING SYSTEM WITH IMPROVED FORECASTING CAPABILITIES

Based on the work of the FP7 projects PERSEUS and GEOWOW and the H2020 project AtlantOS, it is evident that cooperation on ocean observations, data sharing and modelling and forecasting tools should be expanded along the lines of the G7 S&T Ministerial Tsukuba Communiqué[48], notably to support SDG 14 ("Conserve and sustainably use the oceans, seas and marine resources"), and implementation of the Communication on International Ocean Governance[49] and conventions (for example, on biodiversity and climate change[50]).

Where appropriate, regional and national authorities should ensure that their observation systems are integrated globally and can be coordinated with each other, that sustainable funding is available, and that data are shared and made interoperable (open access policy).

7. ENSURE DISCOVERABILITY[51] OF, OPEN ACCESS TO AND INTEROPERABILITY OF DATA COLLECTED

Fisheries management, maritime spatial planning, mitigation of stressors and the use of both new and old resources (for example, different trophic levels, marine energy or mineral resources) must be based on the best available scientific advice. This requires the availability of harmonised, reliable and accurate biological, environmental, technical and socio-economic data sets. Many projects have shown that this data is not generally available to scientists.

Although a lot of effort has gone into data sharing and data compatibility over the last 20 years (notably by the Intergovernmental Oceanographic Commission[52] and by a number of EU Framework Programme-supported actions, such as EDMED, iMarine and SeaDataNet, or the open data pilot and open data policy, and EMODnet[53]) access to data can still be a challenge.

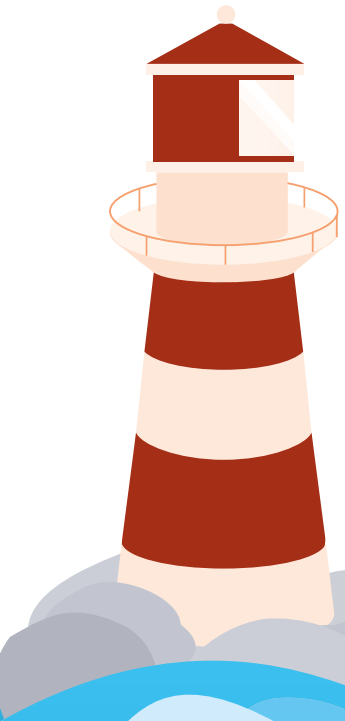
In 2017, EMODnet has confirmed that much data remains hidden, is poorly organised and is beyond the reach of researchers or engineers. Metadata, such as ownership or measurement date information, are often missing.

The difficulty in accessing fisheries data is particularly surprising given that the EU spends EUR 70 million a year supporting their collection. All marine data, including fisheries data that are not commercially sensitive, should be fully documented, readily available and interoperable. This would enable a greater use of knowledge for scientific advice and enhance the accuracy of forecasting, thereby saving huge sums of money for industry and the public and private sectors. New observation systems or essential ocean variables should include a data standard and a data-sharing agreement.

Therefore, Member States should also pave the way for all data, including fisheries data, to be integrated into common open structures such as the recently launched European Open Science Cloud which will provide the scientific community with a 'blue dimension' via a virtual environment to store, share and reuse their data across disciplines and borders.

48 http://www8.cao.go.jp/cstp/english/others/communique_en.html
49 https://ec.europa.eu/maritimeaffairs/sites/maritimeaffairs/files/join-2016-49_en.pdf
50 http://unfccc.int/paris_agreement/items/9444.php
51 The quality of being able to be discovered or found.
52 http://ioc-unesco.org
53 http://www.emodnet.eu/

ANNEXES



ANNEX I RECOMMENDATIONS FOR FUTURE R&I PROGRAMMING

This Annex provides recommendations for addressing the policy challenges of marine research for future R&I programming and funding activities. The recommendations are targeted at those developing the future EU Framework Programme for Research and Innovation, and to national R&I policymakers and funders.

European R&I have all the potential and capacity to lead on the ocean, the new economic frontier. Our oceans, seas and coasts are an integral part of Europe's identity and culture, with 23 of the 28 Member States having a coast, and two-thirds of European frontiers being bound by the sea. The EU is a global maritime power with the world's largest maritime territory, with an Exclusive Economic Zone extending over 20 million km^2.

Sustainability is a European brand, the EU is a global leader in sustainability[54], including for the Sustainable Development Agenda 2030 and the Sustainable Developments Goals, in particular SDG 14 and its targets (to "conserve and sustainably use the oceans, seas and marine resources").

Responsible science and innovation are critical to better monitoring and understanding, protecting and harnessing our oceans and seas, and creating sustainable value from traditional and new value chains and sectors.

EU-led excellent science and cutting-edge innovation are essential for healthy and productive oceans and the rise of the sustainable Blue Economy worldwide. It is therefore no surprise that in 2016, the strategic foresight report for the 2018-2019 cycle of Horizon 2020 ranked oceans, 'the inner space', among the highest R&I priority themes, next to the 'outer space'.

The EU must continue and increase its efforts on marine and maritime research and innovation in its future R&I programming in order to respond to the challenges identified in this report, to build a strong Blue Economy, to support the EU's international commitments and to lead on the oceans.

RESEARCH AND INNOVATION WILL NOTABLY HAVE TO ADDRESS

In the short-term: create new marine-based products, services and entire value chains based on co-creation and shared risks which, among others, **contribute to the upcoming revision of the EU Bioeconomy Strategy and support Food 2030: Research and Innovation for Food and Nutrition Security**.

In the mid-term: sustainably manage and exploit marine and coastal environments and resources, including by strengthening their resilience to man-made and natural stressors such as pollution and climate change, and **contribute to a series of UN SDGs (14, 2, 12, 13, etc.)**.

In the long-term: build a stronger Blue Economy at global level based on **robust regional and international marine partnerships, and support international ocean governance under the leadership of the EU**.

In particular, future R&I programming should include calls for further developing and upscaling marine and maritime technologies (for example, large-scale offshore demonstrators), foster market access and support the co-creation of new aquatic bio-based value chains.

54 Report by the European Political Strategy Centre, 2017.

Based on the above-mentioned, the following recommendations are put forward:

INTERNATIONAL COOPERATION ON THE ATLANTIC OCEAN

- A stronger alignment at research programming level on the two shores of the Atlantic Ocean as a whole, including the polar regions, should be further pursued, in particular among the EU Member States;
- Observations of important ocean parameters ("Essential Ocean Variables"), data and ship-time sharing and full access to existing infrastructures together with ecosystem research and high-resolution mapping should be further developed and promoted, both in the North and the South Atlantic, including the polar regions.

Both activities could lead to the creation of a truly connected Atlantic Ocean community and become a model for global marine research cooperation and innovation partnerships.

SUSTAINABLE AND SAFE MARINE FOOD PRODUCTION

- Promote research on the integration of biological ocean and fisheries modelling (full ecosystem approach) to estimate MSY (including for mixed fisheries) for management purposes. This should include, to the extent possible, all relevant environmental and anthropogenic factors affecting the dynamics of marine biological resources;
- Improve and promote open access to data, ensuring that they are readily available, interoperable, fully documented and ready for use, notably data relevant to fisheries;
- Promote R&I related to alternative aquatic protein sources.

HEALTHY MARINE AND COASTAL ENVIRONMENTS

- Support the implementation of the Paris Agreement (COP21) by promoting research into blue carbon (Australia's initiative on blue carbon);
- Promote research to develop a policy tool for all instruments in the freshwater and marine fields with multiple policy applications. This would be the beginning of a long-term commitment, and ecosystem modelling science should be actively developed to support it;
- In support of the EU MSFD, promote more research, demonstration and innovation projects to protect coastal waters from toxins, litter, nutrients, antibiotics, etc. coming from land;
- Promote research on substituting the use of micro-plastics intentionally added in products (which can give EU industry a competitive edge in the development of substitutes/new products);
- Promote the development of standards/products/materials with a reduced release of plastics and micro-plastics during their life cycle (e.g. car tyres, biodegradable materials);
- Promote research on the stability of climate-related ocean ecosystem services which are vulnerable to pressures from climate change and acidification as well as from other pressures (ranging from eutrophication to fishing).

DISSEMINATION OF POLICY-RELEVANT RESULTS

- A mechanism should be set up to effectively (and actively) transfer policy-relevant results from Horizon 2020 and its successor programme as well as from nationally funded R&I projects to, for example, the fisheries scientific advice bodies, national and local policymakers and policy developers. The consortia must be involved in these activities before the projects are finished. This should be complemented by a platform that systematically collects the results of the funded projects, and allows policymakers to access information on policy-relevant results as soon as they are reported by the projects.
- Document and systematically inform other European Commission services (MARE, GROW, HOME, ENV, etc.), the European Parliament, governmental representatives, academia, and public and private stakeholders about the projects' technical/scientific or market-related outputs and recommendations, for example addressing specific technical problems such as diseases or feed formulation, maritime security, and identifying where more research, support for market uptake or investment is needed.

ANNEX II LIST OF PROJECTS MENTIONED

Information of the project, and the link to its website can be obtained by entering the project number in the CORDIS project search at: http://cordis.europa.eu/projects/home_en.html

FP	Project number	Project name
FP7	265863	ACCESS
H2020	633476	AquaSpace
FP7	288925	ARRAINA
H2020	633211	AtlantOS
H2020	678760	ATLAS
H2020	678193	CERES
FP7	308370	CleanSea
H2020	677039	ClimeFish
FP7	245178	COEXIST
FP7	227390	DeepFishMan
FP7	308392	DEVOTES
H2020	633680	DiscardLess
FP7	265401	EcoFishMan
FP7	244706	ECOKNOWS
FP7	311820	ECsafeSEAFOOD
FP7	211816	EMSO
FP7	312762	EUROFLEETS 2
FP7	211597	EURO-ARGO
FP7	264933	EURO-BASIN
FP7	244966	FACTS
FP7	212399	FishPopTrace
FP7	266544	GAP2
FP7	282915	GEOWOW
FP7	288145	H2OCEAN
FP7	283644	iMarine
H2020	727890	INTAROS
FP7	210496	MADE
FP7	652629	MARIBE
FP7	289042	MARLISCO
FP7	265103	MedSeA
FP7	212085	MEECE
FP7	212881	MEFEPO

FP	Project number	Project name
FP7	288710	MERMAID
FP7	226661	MESMA
H2020	634495	MINOUW
FP7	289257	MyFish
FP7	287600	PERSEUS
H2020	652643	ResponSEAble
H2020	652644	Sea Change
FP7	283607	SeaDataNet
FP7	249552	SEAS-ERA
H2020	679849	SponGES
FP7	308473	STAGES
FP7	311993	TargetFish
FP7	288192	TROPOS
FP7	266445	VECTORS

Full list of projects included in the selected project portfolio analysed in the this report can be downloaded at: http://ec.europa.eu/research/p4p

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