New BlueBio ERA-NET COFUND
on the Blue Bio Bioeconomy

Project start: 01 December 2018   **Project duration: 66 months**

MS 37

Report on the Collection and analysis of information

on research projects - 2

(WP 7)

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Executive Summary

The present report refers on the results of a series of exploratory analyses aimed to describe the information contained in the BlueBio research projects' database.

The BlueBio database is built on the basis of the COFASP research projects' database implemented with the inclusion of the research projects dealing on Marine Biotechnology and the projects funded in the time period 2014-2022. Therefore, in the overall, the database spans a total time period of 19 years (2003-2022).

The migration to BlueBio Database has needed a harmonization of the projects' categorization in agreement with the inclusion of "Marine Biotechnology" as a further main category. This has required: 1. an overall and careful review of all projects included in the COFASP database; the review has also allowed to check the information previously collected and to find out additional information which had been missed as well as to better harmonize funding sources and programmes; 2. an integration of the keywords list; and 3. a development of the Search Area Interface of the online database.

This report represents a follow-up to the report produced in July 2021 (MS 7.21), which contained an analysis of the projects funded up until 2019. Since then, the database has been further enhanced by adding projects related to the years 2020-2022, as well as finalizing the harmonization of the data to achieve a more detailed and accurate allocation of projects.

The analysis has been performed on a total of 3761 projects which were already on-going or started from 2003 to 2022. The funding information is available for 2837 projects, corresponding to 75/% of the total. The projects have been analyzed in terms of research categories, marine areas and countries involved, funding programmes and funding budget. They have been divided into 15 research categories that include 4 main categories, and 11 cross-cutting categories, resulting from the combination of the main ones. The assignment of projects to the various categories has been based on the keywords associated with each of them.

Considering the starting date of the projects contained in the database, it appears that most of them were initiated in the period 2004-2013. Aquaculture, Fisheries, and Aquaculture & Marine Biotechnology are the only categories to be consistently addressed without any interruption. However, while projects dealing with Aquaculture and Fisheries were already running before 2000, those related to Aquaculture & Marine Biotechnology started in 2001.

Fisheries is the most investigated research field, accounting for 35% of the overall projects contained in the database. It is followed by Aquaculture (23%) and Aquaculture & Marine Biotechnology (12%). All the other categories appear poorly represented, comprising at most 6% (Seafood Processing) of the projects' universe of the database.

The ratio in number of projects between each main category and its overall related categories (main category + cross-cuttings) is lower for Marine Biotechnology in respect to the others,

highlighting that this thematic is usually investigated in association with other research fields rather than alone.

From a financial point of view, the category Fisheries, which includes the highest number of projects, has also the highest budget, corresponding to 23% of the overall budget over the entire period. It is followed by Aquaculture (23%), Aquaculture & Fisheries (14%), and Aquaculture & Marine Biotechnology (13%), while none of the remaining categories exceed 9%.

In the overall, it appears that 63% of the projects with available budget information have been implemented with national funds, 22% with European funds, and 13% have been co-financed by European and national funds. The number of projects implemented with financial contributions from consortia of countries, international organizations, agencies, or programs not relying on EU funds has been negligible.

In terms of funding amount, instead, the overall budget of the projects supported by EU funds through FP5-7, H2020, LIFE, COST, and Interreg programmes, as well as other instruments directly managed by the EC, corresponds to 52% of the total amount of financial resources for the entire period. The budget of those projects implemented within national programmes accounts for 36%, and the budget of projects co-financed by European and national funds (e.g., BONUS programme, national programmes supported by ESIF) amounts to 11%.

On average, the projects having a budget > 500k € represent around 90% of the overall budget and 50% of the total number of projects within each research category.

Norway is the country dealing with the highest number of projects (51%) followed by Italy, Spain, and the United Kingdom, which however participated in a far lower number of projects.

Norway has also funded 59% of the overall projects supported by national programmes, corresponding to 40% of the total number of projects included in the Database. Moreover, subdividing the projects by country, funding source and funding category (< 100k €, 100-500k €, > 500k €) it results that the Norwegian national projects with a budget > 500k € overcome the highest number of projects in all combinations by country/funding source/funding category.

Italy, the United Kingdom, Spain and Norway have coordinated a similar number of projects supported by European funds and having a budget higher than 500k €.

The analysis of abstracts and keywords associated with the projects in the different research categories has allowed for the identification of the most relevant research gaps and the evaluation of the extent to which the research priorities established for 2050 by the Foresight exercise implemented under BlueBio Cofund have been addressed up to now. This demonstrates that having an overview of already funded projects can be helpful for funders and researchers to avoid duplications and better address the R&I gaps and needs.

The Bluebio database is publicly available for consultation through a dedicated WebGIS application accessible on the BlueBio website (https://bluebioeconomy.eu/) and through the publication on Figshare repository with an accompanying open-access datapaper.

In order to further increase the visibility of the database and ensure its longevity, it has been incorporated into the WaveLinks platform developed by the EU Mission 'Restore Our Ocean and Waters by 2030' CSA PREP4BLUE, one of the five missions launched by the European Commission as a major contributor to the European Green Deal, the UN Decade of Ocean Science, and the Sustainable Development Goals.

Keywords

Database, Research, Projects, Aquaculture, Fisheries, Marine Biotechnology, Seafood Processing, Funding

1.   Introduction

The BlueBio ERA-NET Cofund is implemented by a consortium of European research and innovation programme owners and managers who wish to support an ERA-NET Cofund action to unlock the potential of aquatic bioresources in order to develop a sustainable bioeconomy.

BlueBio Cofund pursues the goals of the Blue Bioeconomy topic BG-02-2018 in the Horizon 2020 Work Programme 2018-2020 and it aims at paving the way for a sustainable and competitive Blue Bioeconomy in Europe through targeted research, and development and innovation activities. The goal is to identify new and improve existing ways of bringing bio-based products and services to the market and of creating value in the Blue Bioeconomy. The main objective of BlueBio is to establish a coordinated R&D funding scheme that will strengthen Europe's position in this complex economic field in a global market.

BlueBio Cofund consists of 30 partners from 17 countries who implement a co-funded call and three additional calls focusing on blue knowledge and technological developments to respond to needs and gaps for R&I in order to:
- create critical mass along the value chains from biomass to products, services and markets;
- apply the '3R principle' of Reducing, Reusing and Recycling to achieve a circular economy;
- explore innovative, sustainable and climate-friendly utilization of aquatic biomass at different trophic levels, as well as sustainable harvesting, and novel aquaculture production systems targeting a range of markets, products (food, feed, chemistry, nutraceuticals, cosmetics, etc.) in existing or new markets;
- target new genetic resources and biomolecules using biotechnology to utilize close to 100 % of the available biomass in multistream biorefineries.

In the BlueBio partnership, the EU acts as a policy driver, giving direction to the strategic priorities and EU/MS commitments BlueBio underpins regional and international policy actions and initiatives. EU funding enabled participation of small and/or new countries across the regional basins of Europe, triggering cross-fertilization, capacity and infrastructure sharing and enhances growth across the whole of the EU.

The BlueBio Cofund addresses gaps such as:
- developing innovative uses of underutilized and waste material from fisheries and aquaculture to achieve zero waste;
- using biotechnology and ICT to develop smart, efficient, traceable food systems and create synergies between aquaculture and fisheries (genetic assessment and digitalization);
- unlock the potential of microbiomes to support growth in aquaculture, fisheries, and food processing and biotechnology; apply the latest developments in ICT (IoT, machine learning, big data) to the Blue Bioeconomy;
- creating predictive tools to improve the identification and targeting of biodiversity "hot-spots" in the oceans (omics based technologies);

- exploring synergies with land-based production in areas such as food and feed production and processing, biorefining, bioenergy, biomaterials, chemicals and nutrients and maximize the use of aquatic bioresources in terrestrial value chains;
- improving aquaculture and wild harvesting of stocks by support for the creation of innovative feeds, improved brood stocks, by introducing new species, defining stock baselines, and assessing stocks and by encouraging the adoption of novel production technologies.

These themes and gaps are also reflected in the gaps identified in the SRIAs/Roadmaps of the previous ERA-NETs COFASP, and MBT, as well as those highlighted by the EU Standing Committee on Agricultural Research (SCAR), JPI Oceans, the Blue Bioeconomy Strategy, the Sustainable Blue Economy Partnership (SBEP), and the SRIA delivered by BlueBio (D 7.1).

In particular, Work Package 7 of BlueBio Cofund, "Related Activities," aimed to support cross-cutting areas by implementing activities that can better address the impact of research and valorization from various actors in the Blue Bioeconomy sector.

Specifically, Task 7.1, "Mapping of R&I projects funded by national, international, and EU financial resources - analysis of gaps," aims to continue, integrate, and update the research projects database created within the COFASP ERA-NET. This is done to provide an overview of previous and ongoing projects dealing with research and innovation in Fisheries, Aquaculture, Seafood Processing, and Marine Biotechnology, funded under national, regional, and international programs. The final goals of the database were:
- address the lack of data on previous and on-going projects at national level;
- take the stock of available knowledge to address the implementation of related activities as well as of additional calls;
- identify potential synergies among actors and networks for follow-up projects as well as synergies among projects financed under the BlueBio joint call;
- to identify gaps and further needs in research that could feed additional calls.

To these, the task foresees:
- to review the COFASP database according to the inclusion of the Marine Biotechnology category, besides Fisheries, Aquaculture and Seafood Processing which were the three main research categories targeted by the COFASP ERA-NET;
- to update the database with projects funded from 2014 (the COFASP database covered the time period 2003-2013) to 2022 through data collection by main consulting national and EU databases and platforms on innovation: this requires a strict cooperation of all the BlueBio partners especially for the provision of projects funded at national level;
- to implement, both in terms of search interface and output of information, the user-friendly online web application associated with the online projects' database;
- to perform a mid-term (Month 23) and a final (Month 54) analysis to identify research gaps and new research drivers. The mid-term analysis is aimed to provide inputs for the identification of topics for the 2nd BluBio Additional call and related activities, while

the results of the final analysis will be used, together with the outputs of other related activities, to draft the SRIA recommendations (Task 7.5, D 7.1).

The first three actions have started just after the beginning of BlueBio Cofund. The result is a collection of research projects dealing on Fisheries, Aquaculture, Seafood Processing and Marine Biotechnology and funded at European level and at national level by the Countries previously involved in the COFASP ERA-NET and currently in BlueBio Cofund. Although it does not have the ambition to include the entire universe of funded projects, it surely represents a unique collection gathering information from international and national repositories, archives of research institutes as well as from individual researchers and allows to get a picture of the main research topics targeted by research in the EU and funding resources devoted to them.

This report is a follow-up to the report produced in July 2021 (MS 7.21), which contained an analysis of projects funded up until 2019. The reference time period for the present report is 2003-2022.

The Bluebio database is publicly available for consultation through a dedicated WebGIS application accessible on the BlueBio website[1] and through the publication on Figshare repository[2] with an accompanying open-access datapaper[3]. (https://bluebioeconomy.eu/the-bluebio-projects-online-database/). Furthermore, the data have been integrated into the incorporated in the WaveLinks platform developed by the EU Mission "Restore our ocean and waters by 2030" CSA PREP4BLUE, one of the five missions launched by the European Commission as a major contributor to the European Green Deal, the UN Decade of Ocean Science and the Sustainable Development Goals. This will help increase the visibility of the database and ensure its longevity.

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[1] https://bluebioeconomy.eu/

[2] https://figshare.com/articles/dataset/BlueBio_database/21507837/1

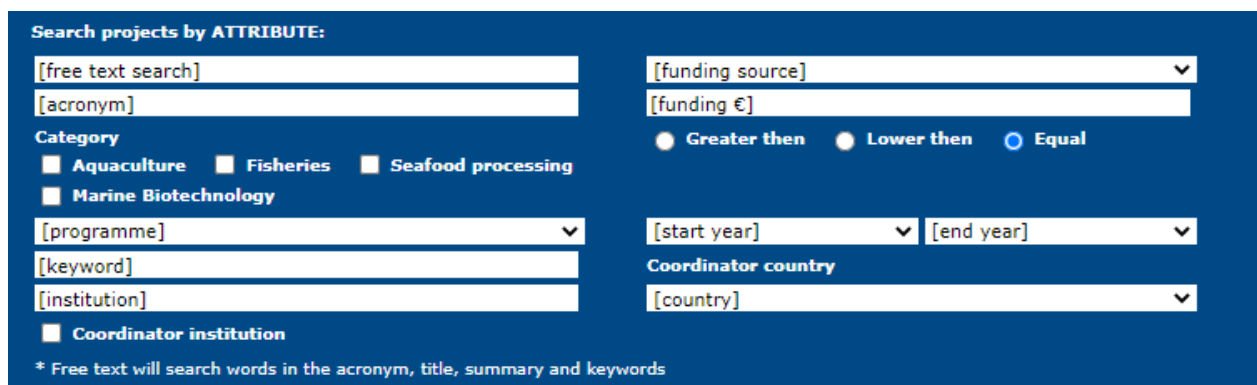[3] https://www.nature.com/articles/s41597-023-02078-2

2. Methodology

2.1. Migration from COFASP Database to BlueBio Database

Based on the project requirements, COFASP database targeted all public funded research projects dealing with Fisheries, Aquaculture and Seafood Processing. The projects which also included issues related to Marine Biotechnology had been categorised within one or more (cross-cutting projects) of the three above mentioned categories.

The migration to BlueBio database has needed a harmonization of the projects' categorization in agreement with the inclusion of "Marine Biotechnology" as a further main category. This has required:

1. an overall and careful review of all projects included in the COFASP database; the review has also allowed to check the information previously collected and to find out additional information which had been missed as well as to better harmonize funding sources and programmes;
2. an integration of the keywords list (Annex I).
3. a development of the Search Area Interface of the online database: a checkbox with the new available category was added (Figure 1), allowing new and cumulative searches to query by attribute the BlueBio database.

Fig. 1 - Search by attribute area interface of the released BlueBio Online database with the new Category "Marine Biotechnology".

The header and sidebar of the different pages (Homepage, the Results Page and the Individual Result page) have been updated with the BlueBio logo and the new contents, while the footer has been revised with new partners and their logos. The new partners have been also used to thematize the country layer that allows the user to spatially query the Bluebio database clicking on the map (Figure 2).
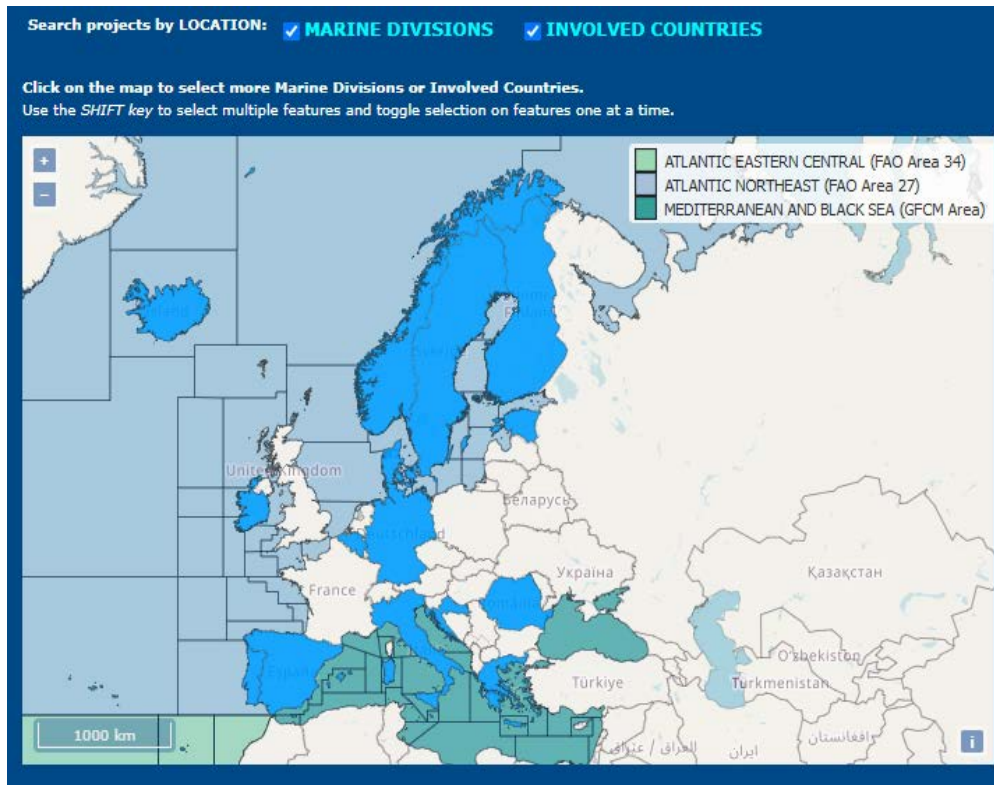
Fig. 2 - Search by location by 2 independent layers: Marine divisions and involved countries. Marine divisions are categorized by Area (see Annex II), while BlueBio countries are filled by blue.

2.2. Data harmonization

2.2.1. Research category

Based on the action fields of the BlueBio Cofund, four main research categories have been considered: Fisheries, Aquaculture, Seafood Processing, and Marine Biotechnology.

The combination of two or more categories (e.g., Aquaculture & Seafood Processing; Aquaculture & Fisheries; Aquaculture, Fisheries & Marine Biotechnology, etc.) has also been taken into account to characterize cross-cutting research projects.

The projects have been allocated to the above categories based on their specific issues, as reported in Table 1.

Table 1 - List of Categories used for projects' categorization.

Main Categories	Aquaculture
	Fisheries
	Seafood Processing
	Marine Biotechnology
2-level Cross-cutting categories	Aquaculture & Fisheries
	Aquaculture & Marine Biotechnology
	Aquaculture & Seafood Processing
	Fisheries & Marine Biotechnology
	Fisheries & Seafood Processing
	Marine Biotechnology & Seafood Processing
3-level Cross-cutting categories	Aquaculture, Fisheries & Marine Biotechnology
	Aquaculture, Fisheries & Seafood Processing
	Aquaculture, Marine Biotechnology & Seafood Processing
	Fisheries, Marine Biotechnology & Seafood Processing
4-level Cross-cutting categories	Aquaculture, Fisheries, Marine Biotechnology & Seafood Processing

2.2.2. Keywords

To allow better characterization of the projects and easier searching in the database, each project has been associated with keywords from a predefined list (Annex I). The list of keywords used for the COFASP database served as a starting point and was then expanded with additional keywords related to Aquaculture, Fisheries, and Seafood Processing, as well as new keywords linked to Marine Biotechnology (302 keywords in total).

2.2.3. Source and funding programme

The projects have been categorized based on the related supporting programs and funding instruments. According to this categorization, each project has been assigned to one of the following funding source categories: National, European, European/National, or Other.

Below is a detailed description of the labeling process.

2.2.3.1 National

The category "National" includes those projects exclusively funded within national programmes or instruments of funding, for instance:

• PNR - Italian National Research Programme, the participatory and dynamic multiannual framework programming tool of the Ministry of Education, University and Research which has supported several research projects such as the national Flagship Project "RITMARE", a pluri-annual, multidisciplinary national project on scientific and technological research dedicated to the sea and to all its challenges;

• PRIN - Projects of Relevant National Interest, a programme funded by the Italian Ministry of Education, University and Research for financing public, multidisciplinary research projects such as "CAULERFISH", "BRITEs", "EMERGE" or "Assessment of quality and safety of Mediterranean seafoods by *omics* sciences";

• the "PROBIO", "BlueMarine³.com", "SYMAPA" funded by the Blauwe Cluster, a Flemish cluster aimed at developing and promoting economic activities linked to the sea by supporting cross-sector partnerships and cooperation of private companies with knowledge centres and government institutions;

• the Ireland National Development Plan (NDP) and its Marine Research Programmes which, through the Irish Marine Institute, provided competitive R&D funding to SMEs and the marine research community, or its Environmental Research Programmes, which, through the Environmental Protection Agency and the Science, Technology, Research and Innovation for the Environment (STRIVE) Programme[4], supported environmental research to provide information, data and evidence to inform and support development and implementation of national and international environmental policy;

• the funding programmes managed by the German Federal Ministry of Food and Agriculture such as the BÖLN - Federal Organic Farming Scheme and other forms of sustainable agriculture, the Federal Scheme for lifestock husbandry, the Research Cooperation for Global Food security which supported, respectively, the projects "Measures against virus diseases in organic aquaculture", "AbiAqua" and "NatKa", "Tank enrichment for juvenile salmonids to produce powerful and robust seedlings for aquaculture in Germany", "Ich liebe Fisch";

• the Regional Programmes and National Activities of GLOBEC, the study of Global Ocean Ecosystem Dynamics initiated in 1990 by the Scientific Committee on Oceanic Research and the Intergovernmental Oceanographic Commission of UNESCO and incorporated into the

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[4] The STRIVE Programme is funded through a number of sources, primarily:
• the Environmental Research sub-programme of the NDP 2007-2013 (the Environment Fund)
• the Inter Departmental Committee for the Strategy for Science, Technology and Innovation (IDCSSTI);
• co-funding with other state agencies and funding groups; and
• EPA core funding
https://ec.europa.eu/invest-in-research/pdf/download_en/ireland.pdf.

IGBP Core Element structure in 1995[5], such as the projects "Investigations on the distribution and migration of sprat" and "Trophic interactions between zooplankton and fish under the influence of physical processes in the Baltic and North Sea", carried out within GLOBEC Germany, which represented part of the national German contribution to the International Geosphere-Biosphere Programme.

2.2.3.2 European

The category "European" includes projects exclusively funded within European programs or funding instruments, such as:

• the EU Framework Programmes for Research and Technological Development (FP4 – 7) and the EU Framework Programme for Research and Innovation (FP8/HORIZON 2020) which represent the main financial tools created by the European Commission to support and foster research in the European Research Area. For the scope of this analysis, it has been considered the 5th FP (1998-2002), the 6th FP (2002-2006), the 7th FP (2007-2013) and Horizon 2020 (2014-2020);

• COST Programme - the European Cooperation in Science and Technology (COST) is a funding organisation for the creation of research networks, called COST Actions, which receives EU funding and offers an open space for collaboration among scientists across Europe (and beyond) and thereby give impetus to research advancements and innovation[6];

• INTERREG Programmes – European Territorial Cooperation (ETC), better known as Interreg, is one of the two goals of cohesion policy and provides a framework for the implementation of joint actions and policy exchanges between national, regional and local actors from different Member States[7]. For the scope of this analysis, all INTERREG's three strands of cooperation funded by ERDF, namely cross-border (Interreg A), transnational (Interreg B) and interregional (Interreg C), have been included in the category European as well as EU external border cooperation programmes (IPA CBC, ENPI CBC, Baltic Sea Region). Such INTERREG Programmes have been furtherly categorized by the related programming periods as follows: INTERREG III (2000-2006) - INTERREG IV (2007-2013) - INTERREG V (2014-2020);

• LIFE Programme - the LIFE programme is the EU's funding instrument for the environment and climate action. Established in 1992, it has been managed by the European Commission through its services DG Environment and DG Climate Action, and its Executive Agency for Small and Medium-sized Enterprises (EASME), till 2020, now replaced by the European

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[5]http://www.igbp.net/researchprojects/igbpcoreprojectsphaseone/globaloceanecosystemdynamics.4.950c2fa1495db7081e23a3.html

[6] https://www.cost.eu/who-we-are/about-cost/#

[7]   https://ec.europa.eu/regional_policy/en/policy/cooperation/european-territorial/#:~:text=For%202014%2D2020%20European%20territorial,investment%20for%20Growth%20and%20Job.&text=Over%20the%20years%2C%20Interreg%20has,cooperation%20between%20partners%20across%20borders.

Climate, Infrastructure and Environment Executive Agency. Since 2014, it has included two sub-programmes, one for environment and the other one for climate action;

• the ESPON 2006[8] Programme, that funded applied research projects and studies on territorial development and spatial planning in support of policy development, carried out by transnational scientific consortia (Transnational Project Groups), such as the project "Territorial impacts of European fisheries policy".

• the Twinning instrument for funding institutional cooperation between Public Administrations of EU Member States and Non-EU Countries (called beneficiary or partner Countries), such as the project "Introduction of Stock Assessment to the Fisheries Management System of Turkey" and "Technical Assistance for Introduction of Stock Assessment to the Fisheries Management System of Turkey" supported by the Instrument for Pre-accession Assistance (IPA) for the transposition, implementation and enforcement of the EU legislation (the Union acquis) in Turkey;

• specific studies or research projects directly funded by EU institutional bodies such as the project "Mitigation of incidental catches of Cetaceans in EU waters" which was funded by the European Parliament - DG IPOL;

• the Calls for Proposals and Calls for Tenders launched and managed directly by the European Commission (through DG MARE, DG Environment and the Executive Agency for Small and Medium-sized Enterprises - EASME), outside of the other programmes here listed, both funded by EMFF (i.e. the implementation of the MSFD - Marine Strategy Framework Directive) and other EC's resources.

2.2.3.3 National / European

The projects co-funded by National and European programmes or funding instruments have been labelled as "European/National". Below is a list of examples of European/National programs and projects.

• ERA-NET scheme – the ERA-NET scheme aims at developing and strengthening the coordination of national and regional research programmes. Under the ERA-NET scheme, national and regional authorities, represented by so-called 'programme owners' and/or 'programme managers', identify research programmes they wish to coordinate or open up mutually. The focus and role of ERA-NETs has varied across the Frameworks Programmes:

   o ERA-NET actions in FP6 provided support for actors implementing public research programmes ("programme owners") to coordinate their activities e.g. by developing joint activities; in particular, joint calls for transnational proposals;

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[8] https://www.espon.eu/programme/espon/objectives-espon-2006

o ERA-NET Plus actions in FP7 provided - in a limited number of cases with high European added value - additional EU financial support to top-up research funding of a single joint call for proposals between national and/or regional programmes;

o The ERA-NET Cofund under Horizon 2020 merged the former ERA-NET and ERA-NET Plus into a single instrument with the central and compulsory element of implementing one substantial call with top-up funding from the Commission. The focus of ERA-NETs was therefore shifted from the funding of networks to the top-up funding of single joint calls for transnational research and innovation in selected areas with high European added value and relevance for Horizon 2020.

The ERA-NET scheme aims at increasing the share of funding that Member States jointly dedicate to challenge-driven research and innovation agendas. In Horizon 2020 the EU contribution was limited to a maximum of 33% of the total eligible costs of the action (i.e. costs for support to or implementation of transnational projects) and the duration of the actions should not have been longer than 5 years. The EU contribution was limited to one call per grant agreement. The EC funding may be used for financing transnational research projects but also as means to cover (partially) the preparation and management of additional joint activities to be performed by the consortium aiming to increase coordination of national/regional programmes. In addition, ERA-NET Cofund allows, when justified by the research area addressed and the underlying national programmes, to target research performing organizations (RPOs) with the co-funded call for proposals being based on in-kind contributions from their institutional funding. This is accommodated within the so-called in-kind ERA-NET Cofund. In this case the beneficiaries carry out the transnational projects resulting from their call for proposals themselves and the Cofund grant reimburses the costs of trans-national projects, implemented by the beneficiaries, on the basis of Horizon 2020 rules for eligible direct and indirect costs[9]. Therefore, for the scope of this analysis, the transnational research projects as well as the preparation and management of additional joint activities, performed by the consortium, co-funded by EU contribution and ERA-NET partners (Member States) falls within the category European / National.

The projects funded within the ERA-NET scheme related to the coordination of the research programmes and fully covered by EU contribution (100% reimbursement rate) are treated as the other projects within the FP4 – 8/HORIZON 2020 and therefore labeled as European.

• Eurostars programme - the Eurostars programme supports research-performing small and medium enterprises, which develop innovative products, processes and services, to gain competitive advantage and exploit the benefits that come with international collaboration. Eurostars is a European joint programme, co-funded by the European Union and by the national budgets of 36 EUREKA Countries (an international network established in 1985 as an agreement between 18 countries to foster European competitiveness and integration and to encourage R&D cooperation. Since then, it has been expanded to include over 45 countries

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[9] https://www.era-learn.eu/partnerships-in-a-nutshell/type-of-networks/partnerships-under-horizon-2020/era-net-scheme

in Europe and beyond who share the same goals and have national funding available to organisations who apply through our programmes)[10].

• BONUS - the joint Baltic Sea research and development programme is based on the previously funded BONUS ERA-NET and ERA-NET PLUS projects and, then, managed by the BONUS EEIG - The Baltic Organisations Network for Funding Science - which coordinates the consortium of the Baltic and North Sea Coordination and Support Action (BANOS CSA). BONUS Programme was funded jointly by the national research funding institutions in the eight EU member states around the Baltic Sea (DK, EE, FI, DE, LV, LT, PL, SE) and the European Union for a total of EUR 100 million. Russia participated in BONUS through bilateral agreements.

• National Programmes supported by European Structural and Investment Funds (ESIF) - for the period 2014-20, cohesion policy was financed by the European Structural and Investment Funds (ESIF) which includes European Regional Development Fund (ERDF), European Social Fund (ESF), Cohesion Fund (CF), European Agricultural Fund for Rural Development (EAFRD), and European Maritime and Fisheries Fund (EMFF). The principles and priorities of cohesion policy are distilled through a process of consultation between the Commission and the EU Countries. At the end of this consultation process, each Member State launches specific national programmes for the implementation of the common cohesion policy, which are co-funded by an European instrument of funding[11]. Therefore, for the scope of this analysis, the projects supported by such national programmes (e.g., OP EMFF CAMPANIA 2014/2020 and OP-ERDF SICILY 2007/2013 – Italy; Call for Funding of Research and Development Projects in all Scientific Domains - Fundação para a Ciência e a Tecnologia - Portugal; National Strategic Framework for Research and Innovation of the General Secretariat for Research and Technology - Greece; Rural Development Programme Western Pomerania 2014-2020 – Germany) have been labelled as European/National.

• FAO projects - the General Fisheries Commission for the Mediterranean (FAO - GFCM) plays a critical role in fisheries governance in all marine waters of the Mediterranean and the Black Sea, having the authority to adopt binding recommendations for fisheries conservation and management and for aquaculture development. The FAO-GFCM is governed by its Contracting Parties and executes Regional Projects co-funded by Contracting Parties and the European Commission such as "MedSudMed - Assessment and Monitoring of the Fishery Resources and the Ecosystems in the Straits of Sicily" (funded by Italy and, since 2012, the European Commission)[12]; "CopeMed - Coordination to support fisheries management in the western and central Mediterranean" (funded by Spain and the European Commission)[13]; "AdriaMed - Scientific Cooperation to Support Responsible Fisheries in the Adriatic Sea"

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[10] https://ec.europa.eu/programmes/horizon2020/en/h2020-section/eurostars-programme
https://www.eurekanetwork.org/about-us/eureka-history

[11] https://ec.europa.eu/regional_policy/en/policy/what/glossary/e/esif
https://ec.europa.eu/regional_policy/index.cfm/en/policy/how/stages-step-by-step/
[12] https://www.faomedsudmed.org/
[13] http://www.faocopemed.org/html/project.html

(initially funded by Italy and, later on, the European Commission, Croatia and Slovenia)[14]; "EastMed - Scientific and Institutional Cooperation to Support Responsible Fisheries in the Eastern Mediterranean" (funded by Greece, Italy and the European Commission)[15].

• The flagship projects foreseen by the action plans of the EU Strategy for the Baltic Sea Region EUSBSR such as "BALTFIMPA - Managing Fisheries in Baltic Marine Protected Areas" and "Baltic SCOPE - Towards coherence and cross-border solutions in Baltic Maritime Spatial Plans" funded, respectively, within the EUSBSR Priority area "Preserving natural zones and biodiversity, including fisheries" and the Horizontal action "Encouraging the use of Maritime and Land-based Spatial Planning in all Member States around the Baltic Sea and develop a common approach for cross-border cooperation.

2.2.3.4 Other

The projects falling out of the previous categories such as those funded by a consortium of countries, international organizations, agencies or programmes not relying on EU funds have been labelled as "Other". Below is a list of examples:

• JPI - Joint Programming Initiatives are developed in a structured and strategic process where EU countries agree on a voluntary basis on common visions and Strategic Research Agendas (SRAs) to address major societal challenges[16]. For the scope of this analysis, the most relevant one is the Joint Programming Initiative Healthy and Productive Seas and Oceans (JPI Oceans), established in 2011 as an intergovernmental platform, open to all EU Member States and Associated Countries who invest in marine and maritime research projects such as "EPHEMARE - Ecotoxicological effects of microplastics in marine ecosystems" and "BASEMAN - Defining the baselines and standards for microplastics analyses in European waters". JPI Oceans actions are initiated by individual member countries and are therefore independent from the European Commission's framework programmes[17];

• ASCOBANS - the Agreement on the Conservation of Small Cetaceans of the Baltic and North Seas was signed in 1991 under the auspices of the Convention on Migratory Species (CMS or Bonn Convention) and entered into force in 1994. ASCOBANS is administered by the United Nations Environment Programme (UNEP), and secretariat services are provided by CMS. Since 2008, ASCOBANS Parties have enabled the Secretariat to support some research and conservation projects, such as "Protection of small cetaceans in the North and Baltic Sea" and "Development of a recovery plan for harbour porpoise (Phocoena phocoena) in the North Sea", from savings made on the previous year's budget, voluntary contributions and from a grant kindly made available by the United Nations Environment Programme[18];

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[14] https://www.faoadriamed.org/html/adriamed_project.html

[15] http://www.faoeastmed.org/html/project.html

[16] https://ec.europa.eu/programmes/horizon2020/en/h2020-section/joint-programming-initiatives

[17] http://www.jpi-oceans.eu/about

[18] https://www.ascobans.org/

• ACCOBAMS-GFCM Project on Mitigating interactions between endangered marine species and fishing activities – it is a project funded by the MAVA Foundation and coordinated by the FAO-GFCM and the Agreement on the Conservation of Cetaceans of the Black Sea, Mediterranean Sea and Contiguous Atlantic Area (ACCOBAMS), in collaboration with the Regional Activity Center for Specially Protected Areas (RAC/SPA) and funded by the MAVA Foundation[19];

• Bilateral/Multilateral Cooperation Agreements – they are international cooperation agreements involving two or more Countries as well as other national/international institutions for the implementation of collaborative research projects such as "AWA - Ecosystem Approach to the management of fisheries and the marine environment in West African waters" (trilateral German-French-African Research initiative in Sub-Saharan Africa), "Toxicity of dietary mercury to cultured fish: implications for fish health, seafood safety and the influence of dietary selenium" (bilateral cooperation between NIFES, Norway and NRIFS, Japan), "Migration ecology of fishes for improved fisheries management in South Africa" (SANCOOP - South Africa - Norway Research Co-operation on Climate, the Environment and Clean Energy), "DIAMETER - DNA Identification and Authentication of Mediterranean Fisheries Resources" (bilateral agreement CNR/CNRS-L within Joint Research Projects 2018/19), "IMPCON - IMProved quality of cultured fish for human CONsumption" and "SAFEFISH - Secondary metabolites from aquatic microorganisms and their impact on seafood and freshwater fish aquaculture" (bilateral agreement for Collaborative research São Paulo Research Foundation – FAPESP & Danish Council for Strategic Research - DCSR), "MmmmmSeafood - Consumer oriented development of new Nordic seafood product concepts for young adults and families with young children" and "SILLQUID - Can a Microwave Quick Tool Predict Quality and Origin of Herring?" (Nordic Innovation Centre).

2.2.4.   Projects' funding

In order to evaluate the amount of allocated financial resources, the overall budget of each project has been considered. When this information was not available, the project was labeled as 'funding not available'.

2.2.5.   Spatial allocation

The projects have been also categorized based on the Area(s) or Country where the research was carried out to highlight eventual differences between the European seas and/or countries. Specifically, projects' allocation has been based on the following criteria:

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[19] http://www.fao.org/gfcm/activities/technical-assistance-and-cooperation/mava-project/en/

- when the study Area and/or case studies have been clearly recognizable the project has been associated with specific marine Area/s;

- when the study Area has not indicated but the project deals on field experiments, the marine Area of the coordinator country has been used;

- if the study Area has not indicated and the project does not deal with field experiments (e.g., genetic projects only carried out in laboratory), the project has been labelled as "not associated to Marine areas".

The research Marine area has been identified following a hierarchical structure composed by 3 different levels of detail: Area; Subarea; Division. The identification of the Areas and Subareas has been based on the FAO Fishing Areas: Atlantic, Northeast (FAO Area 27); Atlantic, Eastern Central (FAO Area 34); Mediterranean and Black Sea (FAO Area 37). The FAO Fishing Divisions have been also considered for the Atlantic Northeast and Atlantic Eastern Central, whereas the FAO-GFCM Geographical subareas (GSAs) have been used for the Mediterranean Sea and Black Sea (Annex II). In the overall, the 3 major Marine areas, Atlantic Northeast, Atlantic Eastern Central, and Mediterranean and Black Sea have been divided in 18 subareas and 75 divisions (Figure 3).

The projects dealing with Aquaculture and Seafood Processing that have not been specifically carried out at sea, as well as all those projects labeled as "not associated with marine areas", have been allocated "by country", meaning the country of the project coordinator and of the other involved partners has been used.
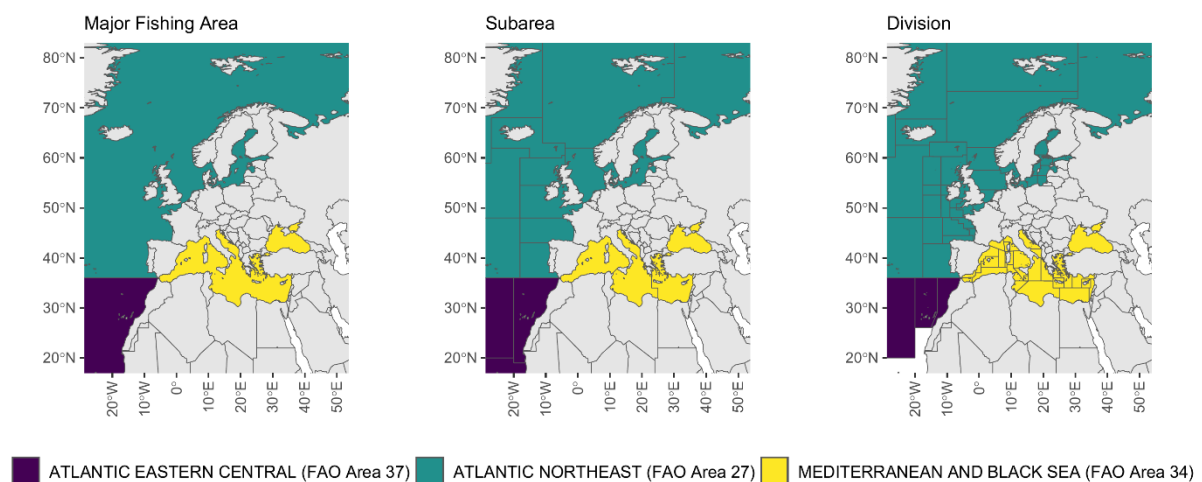

Fig. 3 – Maps with the 3 major Marine areas (left), the 18 subareas (central) and the 75 divisions (right).

2.3. Update of the Database

To further update the Database, the search has been focused on the projects that have been funded in the years 2020-2021 by European Countries and/or in the three major FAO Marine areas related to the EU (FAO Area 27 – Northeast Atlantic; FAO Area 34 - Eastern Central Atlantic; FAO Area 37 - Mediterranean and Black Sea).

At the European level, the identification of information sources has been based both on the assessment of existing Funding Programmes, considering their relevance for marine research and accessibility to standard information on funded projects, and the consultation of EU Project Official Repositories (e.g., Cordis, Keep.eu) as well as those of other Research Funding and Performing Organizations.

At the national level, the identification and extraction process has mainly relied on the cooperation of 'key national contacts' within the BlueBio Cofund, in conjunction with consulting the repositories of national funding agencies, where available, as well as research institutes and universities. To this end, a questionnaire has been periodically sent to the BlueBio Cofund partners to collect updated information. The required information included the following: category, project acronym, project title, coordinator's name, coordinator's email address, starting and ending year of the project, project funding, project summary, project website, funding source, programme, coordinating country and coordinating institution, other involved entities with respective countries, keywords, and marine areas involved in the project (only for those projects including work at sea).It is worthy to specify that it has not been possible to update the database in respect to the national projects funded by France because that country participated in the COFASP ERA-NET but it did not join BlueBio Cofund.

In all cases, the projects have been selected based on the list of keywords previously identified by CNR (Annex I).

2.4. Data analysis

The analysis of data has been performed to extract general information on the projects stored in the BlueBio Database and to explore in depth the research categories, considering the criteria explained in Chapter 2.2.

The input dataset required for the analysis has been extracted from the BlueBio database, using Postgres language in R-environment. All the analysis, maps and plots have been carried out using R libraries.

3. Results

3.1. Distribution of projects by category

A total of 3761 projects have been extracted from the BlueBio database; most of them started in the period 2004-2013 (Figure 4).
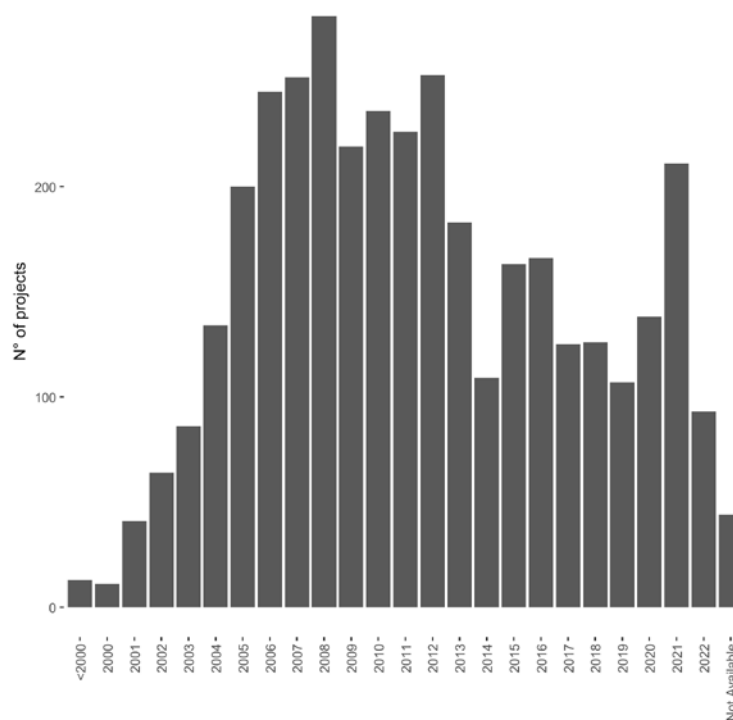

Fig. 4 - Number of projects by starting year. Not available: projects without information on the starting date.

The main categories, Fishery and Aquaculture, dominate in terms of project numbers, accounting for 35% and 23% of the total, respectively (Table 3). In contrast, Marine Biotechnology and Seafood Processing make up only 4% and 6% of the projects.

Among the cross-cutting categories instead, Aquaculture & Marine Biotechnology results the most abundant, including 12% of the projects, while all the others appear poorly represented accounting for at most 5% (Aquaculture & Fisheries; Fisheries & Seafood Processing) of the projects' universe of the database.

Table 3 - Overview of the projects by category: total number of projects by category with the respective percentage on the overall number of projects contained in the BlueBio Database and number of projects with available funding information with the total budget (Mln €).

Category	Code	Total projects (#)	Projects funded
Aquaculture	AQC	850 (0.23)	667 (751)
Aquaculture + Fisheries	AQC+FSH	206 (0.05)	159 (287)
Aquaculture + Fisheries + Marine Biotechnology	AQC+FSH+MBT	83 (0.02)	74 (91)
Aquaculture + Fisheries + Marine Biotechnology + Seafood Processing	AQC+FSH+MBT+SFP	42 (0.01)	38 (414)
Aquaculture + Fisheries + Seafood Processing	AQC+FSH+SFP	48 (0.01)	42 (56)
Aquaculture + Marine Biotechnology	AQC+MBT	436 (0.12)	402 (628)
Aquaculture + Marine Biotechnology + Seafood Processing	AQC+MBT+SFP	30 (0.01)	30 (60)
Aquaculture + Seafood Processing	AQC+SFP	93 (0.02)	67 (54)
Fisheries	FSH	1308 (0.35)	883 (959)
Fisheries + Marine Biotechnology	FSH+MBT	15 (<0.01)	11 (14)
Fisheries + Marine Biotechnology + Seafood Processing	FSH+MBT+SFP	35 (0.01)	29 (43)
Fisheries + Seafood Processing	FSH+SFP	200 (0.05)	125 (68)
Marine Biotechnology	MBT	164 (0.04)	149 (299)
Marine Biotechnology + Seafood Processing	MBT+SFP	43 (0.01)	32 (24)
Seafood Processing	SFP	208 (0.06)	128 (79)
Total		3761	2836 (3827)

This is also confirmed by Figure 5 showing that, although most of 2-levels cross-cutting categories have been addressed since 2001-2002, the number of related projects has always remained rather low except for Aquaculture & Marine Biotechnology which has shown a slow, gradual increase over time. The interdisciplinary projects addressing 3- and 4-level categories, instead, have generally started later and show a discontinuous trend characterized by very low numbers.

With regards to the main categories, Aquaculture and Fisheries were targeted throughout the overall period, with higher values in the years 2004-2016. The highest number of projects related to Seafood Processing was funded in the time interval 2005-2012. In contrast, projects dealing with Marine Biotechnology showed a slight, gradual increase over time.
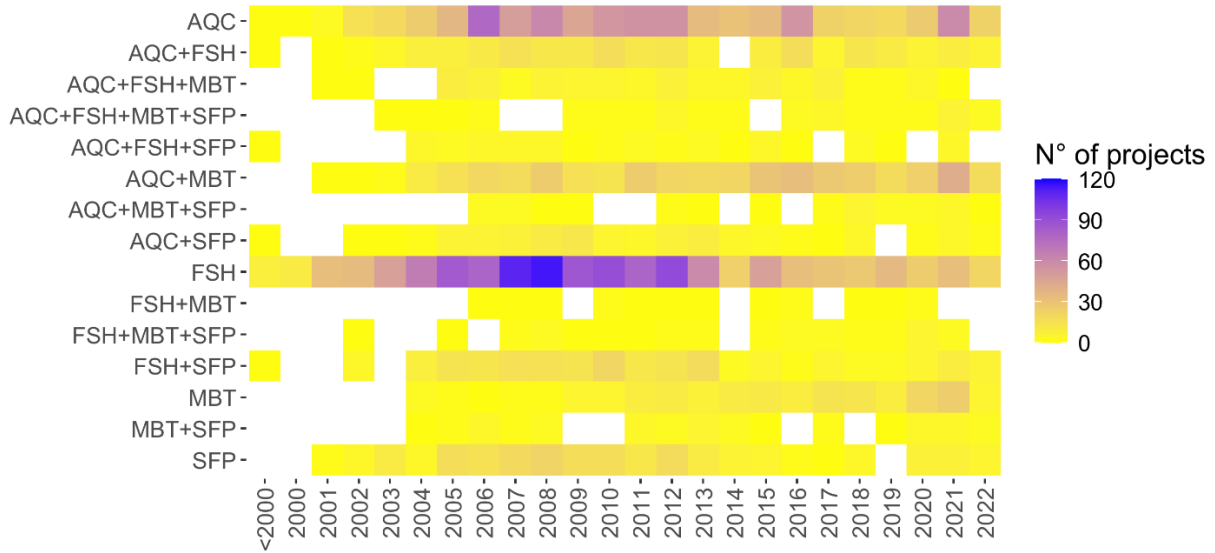
Fig. 5 - Number of projects by category and starting year.

3.2. Distribution of projects by country

The information of the coordinator and/or partners is missing in 18 and 63 projects corresponding to 0.5% and 1.7% of the total number of projects contained in the database, respectively.

Overall, the projects have involved 106 countries, 28 of which are EU MS (including the United Kingdom as Brexit entered into force in 2020) and 78 non-EU countries.

Norway is the country dealing with the highest number of projects (1916) followed by Italy, Spain, and the United Kingdom, which however participated in a far lower number of projects ranging from 643 to 468 (Figure 6).

The analysis of the projects by the coordinator's country also shows that Norway has the highest number of projects (1656), accounting for more than 44% of the total database (Figure 7). An appreciable number of projects have also been coordinated by Italy (379 projects; 10%), followed by Germany, Portugal, and Spain with 195, 185, and 176 projects respectively, each corresponding to around 5% of the total.

On the other hand, Spain, the United Kingdom and France are the three countries involved in the highest number of projects as partners with a number of projects ranging from 351 to 289 (9-8%; Figure 7). Most of the non-EU countries have only participated as involved country and never as coordinator.
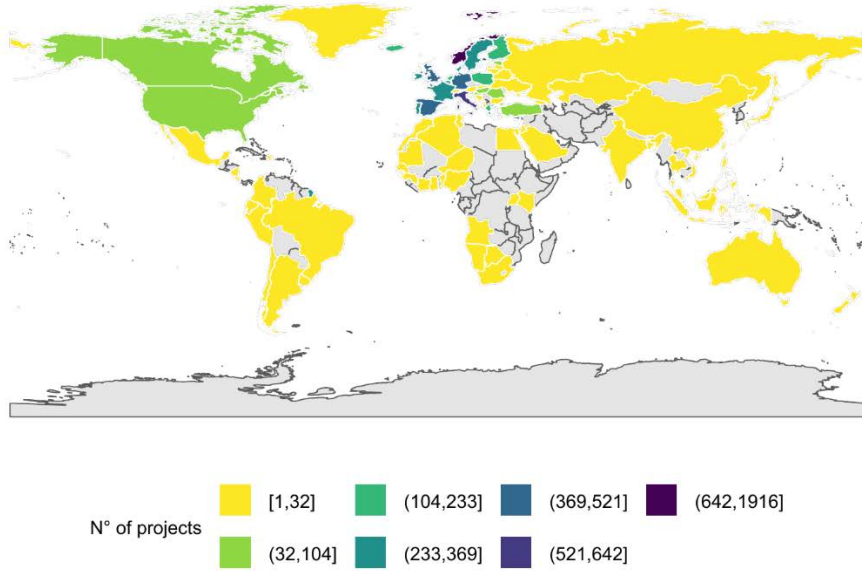
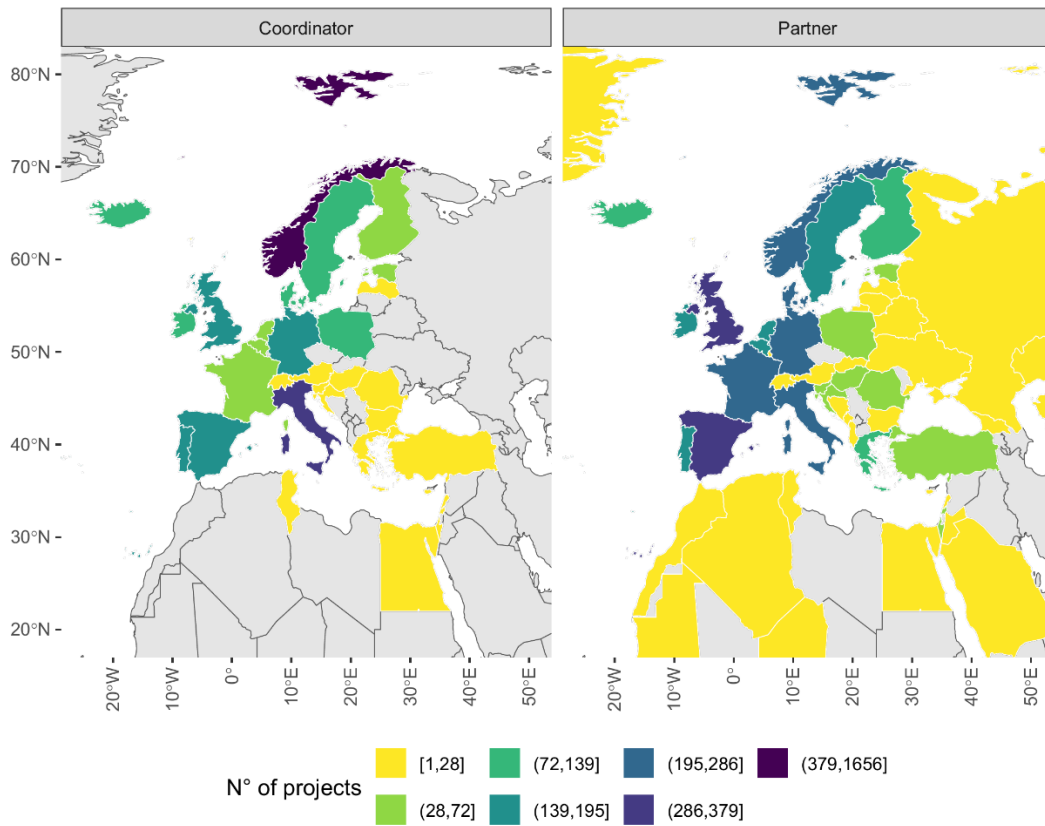**Fig- 6** - Map of the involved countries with number of projects by country.

Fig. 7 - Number of projects by coordinator country (left) and involved country (right).

3.3. Funding source

Taking into account the funding source, the majority of the projects have been funded with National funds (69%), while 18% of the total have been funded by the European Commission (Figure 8). The projects co-financed by European and National funds and those supported by Other funding sources account for 13% and 1% respectively of the total number of projects included in the BlueBio database.
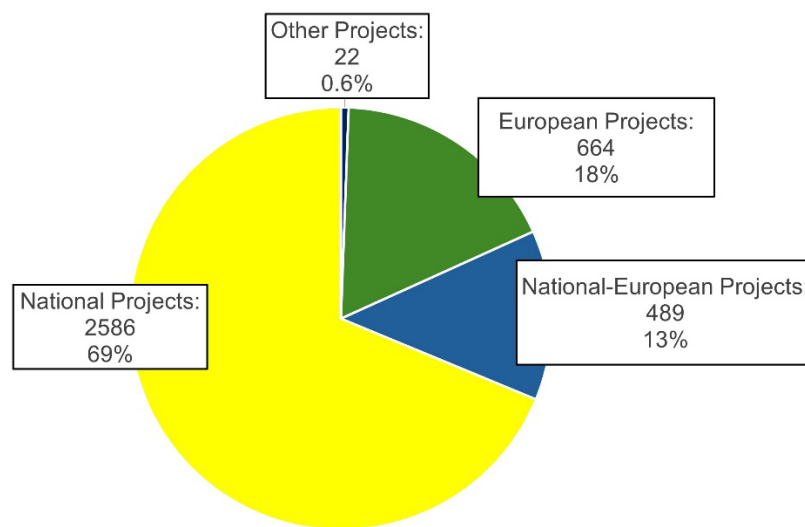
Fig. 8 - Number of projects, and relative proportion, by funding source.

Norway is the country that has coordinated the highest number of national projects (1514), followed at a great distance by Italy and Germany and (155 and 129 respectively) (Figure 9).

Italy, on the other hand, appears to be the coordinator country for the highest number of projects that are either co-funded at the European/national level or solely at the European level (113 and 110, respectively), ahead of Portugal (91) and Norway (57) in the former case, and of Norway (82), Spain (81) and the United Kingdom (73) in the latter case (Figure 10). Other countries demonstrating a strong capacity to access European funds include France, Germany, and the Netherlands. It is also worth noting that several non-EU countries participate in European projects as partners (e.g., Israel, Turkey, Russian Federation, China) and, in a few cases, as coordinators (e.g., Turkey, Israel).
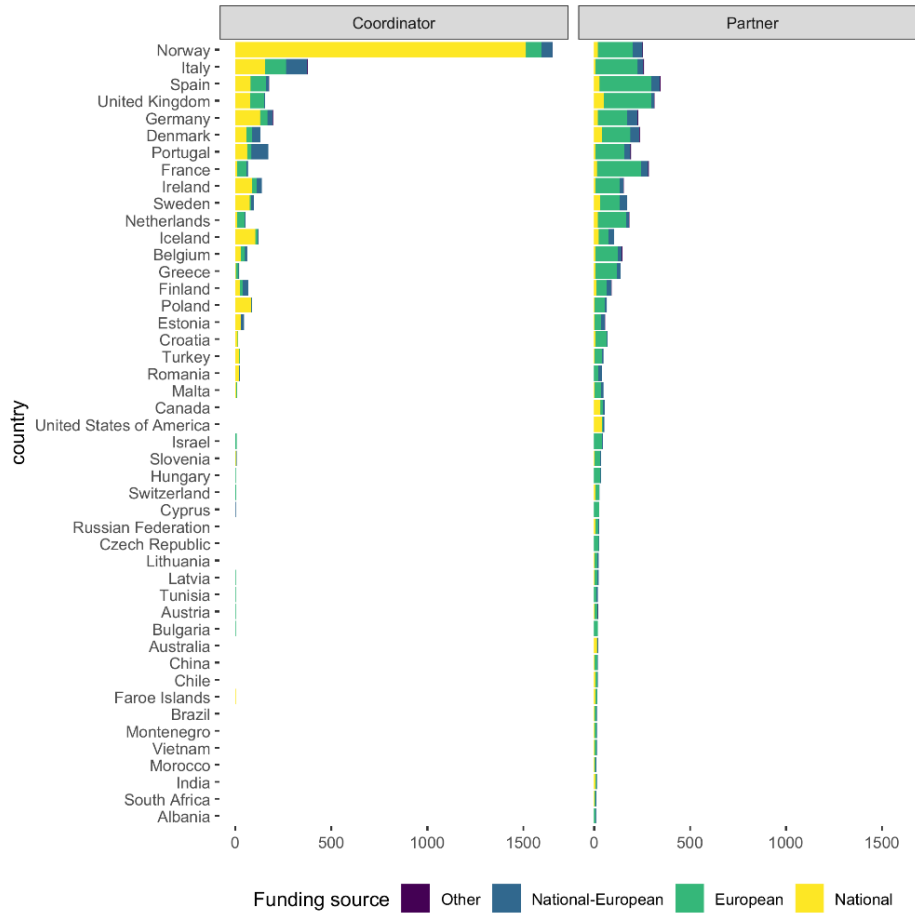
Fig. 9 - Number of projects by funding source and country. The projects have been split into two categories based on the role held by the country (coordinator or involved partner); only countries with a number of projects ≥ 10 are reported.

3.4. Funding

The budget information was not available for 924 projects, corresponding to around 25% of the total database (Table 3). These projects were funded almost exclusively under national and national/European programs.

Excluding those projects, the overall budget of the projects supported by EU funds through FP5-7, H2020, LIFE, COST, and Interreg programmes, as well as other instruments directly managed by the EC, corresponds to 52% of the total financial resources for the entire period. The budget of those projects implemented within national programmes accounts for 36%, while the budget of projects co-financed by European and national funds (e.g., BONUS programme, national programmes supported by ESIF) amounts to 11%. Funding from other sources is negligible (1%).

The annual trend of funding is characterized by some fluctuations and a sharp peak in 2012, due to the financing of a number of projects with very high budgets comprised between 10Mln€ and 250Mln€ (Figure 10).

Around 36% of the projects have a budget greater than 500k€, 13% lower than 100k€ and 26% between 100k€ and 500k€ (Figure 11).
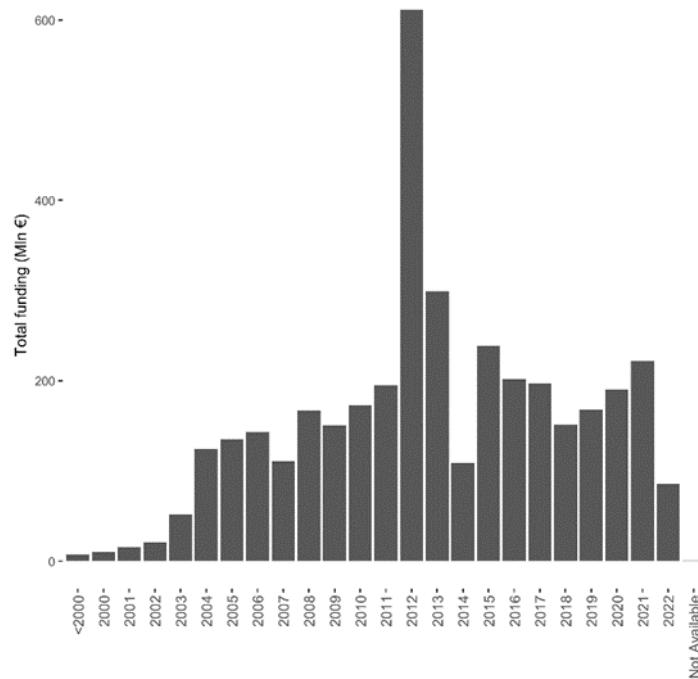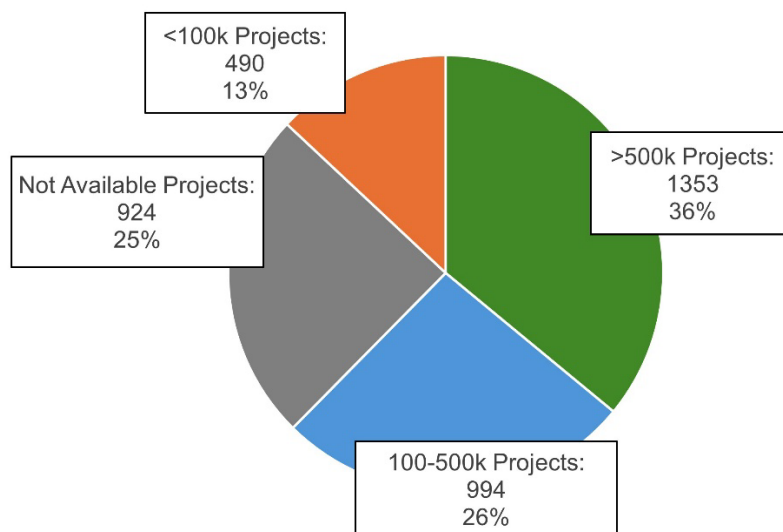

Fig. 10 - Total funds by year.

Fig. 11 - Number of projects by funding category.

The temporal distribution of projects by funding category shows a decrease in the last decade in projects with a budget lower than 100k€, alongside an increase in those with a budget higher than 500k€. The number of projects in the 100-500k€ category has remained practically constant since 2004 (Figure 12).
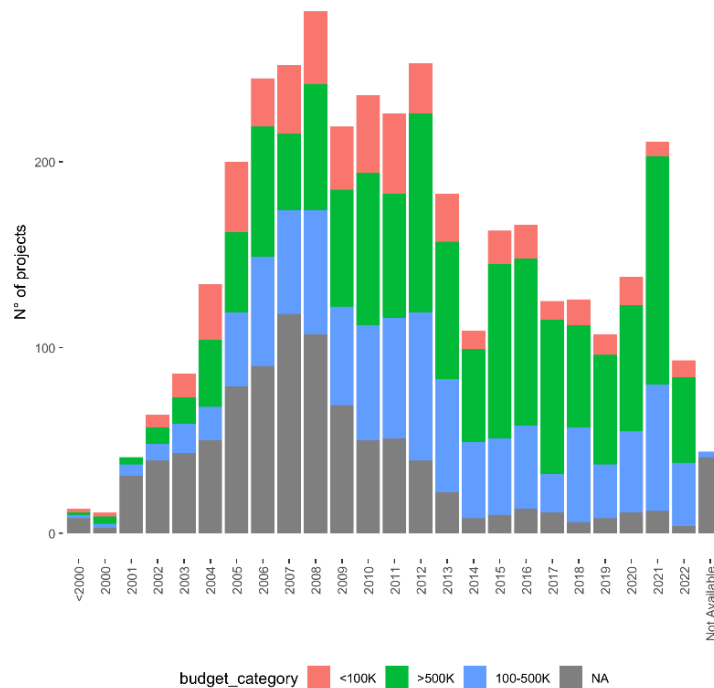
Fig. 12 - Number of projects by funding category and by year. NA: budget not available.

Looking at the spatial allocation of the projects by funding category and coordinator country, it appears that Norway has coordinated the greatest number of projects in each funding category. It is followed by Italy and Germany for projects with a budget over 500k€, by Italy and Portugal for projects with a budget between 100k€ and 500k€, and by Italy and Poland for those with a budget under 100k€ (Figure 13).

Combining the information on funding sources and budget categories, it appears that most of the projects coordinated by Norway have a budget over 500k€ and are funded under national programmes (Figure 14). The same is true for Italy, the United Kingdom and Spain, but for these countries most of the projects are funded by European funding programmes. Conversely, in all countries, the majority of projects with a budget of less than 500k€ are funded by national funding programmes, with the exception of Portugal, where national-European programmes appear to be the major funding source for these projects.

Italy, the United Kingdom, Spain and Norway have coordinated a similar number of projects supported by European funds with a budget exceeding 500k€.

The number of projects with a budget over 500k€ ranges from 41% to 74% in each research category, except for Seafood Processing and Fisheries & Seafood Processing (Table 4). The overall average is 52%, corresponding to around 90% of the total funding of each category. The projects with budget lower than 100k€ represent more than 10% of the total number of projects in most research categories and do not exceed 3% of the total funds allocated to each category. Finally, projects within the budget range of 100-500k€ typically hold intermediate significance across almost all research categories, varying from 18% to 44% in number of projects. However, they account for more than 10% of the total funding in only 4 out of 15 cases within the research categories.
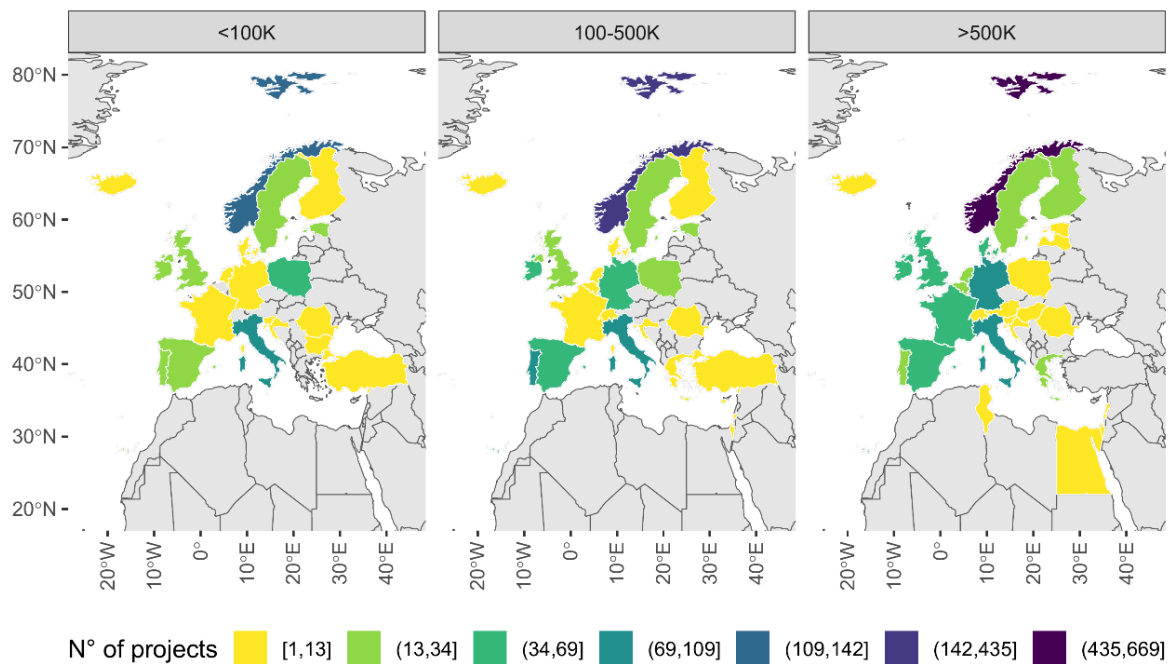

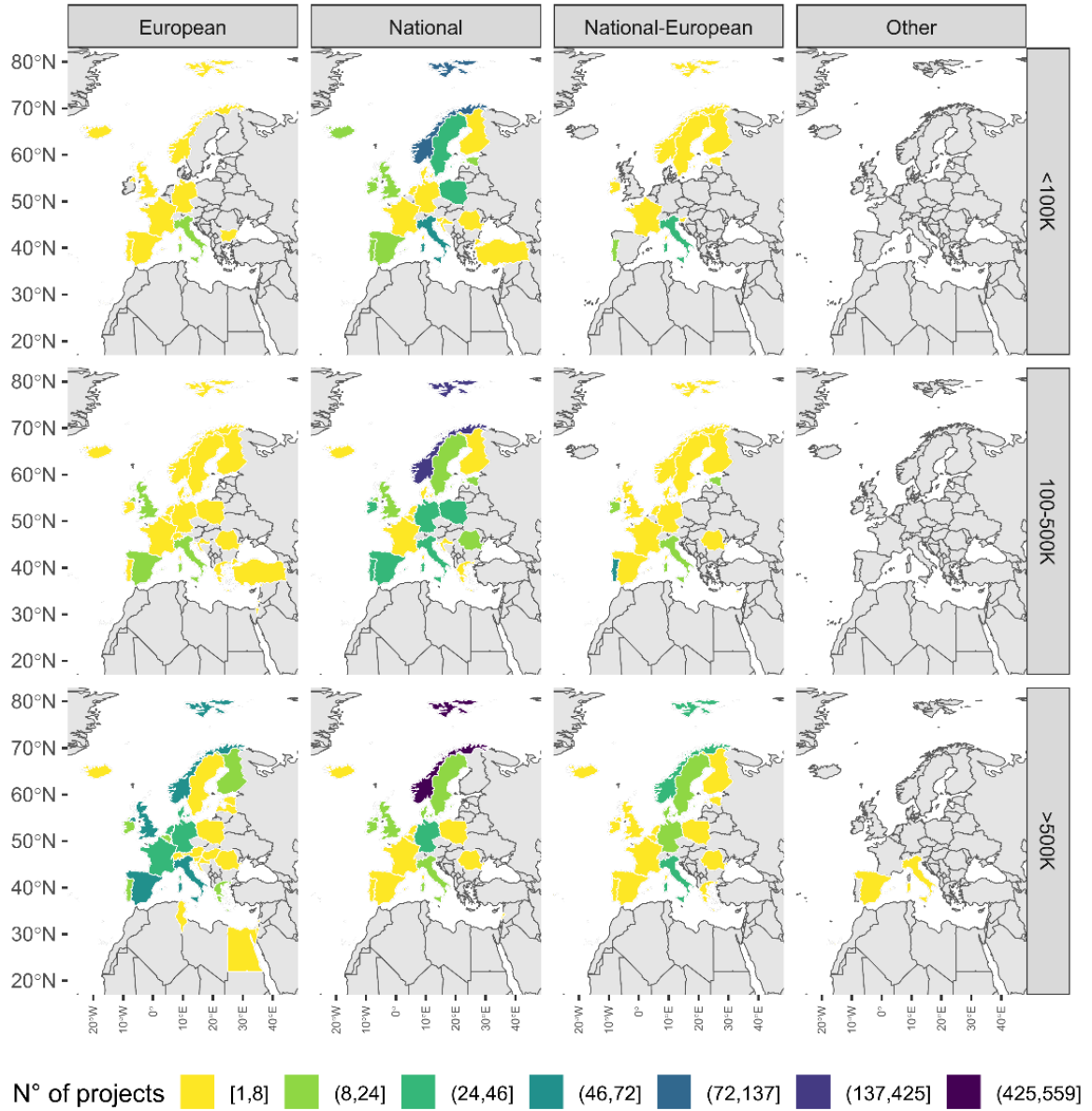**Fig. 13** - Number of projects by funding category and country.

Fig. 14 - Number of projects by country, funding category and funding source.

Table 4 - Importance of each funding category in each research category. Importance of each funding category in each research category is evaluated in terms of proportion concerning both the number of projects with available budget information and the total budget of the research category.

Category	Projects number (#)			Total funding (€)		
	<100k	100-500k	>500k	<100k	100-500k	>500k
Aquaculture	0.15	0.37	0.47	0.01	0.09	0.90
Aquaculture + Fisheries	0.13	0.29	0.58	0.00	0.04	0.96
Aquaculture + Fisheries + Marine Biotechnology	0.16	0.30	0.54	0.01	0.06	0.93
Aquaculture + Fisheries + Marine Biotechnology + Seafood Processing	0.08	0.18	0.74	0.00	0.00	1.00
Aquaculture + Fisheries + Seafood Processing	0.07	0.38	0.55	0.00	0.08	0.92
Aquaculture + Marine Biotechnology	0.06	0.33	0.61	0.00	0.06	0.94
Aquaculture + Marine Biotechnology + Seafood Processing	0.00	0.33	0.67	0.00	0.04	0.96
Aquaculture + Seafood Processing	0.18	0.40	0.42	0.01	0.14	0.85
Fisheries	0.24	0.35	0.41	0.01	0.08	0.91
Fisheries + Marine Biotechnology	0.18	0.18	0.64	0.01	0.04	0.96
Fisheries + Marine Biotechnology + Seafood Processing	0.21	0.34	0.45	0.01	0.06	0.94
Fisheries + Seafood Processing	0.30	0.42	0.27	0.03	0.18	0.79
Marine Biotechnology	0.12	0.29	0.59	0.00	0.03	0.97
Marine Biotechnology + Seafood Processing	0.19	0.34	0.47	0.01	0.14	0.85
Seafood Processing	0.24	0.44	0.32	0.02	0.16	0.82

3.5. Identification of research gaps

The analysis of abstracts and keywords associated with the projects in the different research categories has allowed for the identification of the most relevant research gaps. These identified gaps have been compared with the research priorities for 2050 established by the Foresight exercise implemented under BlueBio Cofund, as listed in the BlueBio Research and Innovation Agenda (D 7.1), to evaluate the extent to which the research priorities have been addressed up to now (Table 5).

Table 5 shows that only 5 out of 28 research priorities identified by the BlueBio Foresight are well addressed by the projects contained within the BlueBio database. Some of these include optimizing coastal and maritime planning and management, developing recirculating systems, and implementing full-chain traceability. Ten priorities appear to be only partially addressed

because, although they are investigated by a certain number of projects, they require further investigations for a better understanding of the issues, or the studies have only focused on a very limited number of species. An example of the former case is understanding and modelling the direct and indirect effects of climate change on the ecological and social systems. Examples of the latter case include exploring the potential of genetic engineering to optimize aquaculture production and enhance its sustainability, finding alternatives to antimicrobials in aquaculture, and developing low and multi-trophic aquaculture. The remaining priorities are poorly or very poorly addressed.

Additionally, further specific gaps have been identified from the analysis of the database (Table 6). These include, for example, the scarcity of projects focusing on the technological improvement of bottom and pelagic trawl gears to reduce by-catch, discard, and physical impact on the seabed (in the case of bottom trawl gears) in the southern European seas, as well as the lack of projects on set gears (long-lines, set nets, traps) and dredges for molluscs everywhere. There is also a shortage of studies on the effectiveness and impacts of releasing hatchery-reared juveniles into wild populations to sustain fisheries or for conservation purposes, and a need for updated knowledge on capture-based aquaculture.

Table 5 – Main research gaps identified by the BlueBio database compared to the research priorities identified by the Foresight exercise, with specific details extracted from the information available in the database.

🙂 well addressed 😐 partially addressed 🙁 poorly addressed ☹ very poorly or not addressed

BlueBio Foresight priorities		BlueBio project database
BLUE BALANCE		
Understanding structure and functioning of the blue biosphere	🙁	Projects are mainly species-specific
Identifying ecological tipping points to maintain ecosystem services	☹	
Understanding the effects of human impact on the ecosystem	🙂	
Understanding land/sea interactions	☹	
Nature based Solutions (NbS) for restoration, mitigation and production purposes	☹	
SOCIETAL BALANCE		
Optimize coastal and maritime planning and management	🙂	
Developing socially legitimate and trustworthy regulations	☹	
Understanding consumer preferences to develop new markets/demands or reintroduce traditional markets	😐	Mainly focussed on specific products and species (e.g., clipfish, pelagic fish, salmon, cod)
Promote sustainable consumption	🙁	
Assessing the potential recreational value of ecosystems	☹	
Ecological compensation	☹	
CLIMATE CHANGE		
Understanding and modelling direct and indirect effects on the ecological and social system	😐	
Strategies to mitigate negative human impacts on the blue biosphere at every scale	😐	
TECHNOLOGICAL INNOVATION		
Develop monitoring systems using remote sensors and Artificial Intelligence/Machine Learning for Aquaculture production optimisation, safer and efficient marine logistics, and efficient and sustainable fisheries and harvesting.	😐	Poorly addressed for fisheries
Genetic engineering to optimize aquaculture production and enhance its sustainability	😐	Projects mainly focussed on salmon, microalgae and other microorganisms production
Use of carbon capture to produce food, feed and non-degradable deposition forms	🙁	

Finding alternatives to antimicrobials in aquaculture	😐	Projects mainly focussed on salmon and cod
Further development of recirculating aquaculture systems	🙂	
Monitoring levels of toxic substances and standardization of toxicity thresholds in feed and seafood	🙂	
Ensuring animal health and welfare	😐	Projects mainly focussed on salmon, cod and cleaner fish
VALUE CHAIN DEVELOPMENT		
Optimize the use of side streams from aquaculture and fishery industries	😐	Projects mainly dealing on sidestreams from aquaculture Sidestreams, by-catch and discard from fisheries poorly addressed
Reduce the use of plastics in fisheries and aquaculture by novel materials	☹️	
Implement full-chain traceability	🙂	
Optimise the interaction between land-based and ocean-based production	☹️	
Multi-use of ocean space for food production (fisheries, aquaculture), energy production, tourism	☹️	
New species for food production and provision of novel, healthy and functional food/feed products and ingredients	😐	Projects mainly focussed on the use of seaweeds, microalgae and other microorganisms for healthy and functional food/feed products and ingredients Identification of new species for food production poorly addressed
Development of low and multi-trophic aquaculture	😐	Well addressed in land-based aquaculture Scarcely addressed in open-sea aquaculture with few projects mostly dealing on integration of seaweeds or shellfish (mussels) cultures with fish farming
SCIENCE FOR SOCIETY		
Promote uptake of research in society and industry and interlinkage between science and decision making improving education, empowering people, building capacity and promoting ocean literacy	☹️	

Table 6 – Additional gaps identified from the analysis of the BlueBio database.

Drivers		Gaps
TECHNOLOGICAL INNOVATION		✓ Integrated assessment of the overall impacts of different aquaculture systems on the entire marine ecosystem
		✓ Technological improvement on bottom and pelagic trawl gears to reduce by-catch, discard and physical impact on the seabed (in the case of bottom trawl gears) scarcely addressed in the southern European seas
		✓ Technological improvement of set gears (long-lines, set nets, traps) and dredges for molluscs to reduce by-catch, discard and physical impact on the seabed (in the case of dredges) scarcely addresses everywhere
		✓ Limited number of species investigated in terms of selectivity, by-catch and discard
BLUE BALANCE		✓ Effectiveness and impacts related to releasing hatchery-reared juveniles into wild population(s) to sustain fishery or for conservations purposes
VALUE CHAIN DEVELOPMENT		✓ Updated and more extensive research on capture-based aquaculture
		✓ Use of biomaterials/substances produced by aquatic organisms to obtain new sustainable materials for human use (Biomimicry; e.g., glues, antifouling paints)

4.   Conclusions

The explorative analysis has been aimed to describe the information contained in the BlueBio database of the research projects already on-going or funded in the fields of Fisheries, Aquaculture, Marine Biotechnology and Seafood Processing during the period 2003-2022 by European countries in the three major FAO Marine areas related with EU: Atlantic Northeast (FAO Area 27), Atlantic, Eastern Central (FAO Area 27), and Mediterranean and Black Sea (FAO Area 37). The main findings are here under reported.

Considering the starting dates of the projects contained in the database, it is evident that most of them were initiated between 2004 and 2013. Aquaculture, Fisheries, and Aquaculture & Marine Biotechnology are the only categories consistently addressed without any interruption. However, while the projects related to Aquaculture and Fisheries began before 2000, those associated with Aquaculture & Marine Biotechnology started in 2001.

Fisheries is the most investigated research field, accounting for 35% of the overall projects contained in the database. It is followed, in order, by Aquaculture (23%), Seafood Processing (6%), and Marine Biotechnology, only comprising 4% of the projects. The low ratio in number of projects between each main category and its overall related categories (main category + cross-cuttings) confirms that this last category is usually investigated in association with other research fields rather than alone.

Aquaculture & Marine Biotechnology is the most populated cross-cutting category including 12% of projects. Its gradual increase over time is likely due to the increasing use of new biotechnologies to improve health and welfare of cultured animals as well as to develop new cultures of microalgae and other microorganisms for producing novel, healthy and functional food/feed products and ingredients.

All the other cross-cutting categories are poorly represented, comprising at most 5% (Aquaculture & Fisheries; Fisheries & Seafood Processing) of the projects in the database.

The relatively low percentages in the cross-cutting categories underscores a persistent tendency to focus on specific issues rather than embracing a more holistic approach to tackling the main challenges related to sustainable production.

From the financial point of view, it results that most of projects with available budget information have been implemented with national funds, 18% with European funds, while 13% have been co-financed by European and National funds. The financial contribution from consortia of countries, international organizations, agencies or programmes not relying on EU funds has been negligible.

Considering, instead, the financial resources allocated over the entire period, the overall EU funds provided through FP5-7, H2020, LIFE, COST and Interreg programmes as well as other instruments directly managed by EC correspond to around 52% of the total, while the amount of those projects implemented within national programmes accounts for 36%. Finally, the budget of projects co-financed by European and national funds (i.e., BONUS programme,

national programmes supported by ESIF) amounts to 11%. However, the significance of national and national/European funds may be skewed by the fact that the majority of projects lacking funding information have been supported by these programs.

Most of the projects with available funding information have budgets over 500k€. The increase over time in these projects, coupled with a decrease in projects with budgets lower than 100k€ and a stability in those between 100k€ and 500k€, seems to indicate a trend toward funding more complex projects involving numerous participants and areas, rather than small, limited studies.

Norway has funded around 59% of the overall projects supported by national programmes, corresponding to 40% of the total number of projects included in the database. Moreover, subdividing the projects by country, funding source and funding category (< 100k€, 100-500k€, > 500k€), it results that the Norwegian national projects with a budget higher than 500k€ overcome the highest number of projects in all combinations by country/funding source/funding category.

On the other hand, Italy, the United Kingdom, Spain, and Norway have coordinated a comparable number of projects supported by European funds with budgets over 500k€.

On average, projects with budgets higher than 500k€ represent in average 90% of the overall budget and 52% of the total number of projects within each research category, with peaks of 100% and 74%, respectively, both in the cross-cutting category Aquaculture, Fisheries, Marine Biotechnology & Seafood Processing. Indeed, the projects within this category have by far the highest average budget, as most of them are projects funded within the European programmes FP6, FP7 and H2020, European/national ERA-NET Cofunds, and national flagship projects.

Despite this, when considering the total budget allocated to each research category, Fisheries, which encompasses the highest number of projects, also commands the highest budget, corresponding to 25% of the overall budget over the entire period. It is followed by Aquaculture (20%), Aquaculture & Marine Biotechnology (16%), and Aquaculture, Fisheries, Marine Biotechnology & Seafood Processing (11%). None of the remaining categories exceed 8%.

The comparison of the issues addressed by projects in the database and the research priorities identified by the BlueBio Foresight has shown that only around 18% of the priorities have been addressed to a satisfactory extent to date, 36% are addressed by a number of projects but need further investigation, while the remaining ones have been poorly or very poorly investigated. The analysis of projects has also allowed to identify additional, specific gaps. This demonstrates that the availability of an overview of already funded projects can help funders and researchers to avoid duplications and better address the R&I gaps and needs. The overlap between initiatives is necessary to ensure the continuation of infrastructures that enables this overview.

Annex I - List of Keywords

Abalone	Biogenic reefs	Cod	Fish meal replacement
Acoustic survey	Biology	Common piddock	Fish oil replacement
Algae	Biomass	Corals	Fish products
Algal toxins	Biomaterial	Cosmetics	Fish quality
Alien species	Biomimicry	Crab	Fish reproduction
Amberjacks	Biopolymer	Crustacean	Fish stocks
Anchovy	Bioprocess	Crustacean fisheries	Fisheries development
Anglerfish	Bioproduct	Cuttlefish	Fisheries management
Animal feed	Bioprospecting	Diagnostic application	Fisheries research
Animal welfare	Biorefinery	Diets	Fishery
Anthropic activity	Bioremediation	Discard	Fishery policy
Antibacterial	Biosensors	Disease	Fishing effort
Antifouling	Biotechnology	Dissemination	Fishing fleets
Antimicrobials	Bivalve	Dolphins	Fishing industry
Aquaculture development	Black scabbardfish	Drift nets	Fishing mortality
Aquaculture diversification	Blue economy	Drug discovery	Fishing technology
Aquaculture industry	Blue growth	Dusky grouper	Fishing vessels
Aquaculture management	Blue whiting	Echinoderm	Flatfish
Aquaponics	Brill	Economy	Floating structures
Artic charr	Broodstocks	Ecosystem approach	Flounder
Artificial reef	Bycatch	Eel	Food products
Ascidian	Byproducts	Engineering	Food quality
Bacteria	Cage aquaculture	Environmental impact	Food safety
Bacteriocins	Capture-based aquaculture	Escapes	Food web
Barnacle	Carp	Estuarine fisheries	Fuel consumption
Benthic communities	Catch	Exploitation	Fungus
Bioactive compounds	Cephalopod	Extreme enzymes	Gastropod
Biocatalyses	Certification	Feed composition	Gear selectivity
Biodegradation	Cetaceans	Feed quality	Gear technology
Biodiversity	Changeable nassa	Fish	Genetic
Biofilm	Clam	Fish aggregating device	Genomic
Biofouling	Climate change	Fish biology	Genomic and gene mining
Biofuel	Clown fish	Fish habitat	Genomic sequencing
Biogas	Cobia	Fish health	Germ cell-free animals

Gillnets	Lump fish	Pollution	Scallop
Grey mullet	Mackerel	Population dynamic	Sea cucumber
Grooved carpet shell	Manila clam	Population structure	Sea ranching
Growth rate	Management	Pots	Sea turtles
Guidelines	Mapping	Probiotics	Sea urchin
Habitat mapping	Marine Biotech Management	Process	Seabass
Habitat enhancement	Marine enzymes	Process efficiency	Seabream
Haddock	Marine litter	Product development	Seafood
Hake	Market	Production	Seagrass
Halibut	Meagre	Production management	Seals
Herring	Metabolites	Protein	Sea star
Houting	Metagenomic	Protein source	Seaweed
Human food	Microbial communities	Protocol	Seed production
Human health	Microbiome	Prototype	Selective breeding
Impacts	Microplastics	Purse seine	Sensors
Indicators	Mollusc	Quality	Sharks
Integrated management	Monkfish	Queen conch	Shellfish
Integrated multi-trophic aquaculture	Monitoring	Quota regulation	Shi Drum
Jellyfish	MPA	Ray	Shrimp
Krill	Mussel	Razor clam	Slaughtering systems
Labelling	Nursery area	Recirculating systems	Small scale fisheries
Land-based aquaculture	Nutraceutical substances	Recreational fisheries	Sole
Landing	Octopus	Recruitment	Spatial planning
Larvae	Offshore platforms	Red mullet	Spawning area
Larval development	Offshore renewable energy	Red porgy	Sponge
Larval dispersion	Open sea aquaculture	Redfish	Sprat
Larval mortality	Oyster	Restocking	Squid
Larval quality	Packaging	Restoration	Stock
Larval rearing	Parasite	Risk assessment	Stock assessment
Life cycle	Passive gears	Saithe	Stock enhancement
Lobster	Pharmaceuticals	Salmon	Storage
Logbook	Physical disturbance	Sand steenbras	Striped venus
Longline fishing	Plaice	Sandeel	Sturgeon
Longline systems	Policy	Sardine	Sustainable aquaculture

Sustainability	Traps	Vessels technology	Whale
Swordfish	Trawling	VMS data	Whitefish
Tagging	Trout	Waste management	Wild animals
Technology	Tuna	Waste valorization	Wrasse
Toxic substances	Turbot	Waste water	Wreckfish
Toxins	Tusk	Wastes	Zooplankton
Traceability	Vaccines development	Water management	
Trammel nets	Value chain	Water quality	

Annex II - List of Marine Areas

AREA	SUBAREA	DIVISION
ATLANTIC EASTERN CENTRAL (FAO Area 34)	Northern Coastal	Canarias and Madeira Islands (34.1.2)
		Morocco coastal (34.1.1)
	Northern Oceanic	Northern Oceanic (34.2)
ATLANTIC NORTHEAST (FAO Area 27)	Azores Grounds Azores	Azores Grounds (27.Xa, 27.Xb)
	Barents Sea	Barents Sea (27.I)
	Bay of Biscay	Bay of Biscay Central (27.VIIIb)
		Bay of Biscay North (27.VIIIa)
		Bay of Biscay offshore (27.VIIId)
		Bay of Biscay Southern (27.VIIIc)
		West of Bay of Biscay (27.VIIIe)
	East Greenland	Northeast Greenland (27.XIVa)
		Southeast Greenland (27.XIVb)
	Iceland and Faroes Grounds	Faroes Grounds (27.Vb)
		Iceland Grounds (27.Va)
	Irish Sea, West of Ireland, Porcupine Bank, English Channel, Bristol Channel, Celtic Sea, Southwest of Ireland	Bristol Channel (27.VIIf) (27.IIId.25)
		Celtic Sea North (27.VIIg)
		Celtic Sea South (27.VIIh)
		Eastern English Channel (27.VIId)
		Irish Sea (27.VIIa)
		Porcupine Bank (27.VIIc)
		Southwest of Ireland-East (27.VIIj)
		Southwest of Ireland-West (27.VIIk)
		West of Ireland (27.VIIb)
		Western English Channel (27.VIIe)

	North of Azores	North of Azores (27.XIIa, 27.XIIb, 27.XIIc)
	North Sea	Central North Sea (27.IVb)
		Northern North Sea (27.IVa)
		Southern North Sea (27.IVc)
	Norwegian Sea, Spitzbergen and Bear Island	Norwegian Sea (27.IIa)
		Spitzbergen and Bear Island (27.IIb)
	Portuguese Waters	Portuguese Waters (27.IXa, 27.IXb)
	Rockall, Northwest Coast of Scotland and North Ireland	Northwest Coast of Scotland and North Rockall (27.VIb)
	Skagerrak, Kattegat, Sound, Belt Sea and Baltic Sea	Archipelago Sea (27.IIId.29)
		Baltic West of Bornholm (27.IIId.24)
		Bothnian Bay (27.IIId.31)
		Bothnian Sea (27.IIId.30)
		East of Gotland or Gulf of Riga (27.IIId.28)
		Gulf of Finland (27.IIId.32)
		Skagerrak, Kattegat (27.IIIa)
		Sound, Belt Sea (27.IIIb, 27.IIIc)
		Southern Central Baltic-East (27.IIId.26)
		Southern Central Baltic-West (27.IIId.25)
		West of Gotland (27.IIId.27)
MEDITERRANEAN AND BLACK SEA (GFCM Area)	Western Mediterranean (Subarea 37.1)	Northern Alboran Sea (GSA 1)
		Alboran Island (GSA 2)
		Southern Alboran Sea (GSA 3)
		Algeria (GSA 4)
		Balearic Island (GSA 5)
		Northern Spain (GSA 6)
		Sardinia West (GSA 11.1)
		Gulf of Lions (GSA 7)
		Corsica Island (GSA 8)
		Ligurian and North Tyrrhenian Sea (GSA 9)
		South Tyrrhenian Sea (GSA 10)

		Sardinia East (GSA 11.2)
		Northern Tunisia (GSA 12)
	Central Mediterranean (Subarea 37.2)	Northern Adriatic Sea (GSA 17)
		Southern Adriatic Sea (GSA 18)
		Gulf of Hammamet (GSA 13)
		Gulf of Gabes (GSA 14)
		Malta Island (GSA 15)
		South of Sicily (GSA 16)
		Western Ionian Sea (GSA 19)
		Eastern Ionian Sea (GSA 20)
		Southern Ionian Sea (GSA 21)
	Eastern Mediterranean (Subarea 37.3)	Aegean Sea (GSA 22)
		Crete Island (GSA 23)
		North Levant (GSA 24)
		Cyprus Island (GSA 25)
		South Levant (GSA 26)
		Levant (GSA 27)
	Black Sea (Subarea 37.4)	Marmara Sea (GSA 28)
		Black Sea (GSA 29)
		Azov Sea (GSA 30)