

EFARO'S RECOMMENDATIONS

**ON RESEARCH & INNOVATION GAPS
AND NEEDS BEYOND HORIZON 2020**

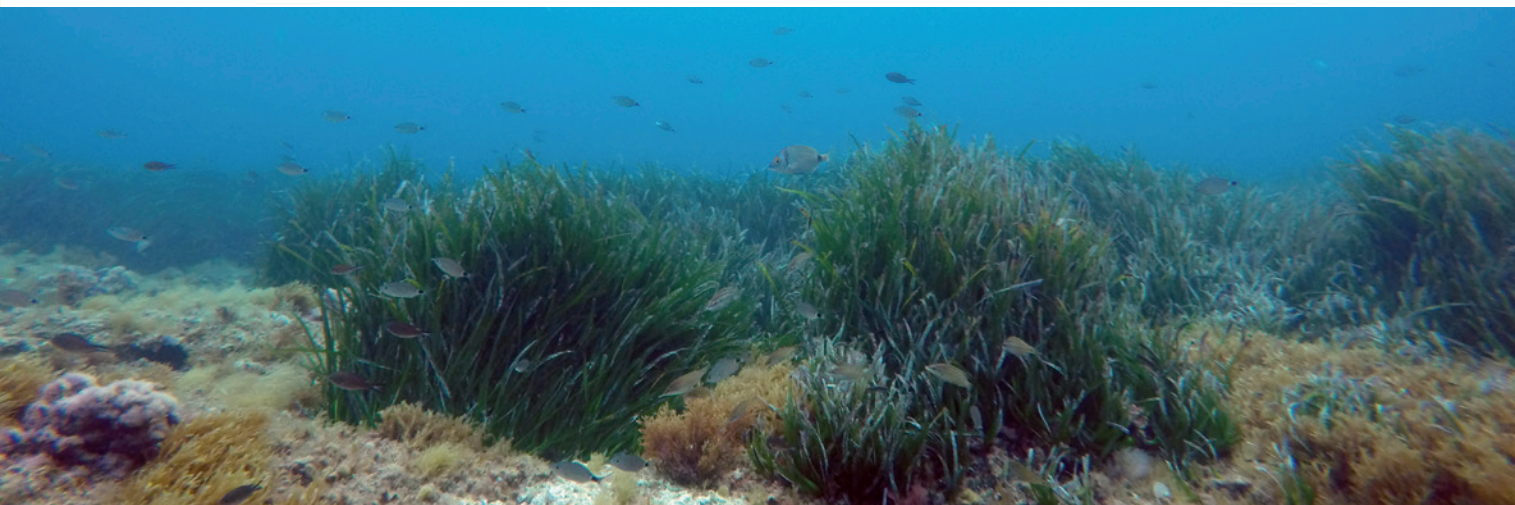
**European Fisheries and Aquaculture
Research Organisations**





European Fisheries and Aquaculture
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SUMMARY OF **EFARO'S** **KEY** **RECOMMENDATIONS**

The European Union considers research and innovation among the main tools to achieve Europe's goals related to sustainable growth in the blue bioeconomy. This is highlighted in both EU's Blue Growth Strategy, the recently updated Bioeconomy Strategy, the Food 2030 agenda as well as the global 2030 Agenda for Sustainable Development. To reach these goals Europe needs an effective and successful European marine research and innovation agenda drafted in dialogue with key industries and other stakeholders including academia, policy-makers and society. These ambitions were recently reaffirmed by Commissioner Vella, from DG MARE who expressed that *"there are many opportunities to progress, and stakeholders will need to help us target programmes, policies and funding"* (EC 2018).

As a community of scientific institutions working intensely on the research and innovation (R&I) challenges of the blue bioeconomy's key industries, fisheries and aquaculture, EFARO would like to take up this request by offering its latest analyses and recommendations on Europe's future R&I priorities. EFARO welcomes the European Commission's (EC) acknowledgement of the importance of an ongoing dialogue, especially considering the upcoming Horizon Europe framework programme. We hope that the document at hand can provide the EU with the inspiration it is looking for.

In order to develop its recommendations, EFARO performed an extensive background analyses of EU's funding of fisheries and aquaculture topics since mid-term FP7 throughout H2020. The methodology of background analyses is presented in the following document, with the identified priorities below.

Identified European priorities				
AREAS	HIGH PRIORITY	HIGH/MEDIUM PRIORITY	MEDIUM PRIORITY	NEW TOPICS (2017-2018)
Fisheries	<ul style="list-style-type: none"> - Integrated impact assessment - MSY and management plans - Small scale/ recreational fisheries - Efficient, environmentally friendly fishing gears - Biological processes, lifecycle and distribution 	<ul style="list-style-type: none"> - Institutional setting of regional management - Multispecies and fleet assessment models - End to end ecosystem models - Discards, ecosystem impact, avoidance, landing obligation and utilization 	<ul style="list-style-type: none"> - New marine living resources - Data collection 	<ul style="list-style-type: none"> - Data poor stock assessments methods, allowing delivery of management advice - Advanced analytical and statistical tools such machine learning - Long-term impact of fisheries on genetic diversity - Effects of management plans, MSY & capacity reduction - CFP reform 2013 – performance analysis
Aquaculture	<ul style="list-style-type: none"> - Offshore aquaculture systems - Spatial planning tools for site selection 	<ul style="list-style-type: none"> - New species and diversification - Circular economy incl. multi-trophic systems (IA) 	<ul style="list-style-type: none"> - Enhanced RAS production systems - Improve animal welfare - Impacts of harmful algae blooms 	<ul style="list-style-type: none"> - Microalgae, biological production - Building with nature, e.g. coastal defence systems allowing for food/feed production beyond safety from flooding alone - Impact of climate change
Cross-cutting fisheries & aquaculture	<ul style="list-style-type: none"> - Integrated coastal management - Integrated ecosystem assessments and MSFD 	<ul style="list-style-type: none"> - Predicting effects of human activities 	<ul style="list-style-type: none"> - Maritime spatial plans for different sectors (RIA) 	
Seafood/ blue biomass	<ul style="list-style-type: none"> - Valorisation of underused catch/ production - Certification and branding 	<ul style="list-style-type: none"> - Risk benefit analyses for seafood consumption 		
Cross-cutting all areas		<ul style="list-style-type: none"> - Impact of marine pollution 	<ul style="list-style-type: none"> - Biological molecules (omics) - Social/economic adaptation in aquatic food production 	<ul style="list-style-type: none"> - Impact of global seafood trade on local fisheries, aquaculture, seafood production and communities

Among the identified topics EFARO would like to highlight the following areas, which EFARO consider particularly important to address.

EFARO's key R&I priorities

1. To enable efficient implementation of the CFP, MSFD and MSPD, knowledge gaps concerning **biological processes, lifecycles and distributions** of stocks and biodiversity should be addressed, given the need for assessments and management on biologically relevant spatial scales.
2. Developing **spatial planning tools** for *aquaculture* remains a key enabler for the development of locally sustainable aquatic food production systems in European waters.
3. **Integrated ecosystem assessments in support of the MSFD** represent a priority which cross-cuts fisheries and aquaculture as well as other uses of the Europe's coasts, seas and oceans.
4. **Valorisation of underused catch and production** ought to be a key target for the development of a European blue bioeconomy based on *seafood and other blue biomasses*.
5. **The impact of marine pollution** represents a topic *cross-cutting all marine areas*, from shipping to food systems and recreational uses of Europe's coasts, seas and oceans.

Given the opportunity, EFARO would like to also add a few points for consideration concerning the approach to R&I funding in Europe based on its extensive experience with present and former FPs and associated EU-based funding instruments.



EFARO's recommendations concerning the approach to programming in Europe

1. Cross coordination on research and innovation programming, execution and result implementation can be improved across FP instruments e.g. Era-Nets, Art. 185 and others.
2. Mission-oriented work has earlier been successfully conducted in marine science as seen e.g. in EU's Ocean of Tomorrow in FP7 – and is therefore encouraged.
3. Programming of R&I activities and implementation of results in policy development and implementation faces fundamental problems due to different governance systems acting on different spatial scales, i.e. global, European, regional and member states. Overcoming this challenge should be a target in future programs.



Introduction

The European Union considers research and innovation among the main tools to achieve Europe's goals related to sustainable growth in the blue bioeconomy. This is highlighted in both EU's Blue Growth Strategy, the recently updated Bioeconomy Strategy, the Food 2030 agenda as well as the global 2030 Agenda for Sustainable Development. To reach these goals Europe needs an effective and successful European marine research and innovation agenda drafted in dialogue with key industries, academia, policy makers and society.

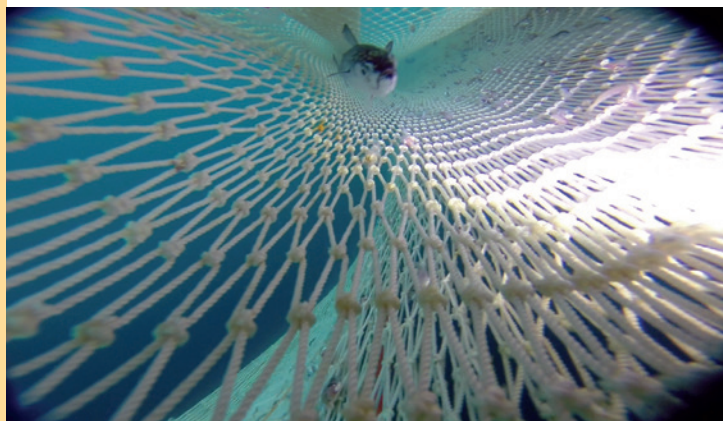
As a community of European Fisheries and Aquaculture Research Organisations EFARO has as its mission to contribute to that dialogue by highlighting the research and innovation gaps and needs, which, from EFARO's perspective, has the highest potential to support such a process. In order to deliver such advice, EFARO continuously maps the development of EUs research, innovation, technology and development (RITD) agendas and the allocation of funding used to achieve the goals of these agendas. This enables EFARO to keep track on recent developments in the complex European R&I landscape, and qualify ongoing discussions about the future R&I priorities essential for a sustainable blue economy.

This document represents EFARO's latest mapping and analysis of such developments, and are here presented as a four step analysis that provide the background for EFARO's recommendations on page 1-2. The four steps are here presented as:

- A.** An overview of the present state and future significance of the fisheries and aquaculture industry in Europe and globally.
- B.** An mapping of how the EU's strategic programming related to fisheries and aquaculture have evolved in structure, topics and funding from Framework Program 4 (FP4) through Horizon 2020 (H2020).
- C.** A detailed analysis of what stakeholder priorities (14 agendas developed 2013-16) have been covered by the EC's key funding instruments 2012 - 2019, to what degree and whether these priorities are still valid and present in recent science agendas issued in 2017-2018.
- D.** A synthesis of EFARO's recommendations related to programming implementation and priority topics, based on the results from step a, b and c as well as input from the EFARO's seminar on "The reformed CFP: An analyses what went wrong, what went well and how the next CFP should look like", held in Brussels on 24. May 2018, and the results from step 3 in the analysis.

To EFARO's knowledge, this work presents the most comprehensive analysis of extent to which the EU has addressed known R&I gaps and needs and what priorities remain to be addressed for fisheries and aquaculture beyond H2020. It is thus the hope, that the derived recommendations will provide inspiration for all stakeholders engaged with developing EU's capacity to pursue the goals related to EUs strategies on Blue Growth, the Bioeconomy, Food 2030, and the 2030 Agenda for Sustainable Development etc., within the analysed areas.

The state and future significance of the fisheries and aquaculture industry in Europe and globally



Fisheries and aquaculture represent the primary production in EU's blue economy and thus supports multiple industries related to processing and preservation, retail and wholesale (European Union 2018). In the 2018 annual report on the European Blue Economy, fisheries and aquaculture were found to support 530,000 jobs creating an added value of 18,6 billion EUR in 2016. This represented a growth in employees of 4% compared to 2009 and a 22% growth in the added value compared to 2008.

The long-term growth expectations for the industries dependent on marine living resources are, however, much larger. These expectations are particularly fuelled by the anticipated global growth in demand for sustainable food and biomass, which the oceans have a particular potential to provide as highlighted in "Food from the Oceans" by EU's High Level Group of scientific advisors. Confirmation of this increasing global demand and corresponding increases in supply can be found in e.g. OECDs analyses of the Blue Economy (2016) or FAO's most recent fisheries and aquaculture status from 2016, which demonstrated an all-time record in global fish production (FAO 2018). In this analyses FAO found the global annual fish consumption to have risen 3,2% annually between 1961 and 2016, hereby exceeding even the rise in meat consumption (2,8%). This translated into a growth in the global per capita fish consumption from 9,0 kg in 1961 to 20,2 kg in 2015. These considerable growth trends are not anticipated to change significantly within the coming years, where FAOs most recent projection indicates a growth in consumption of 18% between 2016 and 2030. Opposite to the last century's reliance on increases in wild captures, the recent and future growth in production is mainly anticipated to be fuelled by increases in aquaculture, who's production is expected to exceed that of wild captures by 2020 (FAO 2018). Aquaculture alone is, thus projected globally to increase its production with 37% between 2016 and 2030.

Being aware of the benefits of positioning Europe as an important supplier and importer of aquatic food and biomass, for both job creation, food and nutrition security, the European Commission has over the past decades taken multiple strategic steps to increase Europe's competitiveness within fisheries and aquaculture. These steps have included the implementation of new policies (i.e. the Revised Common Fisheries Policy, the Marine Strategy Framework Directive, the Maritime Spatial Planning Directive) as well as funding of targeted RITD anticipated to support the industry's development towards a more environmentally, socially and economically sustainable practise and thus a more competitive state. In parallel value chain aspects on seafood and blue biomass production including safety consideration were addressed. This strategic funding has mainly been carried out as an integrated part of the FPs, supported to various degrees by Structural and investment funds such as the European Maritime and Fisheries Fund.

The evolution of focus areas in fisheries and aquaculture and the structure of programming from FP4 to H2020

In order for stakeholders such as EFARO to contribute to the pan-European dialogue on future RITD gaps and needs related to fisheries and aquaculture, it is a relevant starting point to consider the recent developments in the priorities and structure of the EU's FPs. One way to give an overview of this development is presented in figure 1 and 2. Here it should be noticed how the evolving ambitions for the overall topic of "fisheries and aquaculture" in Europe, over the years have included a variety of additional focus areas ranging from e.g. the environmental impact of the industries in FP4, spatial planning in FP7 to the sustainable food security in H2020.

The focus areas and structure of the FPs from FP4 to H2020			
FP4	Impact of environment on fishery and aquaculture, Effect on environment, Economical viability		
FP5	Integrated fisheries management and sustainable aquaculture	+ Product quality, human health and welfare	
FP6	Prio. 8: Support to policy (Ecosystem approach)	Prio. 6: Global (climate) change & ecosystems	Prio. 5: Food quality & safety
	Social impact	Spatial planning	Monitoring, control/surveillance, traceability
FP7	Theme 2 Food, agriculture, biotechnology	Theme 6 Environment and climate	
	None food	+ Cross sectorial approach incl. themes 5 (energy) & 7 (transport)	2010-13: Ocean of tomorrow
H2020	2014-17: Challenge 2 Sustainable food security	2014-17: Blue growth	Challenge 5: Climate & environment

Figure 1: The focus areas of the FPs from FP4 to H2020 (WP's 2014/15 and 2016/17) based on a mapping of call categories relevant for fisheries and aquaculture.

In addition to the development in the EU's fisheries and aquaculture policies, the categorisation of fisheries and aquaculture RITD has also undergone a change, as seen in multiple relocations in figure 1. In FP7, there has been a cross-sectoral focus, with fisheries and aquaculture related topics scattered throughout several parts of the program, which was later followed by the H2020's merger of the topics from "Climate & Environment" with "Blue Growth" in 2017, into one single "sub-program" where it is now an integrated part. Interestingly this appears to have reduced the focus on cross-sectoral "Sustainable food systems", allowing fisheries and aquaculture R&I to a more intrinsic part of the bioeconomy. This set-up was continued in H2020 under Blue Growth, however, being narrowed down again to blue bioeconomy in 2017 for the WP's 2018-20.

The introduction of mission-oriented approaches to R&I funding, has been advertised by the EU, as a new feature of Horizon EUROPE. From a marine and maritime perspective, it appears that this approach has already been tested in e.g. the Ocean of Tomorrow in FP7, which crossed several different DG's and FP7 components in addition to multiple scientific disciplines covering several economic sectors. It is EFARO's impression, that the success of this cross-cutting programme was the motivation for maintaining the cross-disciplinary ambitions in the following Blue Growth calls.

By going into greater detail with the specific calls, it is possible to identify several trends not just within FPs, but also between them (figure 2). These trends include for example the extending from more technical issues, such as assessing stock dynamics, to more integrated research as seen from FP4 to FP5 and further intensified in FP6 and beyond. These have resulted in calls with higher emphasises on e.g. multidisciplinary and stakeholder involvement. Similarly the introduction of ecosystem-based management in FP6 were further emphasised in FP7 and H2020. These and other topic related developments are illustrated in figure 2. An additional example is the emergence of the innovation focus in FP7, with the inclusion of SME's followed by the H2020 introduction of specific Innovation Actions.

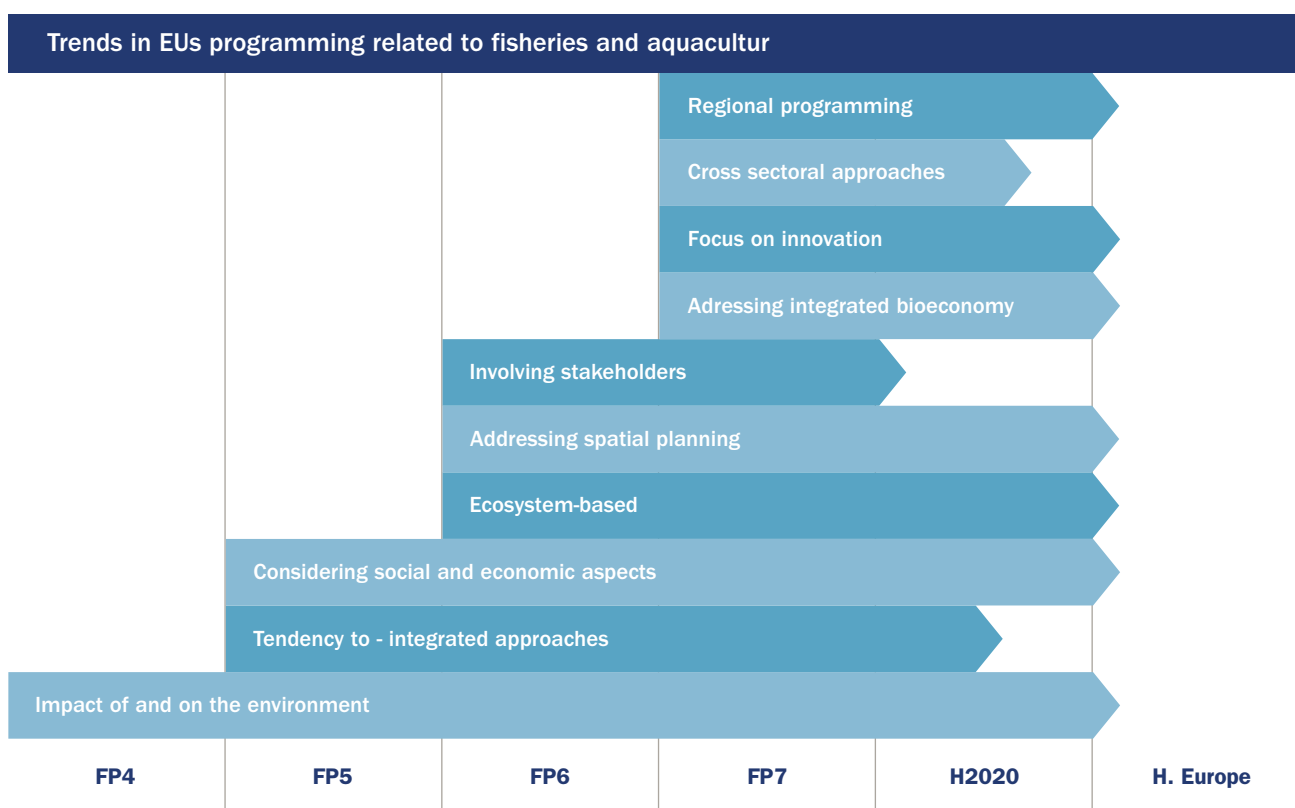


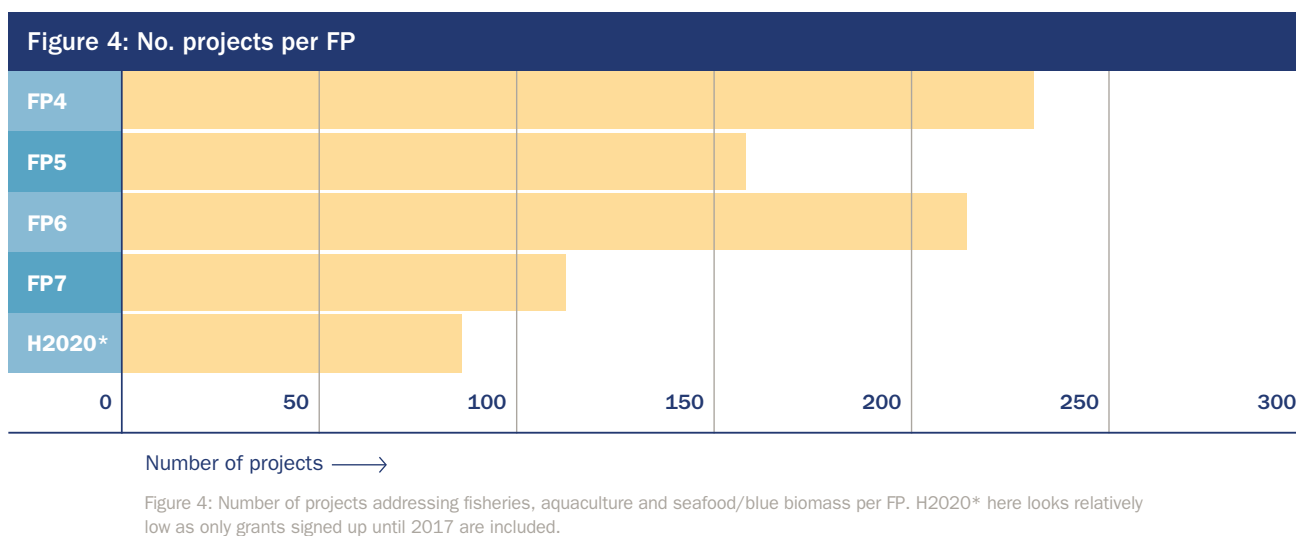
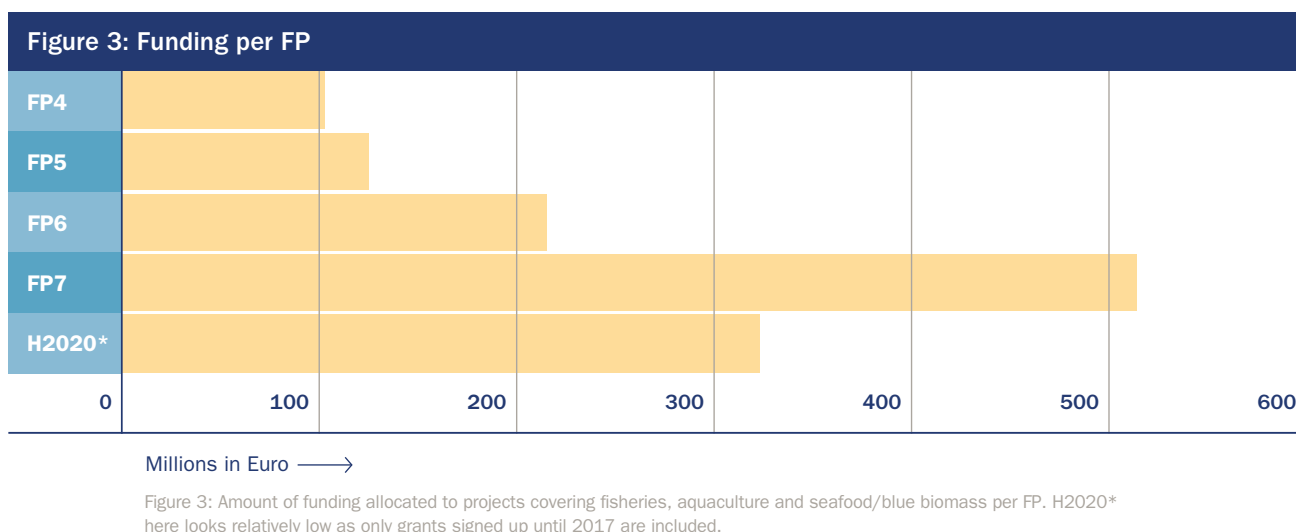
Figure 2: Identified trends in the EU's programming, based on funding for fisheries, aquaculture and marine research.



The reorganisation of fisheries and aquaculture topics in different programme parts and calls has, however, not been the only major change related to the practical implementation of EUs RITD priorities in this area. An additional change has been the move of fisheries and aquaculture FP programming from DG Mare to DG RTD in 2009. This move appears to have created a reduced focus on policy needs and ambitions, but increased focus on innovation. This creates a problem for coherent policy development and implementation, especially as several relevant directives are implemented on national level and EU regional sea basin strategies are not well developed.

An additional understanding of the EC's priorities can be achieved from an overview of the trends in funding between the different FPs. Figure 3-7 presents such overviews for the total number of projects funded within fisheries, aquaculture incl. seafood and blue biomass accounting also for related marine research projects. The data on FP4 and FP5 was compiled by the FP6 project IMPACT FISH, on FP6 by COM (2008) and Fuchs (2007), on FP7 period 2007-09 by Fuchs (2009). Data from 2012-13 onwards include Era-Nets, Art. 169/185 and JTI's, but not before. This will, however, not distort the overall picture as their volume was limited. Data on the total FP budget for FP4-7 are extracted from the EC's website¹. Data on H2020* are extracted from the EC's participant portal including all signed grants in H2020 between 2014 and 2017. For a more detailed description of the methodology behind the selection and analyses of data consult the annex.

¹ https://ec.europa.eu/research/fp7/pdf/fp-1984-2013_en.pdf#view=fit&pagemode=none



The total EU funding allocated to the area has increased from FP4 to FP7 from 100 mill. to >500 mill. EUR. When comparing FP7 and H2020 funding, it should be noted that funding allocated for 2018-2020 is missing in figure 3. The number of funded projects declined at least from FP6 to FP7 indicating larger project sizes. However, in the interpretation of these figures, including figure 5, 6 and 7, attention should be paid to the fact that EU changed the financial setup between the FP's with regard to counter financing and overhead percentages for involved project partners. Comparisons like the one presented here should thus be considered with this uncertainty in mind.

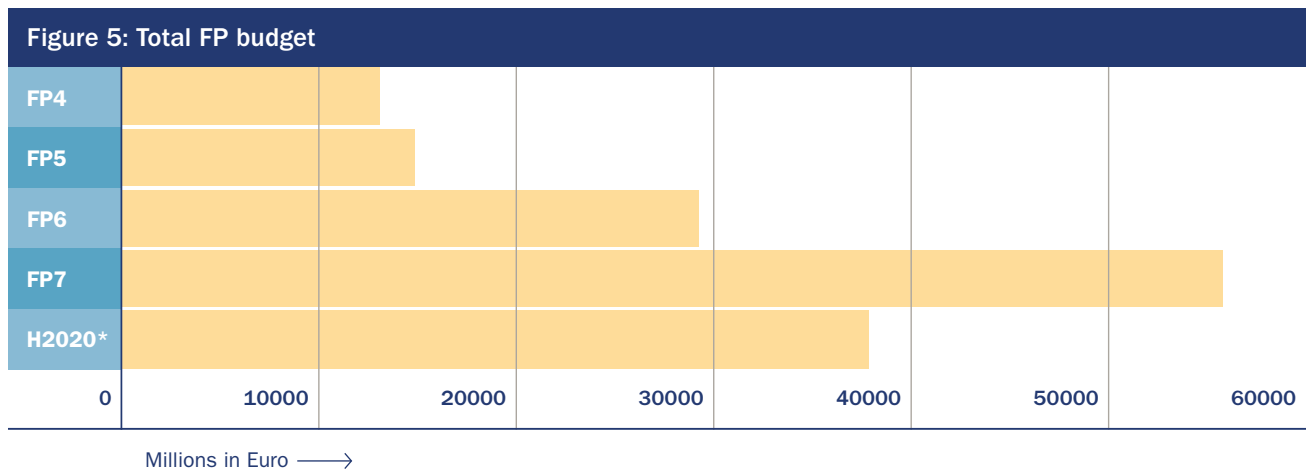


Figure 5: Total budget for FP4-7 and H2020. H2020* here only includes funding agreements signed up until 2017.

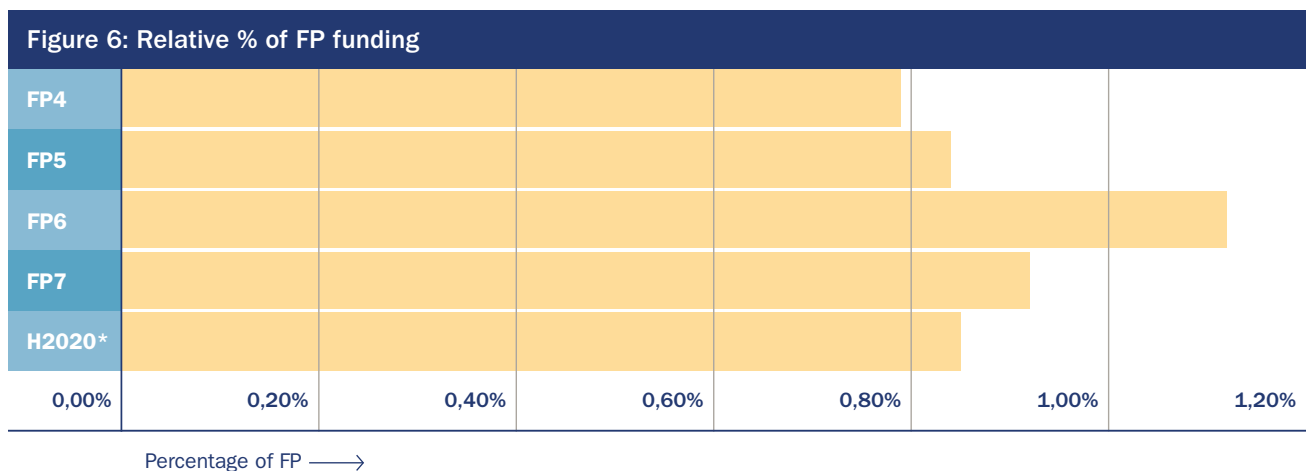


Figure 6: The relative percentage of EU funding allocated to fisheries, aquaculture and seafood/blue biomass per FP. H2020* here includes grants signed up until 2017.

Considering the relative share of fisheries, aquaculture and marine research funding (Fig. 6) from the total framework budget (Fig. 5), one can conclude, that the importance of the research areas is unchanged, i.e. ca. 0,9% of the framework funding is allocated to these areas. While prioritisation do take place among subtopics in this field, the overall EU ambitions have not changed substantially compared to other RITD topics over the past decades, (i.e. assuming a linear trend in figure 6, the increase is only 0,02%).

Going a step further down in the analysis we can observe the development in the number of supported projects (table 2), as well the average size of funding for each project in the FPs and their work programs (figure 7).

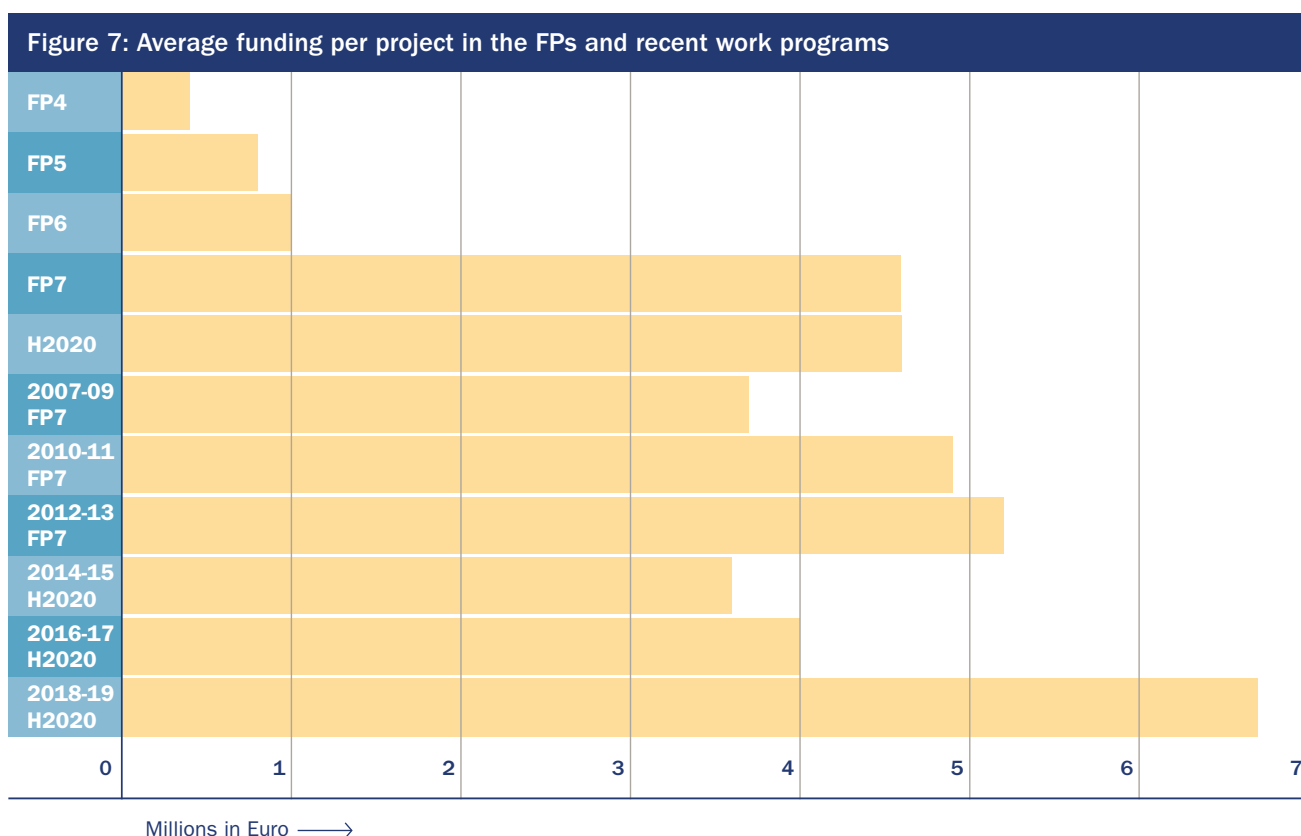


Figure 7: Trends in funding per project within and between FPs with data for 2018-19 representing the allocated funding in call texts.

Among notable observations, we here find a clear trend between FP4 and FP7 towards larger projects, with projects being generally broader and more complex due to increasing demands for both science, innovation, outreach and stakeholder involvement. Unsurprisingly this appears to have caused a decrease in the total number of projects with H2020 (figure 5) presently having planned only 121 (2014-2019, with 2020 still missing) projects compared to FP4's 231 projects.

This increase in project size and number of partners per consortium (not shown) appears however, to have been offset to some degree by overall increases in the average budget size per project (Fig. 7) as well as the total funding for the area (Fig. 3).

Taking a closer look at the most recent developments from mid FP7 through H2020, it is possible to observe how the different research areas have been prioritised in relation to the number of projects funded and the respective amounts of funding (table 2).

Trends in funding per research area							
RESEARCH AREAS	2012/13	2014/15	2016/17	2018/19	NO. PROJECTS	FUNDING (MILL. EUR)	FUNDING PER PROJECT
Fisheries	11/62,4	15/89,8	8/47,2	11/77,0	45	276,4	6,1
Aquaculture	17,5/84,8	17/36,8	11/48,2	13/90,5	58,5	260,3	4,4
Cross-cutting fisheries & aquaculture	7/33,5	6/17,9	5/18,6	7/38,5	25	108,5	4,3
Seafood/blue biomass and value chain	7/41,5	15/47,5	9/17,3	4/29,0	35	135,2	3,9
SUM	42,5/222,2	53/192,0	33/131,2	35/235,0	161,5	780,4	4,8

Table 2: Number of projects funded/funding amount (mill. EUR) for each research area.



As documented in table 2, fisheries and aquaculture have been allocated roughly the same amount of funding in recent years, with somewhat smaller projects in aquaculture. In contrast, the development from FP4 to FP7 was characterised by an increasing allocation of funding to aquaculture. In comparison cross-cutting projects related to fisheries and aquaculture have received 14% of the funding. Seafood, blue biomass & value chain get ca. 17% of the budget, with allocation being somewhat uneven over the years, and with reduced financing in most recent work programs. In all areas financing in 2016/17 was under the level of preceding and subsequent years.

Analyses of recent and future R&I priorities

In order to reach its goals related to e.g. the Blue Growth agenda, the EU like other R&I funding institutions, use input from key scientific organisations and stakeholders to qualify its scoping and implementation of R&I actions. Within European fisheries and aquaculture these stakeholders are organised in both short- and long term collaborations as well as strategic platforms such as EFARO it-self, SCAR, JPI Oceans, European Marine Board (EMB), ICES, European Technology Platforms (e.g. EATIP), ERA-nets (e.g. COFASP) and Article 185 actions (e.g. BONUS). To define their priorities most of these organisations produce strategic research and innovation agendas (SRIAs) and position papers identifying science and innovation needs. These strategic documents act as both an internal thematic scoping as well external communication to funding organisations including the EU, about what topics are of highest relevance to achieve progress in science and innovation. Publications of such documents hereby enables communities such as EFARO to keep track on the historic developments in high priority RITD topics as well as the tendency of e.g. the EU to address these topics through targeted funding.

In the following section we present the results of EFARO's latest analysis. The analyses aimed at firstly mapping the development in priorities and their funding as well as identify what recent priorities remain relevant for future funding. This analyses represent EFARO's key contribution to the ongoing discussions on RITD priorities within fisheries and aquaculture, with the final recommendations being particularly relevant for e.g. Horizon Europe.

Analytical approach

In order to arrive at a list of prioritised RITD topics for each research area, both former as well as recent priorities and their coverage in EU's strategic funding were considered in the analyses. This was done, by taking a 4 step approach (figure 6), of which the main steps are described below, with the full details supplied in the annex.

- 1.** As a first step, priorities identified in SRIAs and position papers (n 14) by key scientific organisations and stakeholder communities during the period 2013-2016 (incl. reviews/updates issued in 2017) were identified. This process was structured so that priorities were assigned to a category of four predefined research areas: 1) Fisheries; 2) Aquaculture; 3) Cross-cutting priorities in fisheries and aquaculture; and 4) Seafood/blue biomass & Cross-cutting priorities considering the value chain. To reflect the relative importance of each priority within these research areas, priorities were scored based on the number of times they were mentioned in the strategic documents and subsequently ranked within their research area.
- 2.** The second step of analyses aimed at understanding the extent to which the identified priorities had been covered by EU's strategic funding instruments. To improve the accuracy of mapping research area 4, it was divided into two sub priorities (i.e. 4a Seafood/blue biomass and 4b Cross-cutting priorities). Coverage in funding for each priority was analysed by mapping funded projects in FP7's work programme (WP) 2012 to 2013 and H2020's WPs 2014 to 2019. In FP7 WPs the mapping included funding under "Cooperation: Food, Agriculture & Fisheries, Biotechnology" as well as ERA-Nets and Art. 185 actions. In H2020's WP's the mapping included funding under "Societal Challenges", Era-Net Cofund, Art. 185 and JTI's. In essence this part of the analyses had the aim to understand how the priorities had

been addressed, by which funding instrument, and which of the priorities remained to be addressed (i.e. those which had not received sufficient funding). In this part of the analyses, priorities were considered “sufficiently funded” when in total 20 mill. EUR or more were allocated to projects covering this specific priority.

3. The third step of the analyses focused on identifying to what extent the high priority topics, identified in step one, were reflected in more recent strategic agendas (i.e. new strategic documents and science plans issued in 2017-2018). Similar to the approach taken in step one, priorities from the recent agendas were scored and ranked according to the time they were mentioned, though with less confidence due to only four available strategic documents.
4. As the fourth and last step of the analyses, ranking, coverage in funding and presence in recent agendas were used to identify a final list of presently relevant research priorities, corresponding to EFARO's recommendations to prioritise these in future RITD funding. High priorities were defined as those which had a score of 3-4, i.e. were mentioned 3-4 times in the 4 new strategic documents, and were not or insufficiently funded. High to medium priority areas had a score of 2 without sufficient funding or a score of 3-4 with sufficient funding, but lacking coverage of an instrument. Medium priority areas had a score of 1 and were insufficiently funded or a score of 2 with sufficient funding, but lacking coverage by an instrument.

Analytical approach				
STEP 1	Priorities in 14 key strategic research agendas			
	Score			
	1. Fisheries	2. Aquaculture	3. Cross-cut. fish/aquaculture	4. Seafood/blue biomass + cross-cutting
	1. Fisheries	2. Aquaculture	3. Cross-cut. fish/aquaculture	4a. Seafood/blue biomass 4b. Cross-cutting all
STEP 2	Coverage in funding in FP7 and H2020 2012-2019			
STEP 3	Coverage in recent science plans			Priorities in 4 recent research agendas
STEP 4	Future priorities 1. Fisheries	Future priorities 2. Aquaculture	Future priorities 3. Cross-cut. fish/aquaculture	Future priorities 4. Seafood/blue biomass + cross-cutting all

Figure 8: The analytical approach used to identify future R&I priorities related to particular topics.



Results

Overall the analyses revealed a demand among stakeholders for funding in 11 high priority areas, 9 high to medium priorities, 8 medium priorities and 7 new areas.

These priorities are here presented, categorised and ranked according to research areas together with comments on the results as well as EFARO's general comments to topics and structure of future EU fisheries and aquaculture RITD.

1) Fisheries

The analysis identified 15 distinct priorities in the strategic documents issued between 2013 and 2017. Among these, 4 were found to be sufficiently funded (20 mill. EUR or more), 5 were funded, but with limited amounts (i.e. 5 to <20 mill. EUR), but only in one case covering both RIA and IAs as instruments. The remaining 6 priorities did not receive any or only marginal funding (0 to <5 mill. EUR). Both Era-nets and Art. 185 did fund smaller projects, though ranked as high priorities.

Most recent science plans (2017-2018) confirmed the necessity for funding in 5 high priority areas, 5 high to medium priority areas, however one (*Management evaluation strategies*) could be combined with a high priority area (*Integrated impact assessments*) and 2 medium priority areas, see table 4. One area, Data collection, was ranked as medium priority, although having a higher score; the reason being that it gets substantial funding through DG Mare and the EU Data collection framework financed under the European Maritime and Fisheries Fund.

In addition to these priorities, the new strategic documents revealed 3 new topics, being
 1) *Methods for assessing stock status* and allowing delivery of management advice for data poor; progress made, funded partly by DG Mare, but needs further attention (ICES 2018),
 2) *New advanced analytical and statistical tools*, such as machine learning (ICES 2018) and
 3) *Long-term impact of fisheries on genetic diversity* (STECF 2018), projects under FP6 have not resulted in methods being implemented.



The combination of both assessments therefore provide the general background for EFARO's recommendations, which are summarised in table 3.

Identified future research priorities for fisheries			
HIGH PRIORITY	HIGH/MEDIUM PRIORITY	MEDIUM PRIORITY	NEW TOPICS (2017-2018)
Integrated impact assessment	Institutional setting of regional management	New marine living resources	Data poor stock assessments methods, allowing delivery of management advice
MSY and management plans	Multispecies and fleet assessment models	Data collection	Advanced analytical and statistical tools such machine learning
Small scale/recreational fisheries	End to end ecosystem models		Long-term impact of fisheries on genetic diversity
Efficient, environmentally friendly fishing gears	Discards, ecosystem impact, avoidance, landing obligation and utilization		
Biological processes, lifecycle and distribution			

Table 3: A summary of identified research priorities for fisheries.

2) Aquaculture

The analysis of research priorities in aquaculture identified 14 distinct priorities in the strategic documents issued between 2013 and 2017. Among these, 7 were found to be sufficiently funded (20 mill. EUR or more), but 2 lack coverage by instruments (i.e. IA's missing). Additionally 3 were funded, but with limited amounts (i.e. 5 to <20 mill. EUR) and 2 of them last time in work programme 2013. The remaining 4 priorities did not receive any or only marginal funding (0 to <5 mill. EUR).

Era-Nets (16 projects) and Art. 185 projects (3 BONUS) addressed high level priorities and complemented the FP when there were no calls in e.g. in 2014/15 and 2016/17.

Most recent strategic documents (2017-2018) confirmed the former priorities to be still valid, though with some variations in the scoring. Clear necessities for financing were identified for 2 high priority areas, 2 high to medium priority areas and 2 medium priority areas, see table 4.

In addition to these priorities, the new strategic documents revealed 3 new topics: 1) *Microalgae* acc. to EU (2016, Food 2030) having complex genomes, confused taxonomy and there lacks knowledge about metabolism and growth, upscaling to year round systems with continuous harvesting not being ensured, 2) *Building with nature and multiuse of offshore structures* in a broader perspective, e.g. combining coastal protection activities with coastal aquaculture (EFARO 2017) and 3) *Climate change*, addressed implicitly in a number of priorities and in specific projects, will be increasingly important (STECF 2018), affecting all not fully controlled systems incl. parasites, biotoxins and HABs.

The combination of both assessments therefore provide the general background for EFARO's recommendations, which are summarised in table 4.

Identified future research priorities for aquaculture			
HIGH PRIORITY	HIGH/MEDIUM PRIORITY	MEDIUM PRIORITY	NEW TOPICS (2017-2018)
Offshore aquaculture systems	New species and diversification	Enhanced RAS production systems	Microalgae, biological production
Spatial planning tools for site selection	Circular economy incl. multi-trophic systems (IA)	Improve animal welfare	Building with nature, e.g. coastal defence systems allowing for food/feed production beyond safety from flooding alone
Small scale/recreational fisheries	End to end ecosystem models	Impacts of HAB's	Impact of climate change

Table 4: A summary of identified research priorities for aquaculture.

3) Fisheries and Aquaculture cross-cutting

In the analysis of research priorities in cross-cutting fisheries and aquaculture research, 4 distinct priorities were identified. Among these, 3 were sufficiently funded, but two were lacking a good instrument coverage (i.e. RIA's are missing). Additionally, 1 was funded insufficiently.

Era-Nets (2 projects) and Art. 185 projects (3 BONUS) addressed spatial planning and coastal zone management and supplemented especially in the latter area framework projects with insufficient funding.

Most recent science plans (2017-2018) confirmed the former priorities to be still valid, with 2 high priorities and 1 high to medium priority and medium priority each, see table 5. The high priority *Integrated ecosystem assessments and MSFD* received actually sufficient funding, but last time in 2015, however, plans for a call exist for 2020.

No additional priorities were identified by the new strategic documents. The assessment provides the general background for EFARO's recommendations which are summarised in table 5.

Identified future research priorities for cross-cutting fisheries and aquaculture			
HIGH PRIORITY	HIGH/MEDIUM PRIORITY	MEDIUM PRIORITY	NEW TOPICS (2017-2018)
Integrated coastal management	Predicting effects of human activities	Maritime spatial plans for different sectors (RIA)	
Integrated ecosystem assessments and MSFD			

Table 5: A summary of identified research priorities for aquaculture.

4a) Seafood/blue biomass

For seafood and blue biomass research, 5 distinct priorities were identified. Among these, only 2 were found to be sufficiently funded. Era-Nets (9,5 projects) and JTIs (BBI) addressed *Optimized production line* and *Organism screening & molecule extraction technologies* together with H2020 and FP7/H2020 projects. *Valorisation of underused catch/production* was only addressed by Era-Nets (3 projects) and *Certification and branding* by no project at all.

Most recent strategic documents (2017-2018) confirmed the former priorities to be still valid with 2 high and 1 high to medium priorities, see table 6.

No additional priorities were identified. The assessment provides the general background for EFARO's recommendations which are summarised in table 6.

Identified future research priorities for seafood and blue biomass			
HIGH PRIORITY	HIGH/MEDIUM PRIORITY	MEDIUM PRIORITY	NEW TOPICS (2017-2018)
Valorisation of underused catch/production	Risk benefit analyses for seafood consumption		
Certification and branding			

Table 6: A summary of identified research priorities for seafood and blue biomass.

4b) Cross-cutting all areas

In the analysis of research priorities in cross-cutting research priorities relevant to the full value chain, 4 distinct priorities were identified. Among these, 1 was sufficiently and 3 insufficiently funded, but all partly covered by topics addressing other priorities.

Era-Nets (1,5 projects) and Art. 185 (1 project) addressed *Biological molecules (omics)* and *Marine pollution*, respectively, both not at all or severely underfinanced by the framework programmes.

Most recent strategic documents (2017-2018) confirmed the former priorities to be still valid with 1 high to medium priority and 2 medium priorities, see table 7.

One new area was identified by STECF (2018), i.e. *Impact of global seafood trade*, though this could be covered by *Integrated production systems*, which has already been sufficiently funded, if one considers the new Era-Net Cofund on the Blue Bioeconomy.

The assessment provides the general background for EFARO's recommendations which are summarised in table 7.

Identified future research priorities for generally cross-cutting research			
HIGH PRIORITY	HIGH/MEDIUM PRIORITY	MEDIUM PRIORITY	NEW TOPICS (2017-2018)
	Impact of marine pollution	Biological molecules (omics)	Impact of global seafood trade on local fisheries, aquaculture, seafood production and communities.
		Social/economic adaptation in aquatic food production	

Table 7: A summary of identified research priorities for cross-cutting research.

Recommendations

To implement the present strategies for moving the Blue Growth Agenda forward in relation to fisheries and aquaculture, EFARO encourage the EC and other stakeholders to consider the following list of prioritised topics. These topics are built on the presented mapping and analysis presented in step 1 to 4 as well as input from the wider EFARO community provided during EFARO's seminar on "The reformed CFP: An analyses what went wrong, what went well and how the next CFP should look like", held in Brussels on 24. May 2018.

The identified priorities are here divided into two sections with section 1 comprising EFARO's list of priority RITD topics and section 2 providing EFARO's general recommendations related to the implementation of fisheries and aquaculture R&I programming.



Identified European priorities				
AREAS	HIGH PRIORITY	HIGH/MEDIUM PRIORITY	MEDIUM PRIORITY	NEW TOPICS (2017-2018)
Fisheries	<ul style="list-style-type: none"> - Integrated impact assessment - MSY and management plans - Small scale/ recreational fisheries - Efficient, environmentally friendly fishing gears - Biological processes, lifecycle and distribution 	<ul style="list-style-type: none"> - Institutional setting of regional management - Multispecies and fleet assessment models - End to end ecosystem models - Discards, ecosystem impact, avoidance, landing obligation and utilization 	<ul style="list-style-type: none"> - New marine living resources - Data collection 	<ul style="list-style-type: none"> - Data poor stock assessments methods, allowing delivery of management advice - Advanced analytical and statistical tools such machine learning - Long-term impact of fisheries on genetic diversity - Effects of management plans, MSY & capacity reduction - CFP reform 2013 – performance analysis
Aquaculture	<ul style="list-style-type: none"> - Offshore aquaculture systems - Spatial planning tools for site selection 	<ul style="list-style-type: none"> - New species and diversification - Circular economy incl. multi-trophic systems (IA) 	<ul style="list-style-type: none"> - Enhanced RAS production systems - Improve animal welfare - Impacts of harmful algae blooms 	<ul style="list-style-type: none"> - Microalgae, biological production - Building with nature, e.g. multi-use of structures - Impact of climate change
Cross-cutting fisheries & aquaculture	<ul style="list-style-type: none"> - Integrated coastal management - Integrated ecosystem assessments and MSFD 	<ul style="list-style-type: none"> - Predicting effects of human activities 	<ul style="list-style-type: none"> - Maritime spatial plans for different sectors (RIA) 	
Seafood/ blue biomass	<ul style="list-style-type: none"> - Valorisation of underused catch/ production - Certification and branding 	<ul style="list-style-type: none"> - Risk benefit analyses for seafood consumption 		
Cross-cutting all areas		<ul style="list-style-type: none"> - Impact of marine pollution 	<ul style="list-style-type: none"> - Biological molecules (omics) - Social/economic adaptation in aquatic food production 	<ul style="list-style-type: none"> - Impact of global seafood trade on local fisheries, aquaculture, seafood production and communities

Table 8: Identified European R&I priorities related to fisheries and aquaculture based on the analyses carried out in step 3, supplemented with and input from the EFARO seminar "The reformed CFP: An analyses what went wrong, what went well and how the next CFP should look like", held in Brussels on 24. May 2018 (here shown in green).



General recommendations

To implement the present strategies for moving the Blue Growth Agenda forward in relation to fisheries and aquaculture, EFARO encourage the EU and other stakeholders also to consider the following general recommendations:

- 1.** There appears to be limited impact of SRIAs and similar strategic documents from stakeholder communities on the allocation of EU funding. This leaves room for an enhanced dialogue.
- 2.** Analysing various SRIAs and similar strategic documents for a coherent picture of research priorities and contrasting against the allocated international funding is a complex, but useful approach to define future research and innovation needs.
- 3.** The combination of having regional and thematically smaller projects to address fisheries, aquaculture and seafood research and innovation needs, while having the larger/broader FP projects to address sectorial European/global and cross-sectorial issues appears to be a suitable approach and should be maintained.
- 4.** Cross coordination between the regular FP and subcomponents, e.g. Era-Nets, Art. 185, is well established, but can still be improved, as demonstrated for the Seafood and blue biomass area. To solve this, the coordinating role of JPI Oceans and of different regional CSA's and Cofunds should be emphasized more clearly.
- 5.** Policy development and implementation faces fundamental problems. The CFP and various environmental directives as well as the Integrated Maritime Policy and the Maritime Spatial Planning Directive are implemented within different governance systems, and by different institutional players, i.e. sector ministries, with little or no cross coordination on international, regional and national levels (Hoof and Kraus 2017). There is a need to address integrated policy development and implementation more explicitly in Horizon Europe.
- 6.** The link between FPs and Structural and Investment Funds causes difficulties, but should be encouraged, e.g. through regional strategies ensuring a closer coordination of nationally and regionally implemented programmes.
- 7.** Mission oriented work is not new in marine science. Some of the best examples are Oceans of Tomorrow under FP7 and Blue growth programmes under H2020 work programme 2014-2017. There is neither a conflict in relation to regional sub-programmes addressing these missions or having dedicated thematic programmes pushing science and innovation in specific sectors.

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1. Methods

The following section describes the performed analyses on page 3 and onwards in detail, encompassing i) a detailed analyses of topics funded in FP7 work programmes 2012 and 2013 and H2020 work programmes 2014 to 2019 addressing the research and innovation needs as identified in 14 research and innovation agendas issued in 2013 to 2017 (the latter including reviews and updates of earlier published documents) and ii) a check whether identified priorities are still valid and prioritised by most recent strategic documents issued in 2017 and 2018. As described in section Analytical approach in the main text, the analyses was carried out in four steps (figure 8), which are here explained in detail.

1.1 Identifying research and innovation priorities

Based on published SRIAs and key position papers from the marine, fisheries and aquaculture community 2013-2017 (table 9), a screening of priorities across the various organisation was conducted. It should be noted that SRIAs published in 2017 are included only when they are updates or reviews of earlier plans.

Recent key SRIAs and position papers used in the analyses of EU RITD priorities		
STAKEH. COMMUNITY	PUBLIC. MONTH/YEAR	PUBLICATION
BlueMed	4/2017	Strategic Research and Innovation Agenda (first update of version from 2015)
BONUS	1/2014	Strategic Research Agenda 2011-2017 (2014 updated version)
COFASP	12?/2016	Strategic Research Agenda for Fisheries, Aquaculture and seafood Processing
EATIP	10/2017	A Review of the Strategic Research and Innovation Agenda from 2012
Europ. Marine Board	6/2013	Navigating the Future IV
EFARO	5/2013	Marine fisheries science priorities
EFARO	6/2013	Key topics for scientific support to the European Aquaculture Strategy
EFARO	10/2014	Res. priorities for the H2020 2016/17 work program. Addendum to the Key topics
EFARO	8/2016	Research priorities for the H2020 SC2 2018 and beyond
ICES	1/2014	Implementing the ICES Strategic Plan 2014-2018
JPI Oceans	2/2014	Draft implementation plan
MBT	10/2016	Marine biotechnology Strategic Research and Innovation roadmap
SCAR	/2016	SCAR-Fish Report of Sub Group on Research Prioritisation
SCAR	1/2017	Topics of Scar-Fish interest for Fisheries, Aquaculture and Seafood Processing based on an analysis conducted in 2016

Table 9: The list of strategic publications detailing research priorities related to fisheries, aquaculture and marine science. It should be noted here that SRIAs published in 2017 are here included when they are updates or reviews of earlier plans.

The process was structured so that priority were assigned to a category of four predefined research areas: 1) Fisheries; 2) Aquaculture; 3) Cross-cutting priorities in fisheries and aquaculture; and 4) Seafood/blue biomass & Cross-cutting priorities considering all research areas involved in the value chain.

Starting with EFARO's own documents from table 9 the relative importance of each priority within these research areas was scored based on the number of times they were mentioned in the strategic documents and subsequently ranked within their research area. It should here be noted that the last category dealing with Seafood and cross-cutting aspects cannot be considered complete as it potentially could aggregate priorities on a higher level than fisheries and aquaculture alone.

Research priorities in Fisheries 2013-2017		
RANK	RESEARCH PRIORITIES	SCORE
1.	Integrated monitoring systems incl. new observation technology & adequate data bases	7
1.	Environmental, economic & socially integrated impact assessment of management incl. risk analyses	7
3.	Impact of climate change on living resources, biodiversity, ecosystem structure/function	6
3.	Implementation of MSY & spatially/fleet specific fisheries management plans considering as well regulatory, economic & social drivers	6
5.	Spatially explicit end to end ecosystem models , focus on fish & interaction with environment	5
5.	Selective, (also energy) efficient, environmentally friendly fishing gears	5
5.	New marine living resources , incl. open ocean mesopelagic systems & lower trophic levels	5
8.	Fisheries data collection incl. socio-economy using effective sampling tools/new approaches	4
8.	Multispecies & -fleet assessment models & medium- to long-term prediction capabilities	4
8.	Functional habitat & community mapping	4
8.	Fisheries management strategy evaluation tools for multiple objectives incl. stakeholders	4
12.	Discards , role in ecosystems, avoidance, landing obligation & utilization	3
13.	Biological processes, lifecycles & distribution incl. environmental interactions	2
13.	Small scale and recreational fisheries management	2
13.	Institutional setting of regional fisheries management systems incl. cross sectorial aspects	2

Table 10: The list ranks the identified priorities in fisheries RITD, with highest ranking representing those with highest score i.e. those priorities which were mentioned the most.

Research priorities in Aquaculture 2013-2017		
RANK	RESEARCH PRIORITIES	SCORE
1.	Circular economy concepts , e.g. through integrated multi-trophic aquaculture	8
2.	Feed as far as possible from sustainable sources & nutrition, growth & condition	7
3.	Genomics, breeding & hatching incl. tools & measures for quality	6
4.	New species & diversification	5
4.	Enhanced RAS production systems	5
4.	Environmental impact , e.g. minimizing use, losses and emissions of water, pollutants, antibiotics, medicaments, escapees & spread of pathogens/diseases	4
7.	Combatting pathogens & diseases	4
7.	Improve animal welfare	4
7.	Seaweed & micro-algae production for human consumption, feed & biorefinery	4
7.	Integrated environmental, economic & social impact assessment incl. risk analyses	4
11.	Offshore aquaculture systems	4
11.	Spatial planning , decision support tool for site selection	3
11.	Data collection using real time technology & involving stakeholders, incl. socio-economics	3
13.	Impacts of HABs on aquaculture	1

Table 11: The list ranks the identified priorities in aquaculture RITD, with highest ranking representing those with highest score i.e. those priorities which were mentioned the most.

Cross-cutting fisheries and aquaculture priorities 2013-2017		
RANK	RESEARCH PRIORITIES	SCORE
1.	Maritime spatial plans for different sectors incl. multi-usage	7
2.	Integrated coastal management	4
3.	Integrated ecosystem assessments & MSFD implementation , identify pressures & impacts	3
3.	Predicting effects of human activities on ecosystems & ecosystem services	3

Table 12: The list ranks the identified priorities in cross-cutting fisheries and aquaculture RITD, with highest ranking representing those with highest score i.e. those priorities which were mentioned the most.

Research priorities in Seafood & Blue Biomass 2013-2017		
RANK	RESEARCH PRIORITIES	SCORE
1.	Risk benefit analyses for seafood consumption incl. technology for traceability and control of quality	5
1.	Valorisation of underused catch/production components and enhance utilization incl. use for none-human consumption	5
3.	Certification and branding	4
4.	Optimised production line , i.e. catching/aquaculture, processing and storage	3
4.	Chemical and biological biodiversity organism screening and molecule extraction technologies	2

Table 13: The list ranks the identified priorities in seafood and blue biomass RITD, with highest ranking representing those with highest score i.e. those priorities which were mentioned the most.

General cross-cutting research priorities 2013-2017		
RANK	RESEARCH PRIORITIES	SCORE
1.	Impact of marine pollution on food webs & seafood, exploration, mitigation & remediation	5
2.	Omics, i.e. study on biological molecules that translate into the structure, function & dynamics of organisms	5
3.	Social & economic adaptation in aquatic food production	4
3.	Closer integration of fisheries, aquaculture and seafood/blue biomass production	3

Table 14: The list ranks the identified priorities in general cross-cutting research priorities addressing the entire value chain, with highest ranking representing those with highest score i.e. those priorities which were mentioned the most.

1.2 Funding coverage of priorities

Allocation of financial resources to the identified priorities were the focus of the next part of the analyses. Here coverage in funding for each ranked priority was analysed by mapping projects granted in FP7 WPs 2012 to 2013 and H2020 WPs 2014 to 2019. The analysis does only include projects under the pillars “Cooperation” (FP7) and “Societal challenges” (H2020). For FP7s the mapping included funding under “Food, Agriculture & Fisheries, Biotechnology” as well as ERA-Nets and Art. 185. For H2020 the mapping included funding under “Societal Challenges”, Era-Net Cofund, Art. 185 and JTI's. Funding through the pillars “Excellent Science” and “Industrial Leadership” were not considered, due to lack of direct relevance. Tenders funded by the Commission were not included, neither were funding by structural and investments funds and JPIs.

To assign a year of funding, the time of the call (year) was used for each funded project during the period 2012-2017. While funding could be allocated to specific priorities in most cases, some projects covered more than one priority. In these cases funding was allocated proportionally without considering the real allocation to different priorities. Similarly, for topics including both terrestrial and aquatic components, a 50/50 split was assumed. For 2018 and 2019 calls, the allocated topic specific funding is indicated and when covering several priorities by one topic, the envisaged number of projects and their budget was distributed proportionally over priorities/work programme years.

In this part of the analyses, priorities were considered “sufficiently funded” when in total 20 mill. EUR or more were allocated to projects covering this specific priority. Funding below 5 mill. EUR were classified as insufficient.

From 15 priorities in fisheries, only 4 were sufficiently funded (1., 3. and two times 8. rank), while 4 priorities were not funded at all (1., 3., 8. and 13. rank), see table 15 below. However, the priority 13 was addressed by a tender issued by DG MARE. Additionally two priorities got only marginally funded (<2 mill. EUR). IA's were in general seldom issued (only in 2 priorities).

Research priorities in Fisheries 2013-2017 and coverage in EU funding							
RANK	RESEARCH PRIORITIES	2012/13	2014/15	2016/17	2018/19	PROJECTS	FUNDING
1.	Integrated monitoring systems incl. new observation technology & adequate data bases	5/20,5	4/37,2	2/3,9	2/15,0	9 RIA, 2 IA, 2 P	76,6
1.	Environmental, economic & socially integrated impact assessment of management incl. risk analyses					0	0
3.	Impact of climate change on living resources, biodiversity, ecosystem structure/function	3/28,6	3/12,8		5/32,0	11 RIA, 1 P, 1 CSA	73,4
3.	Implementation of MSY & spatially/fleet specific fisheries management plans considering as well regulatory, economic & social drivers					3 P	0
5.	Spatially explicit end to end ecosystem models , focus on fish & interaction with environment	1/3,6	1/0,63	1/2,8		1 RIA, 1 IA	7
5.	Selective, (also energy) efficient, environmentally friendly fishing gears	1/6		1/6		2 RIA	12
5.	New marine living resources , incl. open ocean mesopelagic systems & lower trophic levels				2/12,0	3 RIA	12
8.	Fisheries data collection incl. socio-economy using effective sampling tools/new approaches			2/23,9	1/9,0	0,5 P	32,9
8.	Multispecies & -fleet assessment models & medium- to long-term prediction capabilities		0,5/0,3			4 RIA, 0,5 P	0,3
8.	Functional habitat & community mapping		3,5/26,1		1/9,0	0	35,1
8.	Fisheries management strategy evaluation tools for multiple objectives incl. stakeholders					2 RIA	0
12.	Discards , role in ecosystems, avoidance, landing obligation & utilization		2/10,9			2 RIA	10,9
13.	Biological processes, lifecycles & distribution incl. environmental interactions	1/3,7		2/10,6		2 RIA, 1 P	14,3
13.	Small scale and recreational fisheries management					0	0
13.	Institutional setting of regional fisheries management systems incl. cross sectorial aspects		1/1,9			1 P	1,9

Table 15: Research priorities in fisheries 2013-2017 and FP coverage in number of projects/and allocated funds (mill. EUR). Projects are here divided into IA's (innovation actions), RIA's (research and innovation actions), P's (smaller to mid-sized Era- Net, Art. 185 or JTI projects with a maximum of 4 mill. EUR) and CSA's (coordination and support actions with a maximum of 4 mill. EUR).

From 9 Era-Net/Art. 185 projects funded, 4, 5 were allocated in 3 priorities where no FP7/H2020 funding was available and 3 further addressed high ranked priorities (see table 16 below), which indicates largely complementary call formulation.

Research priorities in Fisheries 2013-2017 and coverage in FP's vs. thematic and reg. programmes					
RANK	RESEARCH PRIORITIES	FP7/H2020 NO. PROJECTS	FP7/H2020 (MILL EUR)	ERA-NETS & ART. 185 (NO.)	ERA-NETS & ART. 185 (MILL. EUR)
1.	Integrated monitoring systems incl. new observation technology & adequate data bases	11	70,2	2	6,4
1.	Environmental, economic & socially integrated impact assessment of management incl. risk analyses	0	0	0	0
3.	Impact of climate change on living resources, biodiversity, ecosystem structure/function	12	69,5	1	3,9
3.	Implementation of MSY & spatially/fleet specific fisheries management plans considering as well regulatory, economic & social drivers	0	0	0	0
5.	Spatially explicit end to end ecosystem models , focus on fish & interaction with environment	0	0	3	7,0
5.	Selective, (also energy) efficient, environmentally friendly fishing gears	2	12,0	0	0
5.	New marine living resources , incl. open ocean mesopelagic systems & lower trophic levels	2	12,0	0	0
8.	Fisheries data collection incl. socio-economy using effective sampling tools/new approaches	3	32,9	0	0
8.	Multispecies & -fleet assessment models & medium- to long-term prediction capabilities	0	0	0,5	0,3
8.	Functional habitat & community mapping	4	34,8	0,5	0,3
8.	Fisheries management strategy evaluation tools for multiple objectives incl. stakeholders	0	0	0	0
12.	Discards , role in ecosystems, avoidance, landing obligation & utilization	2	12,0	0	0
13.	Biological processes, lifecycles & distribution incl. environmental interactions	2	10,6	1	3,7
13.	Small scale and recreational fisheries management	0	0	0	0
13.	Institutional setting of regional fisheries management systems incl. cross sectorial aspects	0	0	1	2,9

Table 16: Research priorities in fisheries 2013-2017 and coverage in specific instruments, described using the number of projects/and allocated funds (mill. EUR)

From 14 priorities in aquaculture, 7 were sufficiently (20 mill. EUR or more) funded (1. to 4. and 7. rank), while 2 priorities were not funded at all (11. and 14. rank), see table 17 below. Additionally two priorities got only marginally (<3 mill. EUR) and 3 insufficient (<20 mill. EUR) funding. IA's were more often used, than in the fisheries area (in 6 priorities).

Research priorities in Aquaculture 2013-2017 and coverage in EU funding							
RANK	RESEARCH PRIORITIES	2012/13	2014/15	2016/17	2018/19	PROJECTS	FUNDING (MILL. EUR)
1.	Circular economy concepts, e.g. thro integrated multi-trophic aquaculture	4/25,2	1/0,8			4 RIA, 1 P	26,0
2.	Feed as far as possible from sustainable sources & nutrition, growth & condition		3/3,4	1/2,9	4/28,0	4 IA, 3 P	34,3
3.	Genomics, breeding & hatching incl. tools & measures for quality	1/6,0	1/0,3	2/1,5	3,5/21	2,5 RIA, 2 IA,	28,8
4.	New species & diversification	2/9,9				3 P	9,9
4.	Enhanced RAS production systems		2/1,8	1/1,0		1 RIA, 1 IA	2,8
4.	Environmental impact , e.g. minimizing use, losses and emissions of water, pollutants, antibiotics, medicaments, escapees & spread of pathogens/ diseases	2,5/6,5	0,5/3,4		3/24,0*	3 P	33,9
7.	Combatting pathogens & diseases	2/10,0	4/14,7	2/3,1		4,5 RIA, 1,5	27,4 RIA
7.	Improve animal welfare		1/1,7			1 A	1,7
7.	Seaweed & micro-algae production for human consumption, feed & biorefinery	2/9,4	3/4,2	2/19,7		4 RIA, 4 P	50,8
7.	Integrated environmental, economic & social impact assessment incl. risk analyses			3/20,0		3 RIA	20,0
11.	Offshore aquaculture systems					0	0
11.	Spatial planning , decision support tool for site selection		1,5/6,5			1,5 RIA	6,5
11.	Data collection using real time technology & involving stakeholders, incl. socio-economics	4/17,7				3 RIA, 1 IA	17,7
13.	Impacts of HABs on aquaculture					0	0

Table 17: Research priorities in aquaculture 2013-2017 and FP coverage, described using the number of projects/and allocated funds (mill. EUR). Projects are here divided into IA's (innovation actions), RIA's (research and innovation actions), P's (smaller to mid-sized Era-Net, Art. 185 or JTI projects) and CSA's (coordination and support actions).

In 2014/15, 13 out of 17 projects were funded by Era-Nets and Art. 185. A similar pattern, was observed in 2016/17 were 6 out of 11 projects were funded by these instruments. In comparison only 1 out of 17,5 projects were funded by Era-Nets and Art. 185 in 2012/13, and 0 out of 12,5 in 2018/19, see table 18 below. This demonstrate temporal coordination, while funding from Era-Nets and Art. 185 addressed all highly ranked priorities (with one exception).

Research priorities in Aquaculture 2013-2017 and coverage in FP's vs. thematic and reg. programmes					
RANK	RESEARCH PRIORITIES	FP7/H2020 NO. PROJECTS	FP7/H2020 (MILL EUR)	ERA-NETS & ART. 185 (NO.)	ERA-NETS & ART. 185 (MILL. EUR)
1.	Circular economy concepts, e.g. thro integrated multi-trophic aquaculture	4	25,2	1	0,8
2.	Feed as far as possible from sustainable sources & nutrition, growth & condition	4	28,0	4	6,3
3.	Genomics, breeding & hatching incl. tools & measures for quality	4,5	27,0	3	1,8
4.	New species & diversification	2	9,9		
4.	Enhanced RAS production systems			3	2,8
4.	Environmental impact , e.g. minimizing use, losses and emissions of water, pollutants, antibiotics, medicaments, escapees & spread of pathogens/ diseases	6	33,9		
7.	Combatting pathogens & diseases	4	22,3	4	5,5
7.	Improve animal welfare			1	1,7
7.	Seaweed & micro-algae production for human consumption, feed & biorefinery	5,5	46,5	4	4,7
7.	Integrated environmental, economic & social impact assessment incl. risk analyses	3	20		
11.	Offshore aquaculture systems				
11.	Spatial planning , decision support tool for site selection	1,5	6,5		
11.	Data collection using real time technology & involving stakeholders, incl. socio-economics	4	17,7		
14.	Impacts of HABs on aquaculture				

Table 18: Research priorities in aquaculture 2013-2017 and coverage in specific instruments, described using the number of projects/and allocated funds (mill. EUR)

From 4 priorities in the area of cross cutting fisheries and aquaculture, 3 were sufficiently (20 mill. EUR or more) funded (1. and 3. rank), while 1 priority (2. rank) was insufficiently (<20 mio. EUR) funded, see table 19 below. In total 8 out of 26 projects were CSA's addressing 3 priorities indicating the conceptual and strategic importance of the cross cutting area. RIA's are missing under priority *Predicting effects of human activities*, while IA's are missing under priorities *Integrated coastal management and Integrated ecosystem assessments and MSFD*.

Cross-cutting research priorities in fisheries and aquaculture 2013-2017 and coverage in EU funding							
RANK	RESEARCH PRIORITIES	2012/13	2014/15	2016/17	2018/19	PROJECTS	FUNDING (MILL. EUR)
1.	Maritime spatial plans for different sectors incl. multi-usage		2/4,0	3/11,6	3/18,0	5 IA, 2 CSA, 2 P	33,6
2.	Integrated coastal management	2/8,4	2/5,2	1/5,0		2 RIA, 3P	18,6
3.	Integrated ecosystem assessments & MSFD implementation, identify pressures & impacts	5/25,1	1/6,7			5 RIA, 1 CSA	31,8
3.	Predicting effects of human activities on ecosystems & ecosystem services		1/2,0	1/2,0	4 /20,5	1 IA, 5 CSA	24,5

Table 19: Research priorities in cross-cutting fisheries and aquaculture 2013-2017 and FP coverage, described using the number of projects/and allocated funds (mill. EUR).

Projects funded by Era-Nets/Art. 185 addressed priorities ranked 1. and 2., especially the priority *Integrated coastal management*, which was insufficiently funded directly under the framework programmes, see table 20 below.

Cross-cutting research priorities in 2013-2017 and coverage in FP's vs. thematic and reg. programmes					
RANK	RESEARCH PRIORITIES	FP7/H2020 NO. PROJECTS	FP7/H2020 (MILL EUR)	ERA-NETS & ART. 185 (NO.)	ERA-NETS & ART. 185 (MILL. EUR)
1.	Maritime spatial plans for different sectors incl. multi-usage	7	28,8	2	4,8
2.	Integrated coastal management	2	9,4	3	9,2
3.	Integrated ecosystem assessments & MSFD implementation, identify pressures & impacts	6	31,8		
3.	Predicting effects of human activities on ecosystems & ecosystem services	6	24,5		

Table 20: Research priorities in the cross-cutting area between fisheries and aquaculture 2013-2017 and coverage in specific instruments, described using the number of projects/and allocated funds (mill. EUR)

From 5 identified priorities in Seafood and Blue biomass, the 3 highest ranked were insufficiently or not at all funded (4 mill. EUR or lower), with only 1 RIA issued in work programme 2012, see table 21 below.

Research priorities in Seafood & Blue Biomass in 2013-2017 and coverage in EU funding							
RANK	RESEARCH PRIORITIES	2012/13	2014/15	2016/17	2018/19	PROJECTS	FUNDING (MILL. EUR)
1.	Risk benefit analyses for seafood consumption incl. technology for traceability and control of quality	1/4,0				1 RIA	4,0
1.	Valorisation of underused catch/production components and enhance utilization incl. use for none-human consumption		2/2,7	1/0,9		3 projects	3,6
3.	Certification and branding					0	0
4.	Optimised production line , i.e. catching/aquaculture, processing and storage		4/11,8	1/7,0	0,5/3,5	2 RIA, 2,5 IA, 2 project	22,3
4.	Chemical and biological biodiversity organism screening and molecule extraction technologies	4/32,0	9/33,0	4,5/5,5	0,5/3,5	7 RIA, 1,5 IA, 9,5 projects	73,5

Table 21: Research priorities in seafood and blue biomass 2013-2017 and FP coverage, described using the number of projects/and allocated funds (mill. EUR).

Era-Nets (9,5 projects) & JTI (BBI) addressed *Optimized production line and Organism screening & molecule extraction technologies* together with H2020 and FP7/H2020 projects, see table 22 below. *Valorization of underused catch/production* was in contrast only addressed by Era-Nets (3 projects).

Research priorities in Seafood & Blue Biomass 2013-2017 and coverage in FP's vs. thematic and reg. programmes					
RANK	RESEARCH PRIORITIES	FP7/H2020 NO. PROJECTS	FP7/H2020 (MILL EUR)	ERA-NETS & ART. 185 (NO.)	ERA-NETS & ART. 185 (MILL. EUR)
1.	Risk benefit analyses for seafood consumption incl. technology for traceability and control of quality	1	4,0		
1.	Valorisation of underused catch/production components and enhance utilization incl. use for none-human consumption			3	3,6
3.	Certification and branding				
4.	Optimised production line , i.e. catching/aquaculture, processing and storage	3,5	20,5	2	1,8
4.	Chemical and biological biodiversity organism screening and molecule extraction technologies	8,5	62,5	9,5	11,0

Table 22: Research priorities in Seafood & Blue Biomass 2013-2017 and coverage in specific instruments, described using the number of projects/and allocated funds (mill. EUR)

4 cross-cutting priorities addressing the entire value chain were identified. The 3 highest ranked priorities were insufficiently or not at all funded (5 mill. EUR or lower), with only 1 RIA issued in work programme 2013, see table 23 below. The priority *Integrated production systems* was in contrast funded also by an Era-Net Cofund to be implemented in 2019, which can be expected to cover also *Social and economic adaptation*, presently uncovered.

General cross-cutting research priorities 2013-17, coverage in funding and presence in recent science plans							
RANK	RESEARCH PRIORITIES	2012/13	2014/15	2016/17	2018/19	PROJECTS	FUNDING (MILL. EUR)
1.	Impact of marine pollution on food webs & seafood, exploration, mitigation & remediation			1/2,8		1 P	2,8
2.	Omics", i.e. study on biological molecules that translate into the structure, function & dynamics of organisms	1/3,5		1,5/1,5		1 RIA, 1,5 P	5,0
3.	Social & economic adaptation in aquatic food production						0
3.	Closer integration of fisheries, aquaculture and seafood/blue biomass production	1/2,0			3/22,0	1 ERA-Net Cofund, 1 RIA, 1 IA, 1 CSA	24

Table 23: Research priorities in the cross-cutting area between fisheries, aquaculture and seafood/blue biomass 2013-2017 and FP coverage, described using the number of projects/and allocated funds (mill. EUR).

Era-Nets (1,5 projects) & Art. 185 (1 project) address *Biological molecules (omics)* and *Marine pollution*, respectively, both priorities hardly addressed under the regular framework programme.

General cross-cutting research priorities 2013-167, coverage in FP's vs. thematic and reg. programmes					
RANK	RESEARCH PRIORITIES	FP7/H2020 NO. PROJECTS	FP7/H2020 (MILL EUR)	ERA-NETS & ART. 185 (NO.)	ERA-NETS & ART. 185 (MILL. EUR)
1.	Impact of marine pollution on food webs & seafood, exploration, mitigation & remediation			1	2,8
2.	Omics", i.e. study on biological molecules that translate into the structure, function & dynamics of organisms	1	3,5	1,5	1,5
3.	Social & economic adaptation in aquatic food production				
3.	Closer integration of fisheries, aquaculture and seafood/blue biomass production	4	24,0		

Table 24: Research priorities in the cross-cutting area between fisheries, aquaculture and seafood/blue biomass 2013-2017 and coverage in specific instruments, described using the number of projects/and allocated funds (mill. EUR)

1.3 Confirmation of identified priorities in recent science plans

The third step of the analyses focused on identifying to what extent the high priority topics, identified in step two, were reflected in more recent science plans from 2017-2018 (table 25).

Recent science plans from 2017-2018		
STAKEHOLDER COM.	MONTH/YEAR OF PUBLIC.	PUBLICATION NAME
EFARO	5/2017	A vision on the future of European Aquaculture
ICES	11/2018	ICES Scientific Committee: Science planning and priorities for ICES
SAPEA	11/2017	How can food and biomass be obtained from the oceans
STECF	4/2018	57th Plenary Meeting Report (PLEN-18-01)

Table 25: Science plans used to check validity of priorities identified in strategic agendas utilised in the 1st step of the analyses.

Similar to the analyses of priorities highlighted by earlier plans, the more recent strategic documents were equally used to confirm the importance of priorities as well as to identify distinct new topics. This allowed a more comprehensive comparison of individual priorities, their previous funding and present importance.

All priorities identified in 2013-2017 for the fisheries research area were confirmed by at least 2 new strategic documents, with the 4 highest ranked priorities 2013-2017 being present in 3-4 new science plans, see table 26 below. This included 2 priorities, which did not get any funding during the period 2012-2019, being *Integrated impact assessment of management and MSY* and Fisheries management plans. The other two priorities without any funding in 2012-2019 were mentioned 2 and 3 times, respectively. The latter priority *Small scale and recreational fisheries* was however recently addressed by a DG MARE tender. Other priorities with insufficient funding in 2012-2019 were mentioned as well 2-4 times in new science plans. In addition, the new science plans revealed 3 new topics, being 1) Methods for assessing stock status and allowing delivery of management advice for data poor stocks (ICES 2018), 2) *New advanced analytical and statistical tools* (ICES 2018) and 3) *Long-term impact of fisheries on genetic diversity* (STECF 2018).

Research priorities in Fisheries 2013-17, coverage in funding and presence in recent science plans					
RANK	RESEARCH PRIORITIES	PROJECTS 2012-19	FUNDING 2012-19	SCORE 2017-18	OTHER FUNDING/ REMARKS
1.	Integrated monitoring systems incl. new observation technology & adequate data bases	13	76,6	3	DG ENV tender
1.	Environmental, economic & socially integrated impact assessment of management incl. risk analyses	0	0	3	No funding
3.	Impact of climate change on living resources, biodiversity, ecosystem structure/function	13	73,4	4	Ok
3.	Implementation of MSY & spatially/fleet specific fisheries management plans considering as well regulatory, economic & social drivers	0	0	3	No funding
5.	Spatially explicit end to end ecosystem models , focus on fish & interaction with environment	3	7,0	2	Mostly Baltic projects
5.	Selective, (also energy) efficient, environmentally friendly fishing gears	2	12,0	4	Insufficient for fleet diversities
5.	New marine living resources , incl. open ocean mesopelagic systems & lower trophic levels	2	12,0	2	No IAs issued
8.	Fisheries data collection incl. socio-economy using effective sampling tools/new approaches	3	32,9	3	DG Mare tender, industry. (IA)
8.	Multispecies & -fleet assessment models & medium-to long-term prediction capabilities	0,5	0,3	2	Insufficient funding
8.	Functional habitat & community mapping	4,5	35,1	3	OK
8.	Fisheries management strategy evaluation tools for multiple objectives incl. stakeholders	0	0	2	No funding, BONUS 2012/14 not filled
12.	Discards , role in ecosystems, avoidance, landing obligation & utilization	2	12,0	3	No IAs issued
13.	Biological processes, lifecycles & distribution incl. environmental interactions	3	14,3	3	Insufficient for biological diversity
13.	Small scale and recreational fisheries management	0	0	3	No funding, DG MARE Project /action
13.	Institutional setting of regional fisheries management systems incl. cross sectorial aspects	1	1,9	2	Insufficient, SFS-20-2017 not filled

Table 26: Comparison of identified fisheries priorities 2013-2017 and their coverage in funding and presence in recent science plans. Additional remarks include more detailed information on e.g. significant other funding, tenders etc.

From the 14 aquaculture priorities identified in 2013-2017, 2 were not mentioned as priority any more in the strategic documents and 4 only once. These encompassed sufficiently funded (2), insufficiently funded (3) and not at all funded (1) priorities, see table 27 below. Priorities identified 3 times with insufficient funding 2012-2019 were *Offshore aquaculture systems* and *Spatial planning*, while *New species and diversification* was mentioned twice as priority. In addition to these priorities, the new science plans revealed 3 new topics: 1) *Microalgae* (EU 2016, Food 2030), 2) *Building with nature and multiuse of offshore structures* (EFARO 2017) and 3) *Impact of climate change* (STECF 2018).

Research priorities in Aquaculture 2013-17, coverage in funding and presence in recent science plans					
RANK	RESEARCH PRIORITIES	PROJECTS 2012-19	FUNDING 2012-19	SCORE 2017-18	OTHER FUNDING/ REMARKS
1.	Circular economy concepts, e.g. thro integrated multi-trophic aquaculture	5	26,0	3	No IA, last action in call 2015
2.	Feed as far as possible from sustainable sources & nutrition, growth & condition	7	34,3	3	Ok
3.	Genomics, breeding & hatching incl. tools & measures for quality	7,5	28,8	3	Ok
4.	New species & diversification	2	9,9	2	Last action in call 2013
4.	Enhanced RAS production systems	3	2,8	1	Insufficient funding
4.	Environmental impact , e.g. minimizing use, losses and emissions of water, pollutants, antibiotics, medicaments, escapees & spread of pathogens/ diseases	6	33,9	4	Ok, serves broad
7.	Combatting pathogens & diseases	8	27,8	1	Ok, but no IA
7.	Improve animal welfare	1	1,7	1	Insufficient funding
7.	Seaweed & micro-algae production for human consumption, feed & biorefinery	7,5	50,8	4	See EU (2016): Food 2030
7.	Integrated environmental, economic & social impact assessment incl. risk analyses	3	20,0	0	Ok
11.	Offshore aquaculture systems	0	0	3	Insufficient funding
11.	Spatial planning , decision support tool for site selection	1,5	6,5	3	Insufficient funding
11.	Data collection using real time technology & involving stakeholders, incl. socio-economics	4	17,7	0	DCF, last action in call 2013
11.	Impacts of HABs on aquaculture	0	0	1	Partly environmental impact

Table 27: Comparison of identified aquaculture priorities 2013-2017 and their coverage in funding and presence in recent science plans. Additional remarks include more detailed information on e.g. significant other funding, tenders etc.

All 4 priorities identified in 2013-2017 for the fisheries and aquaculture cross cutting research area were confirmed by at least 2 new science plans, with the highest ranked 3 priorities being present in 3 new strategic documents, see table 28 below.

Cross-cutting research priorities in fisheries and aquaculture 2013-17, coverage in funding and presence in recent science plans					
RANK	RESEARCH PRIORITIES	PROJECTS 2012-19	FUNDING 2012-19	SCORE 2017-18	OTHER FUNDING/ REMARKS
1.	Maritime spatial plans for different sectors	5	26,0	3	EASME tender, No RIA
2.	Integrated coastal management	7	34,3	3	Mostly smaller scale projects
3.	Integrated ecosystem assessments and MSFD	7,5	28,8	3	DG ENV tender, last action in call 2015.
3.	Predicting effects of human activities	2	9,9	2	Here most CSA allocated RIA missing

Table 28: Comparison of identified cross-cutting priorities in aquaculture and fisheries 2013-2017 and their coverage in funding and presence in recent science plans. Additional remarks include more detailed information on e.g. significant other funding, tenders etc.

All 5 priorities identified in 2013-2017 for the Seafood and Blue biomass research area were confirmed by at least 2 new strategic documents, with the 2 priorities being present in 3 new documents, see table 29 below. The latter were *Valorisation of underused catch/production* and *Certification and branding* being either only marginally or not at all funded.

Seafood and Blue biomass research priorities 2013-17, coverage in funding and presence in recent science plans					
RANK	RESEARCH PRIORITIES	PROJECTS 2012-19	FUNDING 2012-19	SCORE 2017-18	OTHER FUNDING/ REMARKS
1.	Risk benefit analyses for seafood consumption incl. technology for traceability and control of quality	1	4,0	2	Funding insufficient
1.	Valorisation of underused catch/production components and enhance utilization incl. use for none-human consumption	3	3,6	3	Funding insufficient
3.	Certification and branding	0	0	3	No funding
4.	Optimised production line, i.e. catching/aquaculture, processing and storage	6,5	22,3	2	ok
4.	Chemical and biological biodiversity organism screening and molecule extraction technologies	18	73,4	2	ok

Table 29: Comparison of identified general cross-cutting priorities in 2013-2017 and their coverage in funding and presence in recent science plans. Additional remarks include more detailed information on e.g. significant other funding, tenders etc.

From general cross-cutting priorities identified in 2013-2017 addressing the entire value chain, only 1 priority was mentioned 3 times in the new strategic documents, being in fact the only area with sufficient funding in 2012-2019. A priority not funded sufficiently mentioned twice was *Impact of marine pollution*, while other priorities were only mentioned once.

General cross-cutting research priorities 2013-17, coverage in funding and presence in recent science plans					
RANK	RESEARCH PRIORITIES	PROJECTS 2012-19	FUNDING 2012-19	SCORE 2017-18	OTHER FUNDING/ REMARKS
1.	Impact of marine pollution on food webs & seafood, exploration, mitigation & remediation	1	2,8	2	Funding insufficient, even if partly under Risk benefit analyses & Minimize environmental impact
2.	Omics", i.e. study on biological molecules that translate into the structure, function & dynamics of organisms	2,5	5,0	1	Partly under Organism screening & molecule extraction technologies
3.	Social & economic adaptation in aquatic food production	0	0	1	Considered partially under 4
3.	Closer integration of fisheries, aquaculture and seafood/blue biomass production	4	24,0	3	With new Era-Net COFUND sufficient

Table 30: Comparisen of identified general cross-cutting priorities in 2013-2017 and their coverage in funding and presence in recent science plans. Additional remarks include more detailed information on e.g. significant other funding,tenders etc.



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