RESEARCH & INNOVATION ANALYSIS REPORT

Climate Change Adaptation and Mitigation related to Aquaculture

SCAR FISH SWG | 10/11/2022

SCAR Support Team TST SCAR FISH SWG

SCAR
Standing Committee
on Agricultural Research

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1. Introduction

Aquaculture has become a very important socioeconomic sector worldwide. Aquaculture production is no longer just a complement to fishing, it is the animal farming with the greatest projection for the future (APROMAR 2015). According to the World Bank (2013) this expansion trend is expected to be continued and it is expected that by 2030 aquaculture will be able to supply more than 60% of the fish destined for human consumption. However, the most urgent concern is whether aquaculture growth is sustainable and fast enough to meet the projected demands exacerbated by a rapidly growing human population and a changing climate (Maulu et al. 2021). In aquaculture, most of the recent literature indicates that some changes in climate, such as rising temperatures, changing precipitation patterns, and increased frequency of some extreme events are impacting on water resources, while others are still emerging (reviewed in Reid et al. 2019; and Maulu et al. 2021). Understanding the effects of climate change on biological responses, resources, and economics in aquaculture is therefore a requirement. As climate change effects on aquaculture become better understood, innovative approaches for adapting aquaculture production will help to guide strategic planning, which will in turn define needs and expectations for research (Reid et al. 2019).

Currently, there is a portfolio analysis performed by DG MARE, where the H2020 aquaculture-related projects useful for the implementation of the priorities of the Sustainable Aquaculture Guidelines, as well as for the Mission Restore our Oceans and Waters have been evaluated. Results from aquaculture projects within five prioritized areas were included: 1. Environmental performance; 2. Climate change adaptation and mitigation; 3. Animal health and welfare; 4. Diversification (species, products, production methods); 5. Low-trophic aquaculture. Following this initiative, SCAR-Fish wanted to entrust the Tender Support Team (TST) with a portfolio analysis on EU national aquaculture projects for identifying research and innovation gaps. According to the TST, a portfolio analysis within aquaculture was a too broad topic, complex to execute properly, and it was decided to select one of the five prioritized areas for the portfolio analysis: the topic **Climate *Change Adaptation and Mitigation related to Aquaculture***.

2. Project selection methodology. Selection of the 30 most relevant projects

For the initial search of national projects addressing *"Climate change adaptation and mitigation related to aquaculture"*, information was first requested to SCAR-Fish members from their own countries, but feedback was very poor and only four forms were gathered (TST project request forms). Then, TST looked for projects on different resources and databases available online (Table 1), also following specific suggestions from the SCAR-Fish WG and by the TST's contacts (Library and archive of the University of Santiago de Compostela, Professional network of the TST members…).

The main keywords used for were aquaculture and/or climate change. Results were filtered considering only the national projects that were active from 2014 onwards. A first collection of 53 projects was identified using the aforementioned keywords, which was then filtered to obtain a list of the 34 most relevant projects (Supplementary File 1). For filtering, all the projects suggested by the SCAR-Fish WG got through the previously circulated TST project request form were considered, as long as they were directly related to the proposed topic. The remaining selected projects were filtered by the Fish TST according to the following criteria:

- The project addressed evaluation, mitigation and/or adaptation to climate change of aquaculture activities from a species-specific level to a broader and more integrative scale (i.e., Blue Economy or coastal management).
- The project had a significant budget to potentially achieve relevant results and impact (> 100,000€).

Based on these criteria, the initially selected project list covered 9 countries: Norway (12), Ireland (6), UK (6), France (4), Portugal (2), Belgium (1), Finland (1), Germany (1) and Spain (1) (Supplementary File 1).

Table 1. List of online databases visited for the selection of the 34 relevant projects.

GENERAL
Openaire
https://explore.openaire.eu/
BlueBioCofund
http://projectdatabase.cofasp.org/
ITALY
Istituto Superiore per la Protezione e la Ricerca Ambientale
https://www.cnr.it/en/research-projects/project-area/9618/gestione-sostenibile-ed-efficiente-delle-risorse-naturali-degli-ecosistemi-e-della-biodiversita-dta-ad002
Consiglio Nazionale delle Richerche
https://www.cnr.it/it/progetti-di-ricerca/progetti
FRANCE
L'Agence nationale de la recherche (ANR)
https://hal-anr.archives-ouvertes.fr/
PORTUGAL
FCT
https://www.rcaap.pt/projects.jsp

3. Selection of the final 10 project list. Overview

Based on the 34 projects selected by the TST, SCAR-Fish members were asked to rank the projects. The final selection of the 10 most relevant projects was done by the chair and vice-chair in collaboration with the SCAR-Fish representative from DG-RTD. Projects from UK were not included, neither those from EU countries that started in 2021 (It was not expected to have produced tangible results yet). The final selection was a subjective evaluation based on how relevant the project seemed to be for climate change adaptation and mitigation related to aquaculture, according to title, summary and goals (for further information consult Supplementary Files 2-10*).* Figure 1 display a schematic overview of the process followed for selection of the 10 most relevant projects. The 10 projects (summarized in Table 2) were in depth analyzed and search for project results, memories and scientific publications was conducted using different databases (Table 3).

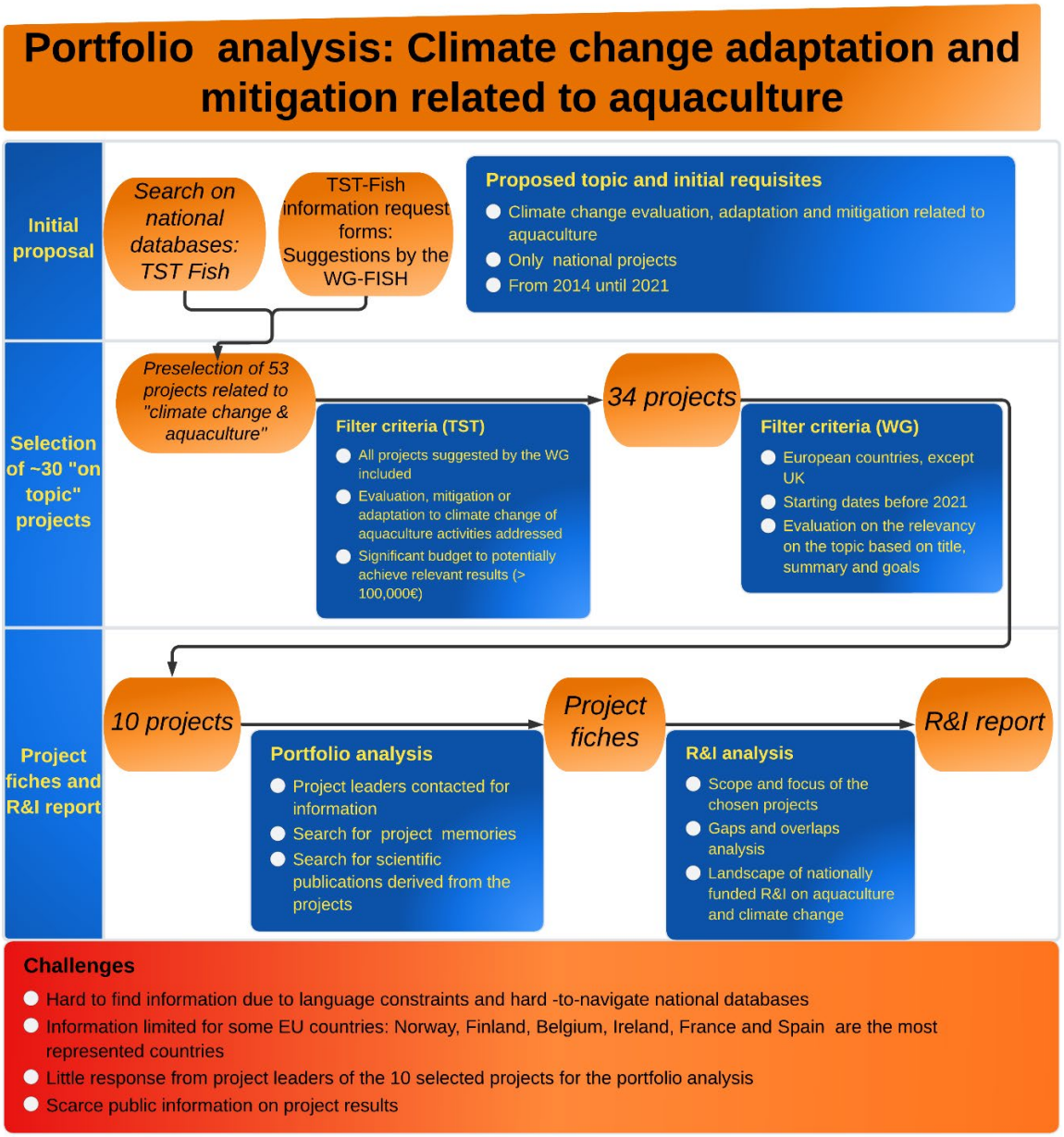

Figure 1. Workflow diagram followed for selection of the 10 most relevant projects

Table 2 Summary of 10 selected projects

Local effects of global warming: Effects of period of higher temperature than the normal range for Atlantic salmon		
PI	Sigurd Stefannson Sigurd.Stefansson@uib.no	The aim was to investigate the physiological mechanisms behind thermal stress in Atlantic salmon. Results suggest that prolonged periods of warmer conditions (GW) may impact growth performance in farmed Atlantic salmon related to endocrine regulation of food intake and energy expenditure and nutrient utilisation. High energy diets under hypoxia at a warm temperature indicates that it is possible to improve survival of salmon. Cells from temperature-stressed fish are more vulnerable to Cd and oxidative stress. High temperature can alter the osmoregulatory ability, carbohydrate metabolism and redox regulation in the lenses (cataract development risk). The project stablished a new method for detecting IGFBPs in Atlantic salmon as biomarkers for growth.
Budget (€)	800.000 €	
Country	Norway	
Institution	University of Bergen	
Category	Adaptation to climate change, Species-specific national project	
Adaptation of oyster-farming ecosystems to global change – GIGASSAT		
PI	Fabrice Pernet Fabrice.Pernet@ifremer.fr	The aim was to observe, analyse, and manage the effect of climate change on pacific oyster farming, particularly on disease transmission, and forecasting and communicating the results to stakeholders. The project is mainly focused on Ostreid herpesvirus 1 infection and how variations on climate-affected water parameters (pH, salinity, temperature, turbidity, tidal height) as well as food levels, growth rate and oyster energy reserves influence mortalities in individuals exposed to the virus. The project included a survey for oyster producers, that unveiled that climate-hazards were seen as a financial challenge but also a source of opportunities if rival farms are affected.
Budget (€)	615.104 €	
Country	France	
Institution	L'Institut Français de Recherche pour l'Exploitation de la Mer (IFREMER PFOM/LPI)	
Category	Adaptation to Global Warming, National aquaculture	
Aquaclimate-aquaculture, climate change, and knowledge: adaptation and Innovation		
PI	Céline Rebours celine.rebours@bioforsk.no	This project aims at exploring how the aquaculture sector relates to and applies knowledge on their strategic planning and policy making. In the databases and other sources used for the portfolio analysis there is lack of information regarding this project results and publications and even the budget allocated. The project expected outcomes include typologies for characterizing and identifying adaptation and innovative approaches to climate change in the aquaculture sector in coastal communities in the North, as well as guidelines for how scientific and professional knowledge can be applied in these processes.
Budget (€)	-unknown	
Country	Norway	
Institution	Nordland Research Foundation. Norwegian Institute of Bioeconomy Research	
Category	Adaptation, Mitigation, Evaluation, National policies related to climate change	

Deciphering multifactorial diseases: insight into oyster mortalities – DECIPHER		
PI	Guillaume Mitta mitta@univ-perp.fr	Integrated multidisciplinary research program focused on different levels of understanding on how the herpesvirus disease impact Pacific oyster aquaculture. It focuses on the study of the "oyster holobiont" (oyster and associated microbiota, including pathogens) integrated with changes in the environment and the history of interactions between this pathosystem and the emergence of the disease. This ambitious goal is now more feasible thanks to recent scientific and technical breakthroughs of this project: (i) a clear answer to the question of summer mortalities affecting oyster and (ii) solutions to improve the eco-efficiency of oyster culture and contribute to the sustainability of this industry.
Budget (€)	793.892 €	
Country	France	
Institution	University of Perpignan (UPVD)	
Category	Adaptation, National aquaculture	
Enhancing production and sustainability in Irish aquaculture – MOREFISH		
PI	Eoghan Clifford eoghan.clifford@nuigalway.ie	The aim was to enhance production efficiency and sustainability, reduce the impact of production and environmental emissions, and reduce finfish mortalities in rearing systems, all by testing improved operating conditions and innovative technologies using trout, salmon, and perch as models. Different aeration and oxygenation systems were studied. The global impact of fish farms in water quality was benchmarked in some model farms, addressing chemical effects and biological impact in the discharge points using previous and newly generated data. The global warming potential (GWP) was addressed at different points in the fish production/distribution chain and showed that the biggest contributors were feed production and transport.
Budget (€)	599.577 €	
Country	Ireland	
Institution	National University of Ireland	
Category	Mitigation	
Gulf of Bothnia as Resource for Sustainable Growth – SmartSea		
PI	Jari Haapala jari.haapala@fmi.fi	The aim was to provide science-based guidance and innovations for sustainable use of Finland marine resources using multidisciplinary expertise, accounting for climate change effects through modelling approaches to provide robust, long-lasting guidelines for marine exploitation. The project included protocols to improve the quality and accessibility of data, but mainly focused on modelling to study key climate-influenced phenomena like big wave events, Baltic ice conditions, behaviour of fjord-type estuaries in warmer climates, SOx and NOx emissions… as well as develop species distribution models and reflect the impact of different activities (bottom trawling, mineral extraction) in their survival.
Budget (€)	6.500.000 €	
Country	Finland	
Institution	Finnish Meteorological Institute	
Category	Adaptation, Mitigation, Evaluation	

Energy efficient PROcessing of MACroalgae in blue-green value chains –PROMAC		
PI	Annelise Chapman annelise@mfaa.no	PROMAC investigate macroalgae as novel raw materials for human food and domestic animal feed. The project evaluates different ways for processing (freeze-drying vs air-drying; high vs low temperatures) for quality products. *Palmaria palmata* contains high protein content of good quality. The macroalgae value chain produces proteins with nearby using naturally occurring marine phosphorus. High-value products such as fucoidan, polyphenols, and fucoxanthin, can be extracted. Positive effects of macroalgae on estimated uCP and fermentation parameters were observed with regard to grass silage in the feed ration. Such a substitution would largely increase the primary energy consumption of protein-rich feed ingredients, but would likely reduce eutrophication, mineral P depletion, as well as land and freshwater use. Heavy metal concentrations varied among species and sites, seasonal variations were minimal.
Budget (€)	3.500.000 €	
Country	Norway	
Institution	Moreforskning	
Category	Adaptation, Mitigation	
Adaptation Plan of the Spanish marine aquaculture sector to climate change – AQUADAPT		
PI	Patricia Quintas Pérez patricia.quintas@ieo.csic.es	This initiative aims to deepen the understanding of the impact of climate change on the marine aquaculture sector and to design adaptation actions aimed at reducing the vulnerability of the sector and increasing its resilience in the 2050 timeframe. These adaptation actions, specific to the sector, will be implemented at national or regional level, as impacts and vulnerabilities are specific to each location and each sector of activity. Contribute to the adaptation of the marine aquaculture sector (turbot, sea bream and sea bass as Atlantic and Mediterranean models) to the effects of climate change on the national territory.
Budget (€)	85.202 €	
Country	Spain	
Institution	Instituto Español de Oceanografía. Centro Oceanográfico de Vigo (CSIC)	
Category	Adaptation, Evaluation	
Beyond biofuel: Advanced seaweed cultivation for marine biodiscovery and climate change mitigation – BEYOND BIOFUEL		
PI	Nessa O'Connor n.oconnor@tcd.ie	The aim was to test methods for seaweed cultivation and quantify the role of seaweed farming for mitigation of climate change effects. "Beyond biofuel" addresses new methods of cultivating seaweed specifically grown to produce high value products, while also harnessing their associated biofuels, thus, developing a novel circular economy model aligned with strategies identified to support our bioeconomy. The project will test empirically whether cultivated seaweed can protect other
Budget (€)	1.300.000 €	
Country	Ireland	
Institution	Trinity College Dublin (TCD)	

Category	Adaptation, Mitigation	organisms from expected changes in ocean chemistry and we will simultaneously monitor the potential environmental effects of our seaweed cultivation methods. In addition, they model the potential for the future growth of these activities nationally and test how these methods can be used to mitigate and adapt to the impacts of our changing climate, thus, facilitating our transition to a low-carbon and climate-resilient society.
Carbon capture by hydrogen-oxidizing bacteria for protein creation for use in aqua feeds		
PI	Vukasin Draganovic vukasin.draganovic@skretting.com	The aim of this research was to show that HOB protein is a suitable ingredient for aquaculture feeding. This research project is the result of an agreement between Nutreco and Kiverdi for the application of Kiverdi's technology in the field of proteins for aquaculture. The ultimate goal of the collaboration is the global commercialization of an innovative microbial protein product for application in aquaculture feeding. Many of the key requirements for successful commercialization of Kiverdi SCP are already in place (patents registered by Kiverdi). The market demand and production capacity for the product have been well characterized by Nutreco for internal use or sale to other companies. Lack of information regarding this project results and publications. It is possible that the project may be linked to patent registration and confidentiality agreements. According to the project summary, fish performance and health results are anticipated to show that this product has sufficient value to warrant commercial production.
Budget (€)	330.000 €	
Country	Norway	
Institution	Skretting	
Category	Adaptation, Sustainable aquaculture	

Table 3. General description of all the databases consulted for the present report.

GENERAL	
Openaire https://explore.openaire.eu/	A comprehensive and open dataset of research information covering 145m publications, 18m research data, 305k research software items, from 110k data sources, linked to 3m grants and 178k organizations
BlueBioCofund http://projectdatabase.cofasp.org/	The available database is a product of the "related activities" implemented within the ERA-NET COFUND BlueBio and comprises research projects funded at international and national level in Fisheries, Aquaculture, Seafood Processing and Marine Biotechnology and active in the time period 2003-2022 (forecasted). It represents an implementation of the databases already developed within the COFASP ERA-NET, based

	on the project lists provided by the Bluebio cofunded partners
ITALY	
Istituto Superiore per la Protezione e la Ricerca Ambientale https://www.isprambiente.gov.it/en/projects	L´Istituto Superiore per la Protezione e la Ricerca Ambientale (ISPRA) is an Italian public research body, subject to the supervision of the Ministry of Ecological Transition. ISPRA participates in several projects financed by European Union Programmes relating to research and development, information sharing, training, and capacity building programs (FP7, LIFE, ENPI), international initiatives, working groups and technical and scientific committees, with reference to the protection of waters, air, soil, subsoil, marine and terrestrial biodiversity, as well as to the protection of nature and warm-blooded animals.
Consiglio Nazionale delle Richerche https://www.cnr.it/it/progetti-di-ricerca/progetti	The National Research Council (Italian: Consiglio Nazionale delle Ricerche, CNR) is the largest research council in Italy. As a public organisation, its remit is to support scientific and technological research
FRANCE	
HAL-ANR PORTAL https://hal-anr.archives-ouvertes.fr/	The HAL-ANR portal brings together and promotes all the scientific publications arising from projects funded by the ANR. The creation of this portal represents a new step in the implementation of the "open access to publications" section of the ANR's open science policy.
L'Agence nationale de la recherche (ANR) https://anr.fr/en/funded-projects-and-impact/funded-projects/	The National Research Agency's mission is to implement funding for research projects in France. It is the operator of the State and takes care of the organization of the selection, contracting, financing, monitoring, evaluation and impact of the projects and actions of the program on this field of action.
PORTUGAL	
Repositórios Científicos de Acesso Aberto de Portugal (RCAAP) https://www.rcaap.pt/projects.jsp	RCAAP Portal - It is a single point of search, location, and access to a vast set of scientific documents. As a national collector it has the function of aggregating and indexing the contents of different institutional repositories.
FCT - Fundação para a Ciência e a Tecnologia https://www.fct.pt/apoios/projectos/consulta/projectos	The FCT-Fundação para a Ciência e a Tecnologia supports the scientific community in Portugal through different funding instruments, aimed at scientists, research teams and R&D centres.
GERMANY	
Deutsche Forschungsgemeinschaft: DFG	GEPRIS: Find DFG-founded projects

https://gepris.dfg.de/gepris/OCTOPUS?task=showSearchSimple	Projects funded by the DFG. This information system provides a detailed overview of DFG-funded research projects, covering nearly all DFG funding programmes since the beginning of the 2000s.
SPAIN	
Programa Pleamar https://buscador.recolecta.fecyt.es/buscador-recolecta-proyecto	It is a platform that brings together all national scientific repositories and provides services to repository managers, researchers, and policy makers (public decision makers).
Fundacion Biodiversidad https://www.programapleamar.es/proyectos	The Biodiversity Foundation is a state public sector foundation created in 1998. It is a non-profit organisation set up to carry out activities of general interest related to the competencies of the Ministry for Ecological Transition and the Demographic Challenge, in the field of protection and conservation of our natural heritage and biodiversity.
FINLAND	
Research.fi https://research.fi/	Research.fi is a service offered by the Ministry of Education and Culture that collects and shares information on research conducted in Finland. The service improves the location of information and experts on research and increases the visibility and societal impact of Finnish research.
NORWAY	
The Research Council of Norway https://prosjektbanken.forskningsradet.no/en/explore/projects?Kilde=FORISS&distribution=Ar&chart=bar&calcType=funding&Sprak=no&sortBy=date&sortOrder=desc&resultCount=30&offset=30&Organisasjon.3=NASJONALT+INSTITUTT+FOR+ERN%C3%86RINGS-+OG+SJ%C3%98MATFORSKNING+%28NIFES%29&view=projects	The Research Council (also the Research Council of Norway; Norwegian: Norges forskningsråd) is a Norwegian government agency that funds research and innovation projects.
GREECE	
ΕΣΠΑ (Εταιρικό Σύμφωνο για το Πλαίσιο Ανάπτυξης) **Partnership Agreement (PA) 2014-2020** https://www.espa.gr/en/pages/BestPractices.aspx	The PA (Partnership Agreement for the Development Framework) 2014-2020 constitutes the main strategic plan for growth in Greece with the contribution of significant resources originating from the European Structural and Investment Funds (ESIF) of the European Union.
ANAPTYXI https://anaptyxi.gov.gr/en-us/PROJECTS-GRANTS#	ANAPTYXI.gov.gr is the official website of the Ministry of Economy and Development that provides detailed information on the progress of the implementation of the National Strategic Reference Framework (NSRF 2007-2013) and the Corporate Pact for Growth Framework (NSRF 2014-2020)).

CLIMATE ADAPT DATABASE	
https://climate-adapt.eea.europa.eu/knowledge/data-and-downloads	The European Climate Adaptation Platform Climate-ADAPT is a partnership between the European Commission and the European Environment Agency (EEA). Climate-ADAPT is maintained by the EEA with the support of the European Topic Centre on Climate Change Impacts, Vulnerability and Adaptation (ETC/CCA). Climate-ADAPT aims to support Europe in adapting to climate change helping users to access and share data and information on: -Expected climate change in Europe -Current and future vulnerability of regions and sectors -EU, national and transnational adaptation strategies, and actions -Adaptation case studies and potential adaptation options -Tools that support adaptation planning.

4. Scope and focus of the selected national projects

The selection of these 10 projects represented only five European countries, with three countries being represented by more than one project. This reflects both the different availability of information on accessible databases among countries, including some with a long aquaculture tradition like Mediterranean countries, but also the uneven funding among national agencies across Europe. However, according to Maulu et al. 2021, the effects of climate change on aquaculture have been extensively studied and reviewed both at regional and global scales. So, it would be interesting to investigate if some of the countries not represented in this portfolio have got other funding resources to address research on this topic, as for example, EU project calls. Moreover, it would be also important to ascertain the involvement of the European countries in projects on Climate Change Adaptation and Mitigation related to Aquaculture at a global rather than to a national scale. As climate change keywords are being introduced gradually in national calls, the representativeness of the European countries on this type of projects would be probably wider in the future.

Norway was represented with four projects focused on mitigation and adaptation of aquaculture to climate change from different perspectives: i) one species-specific project focused on Atlantic salmon growth influenced by global warming scenarios (Local effects of global warming: Effects of periods of higher temperature than the normal range for Atlantic salmon, TRL 3-5); ii) two projects focused, respectively, on macroalgae production sustainability and on hydrogen-oxidizing bacteria as potential alternative sources of protein for aquaculture (PROMAC and Carbon capture by Hydrogen-oxidizing bacteria for protein creation

for use in aqua feeds, TRL 4-5 and TRL 5-7); and iii) the fourth one focused on identifying the main industrial constraints and opportunities to adapt and develop innovative efforts related to adaptation to climate change (AquaClimate, National policies).

The two French projects were both focused on the impact of herpesvirus disease in oyster aquaculture and how it is influenced by climate change (GIGASSAT and DECIPHER, both TRL 4-6).

The two Irish projects focused on mitigation, although one tackled enhancing sustainability in Irish aquaculture through identifying key points in the fish production chain (MOREFISH, TRL 4-6), while the other proposed macroalgae cultivation to reduce the effects of climate change (BEYOND BIOFUEL, TRL 4-6).

The Spanish project (AQUADAPT; TRL 4-5) focused on national policies to fight against the effects of climate change to reduce the vulnerability of the marine aquaculture sector and increasing its resilience.

The Finnish project (SmartSea; TRL 5-6) evaluated the effects of climate change in the region of the Gulf of Bothnia, proposing modelling tools to study and predict both harmful climatic events and local population dynamics and their impact on fisheries and aquaculture production.

Except for SmartSea and, to some extent, AquaClimate and AQUADAPT, most projects were not directly focused on the effects of climate change on aquaculture, but rather on sustainability. SmartSea tackled the evaluation, adaptation, and mitigation of climate change effects. AquaClimate and AQUADAPT tried to identify and design national actions aimed at reducing the vulnerability of the aquaculture sector to climate change through national policies.

Some of these projects used the topic of climate change to justify studies on disease resistance and growth on important local species (i. e. French projects) and on improving energy efficiency for fish production (MOREFISH). The results of these projects seemed still far from application (TLR 4-6) and were to some extent academic (Project 1 – Norway; GIGASSAT; DECIPHER); nonetheless, they still represent useful models for other aquaculture species regarding the impact of climate change on important national cultured species.

Two of the selected projects focused on macroalgae production (PROMAC and BEYOND BIOFUEL) analysed their potentialities as highly valuable and sustainable aquaculture products. Although the topic seems to be similar, the approach and methodologies were quite different. While PROMAC investigated how macroalgae can be processed to become novel raw materials for human food and domestic animal feed, BEYOND BIOFUEL explores their effect on mitigating climate change and as sources of alternative energy.

Currently, it was not possible to report tangible results of the analysed projects and how to make them available to potential end-users. This could be the scope of an in-depth subsequent portfolio analysis.

5. Considerations on the landscape of nationally funded research and innovation on aquaculture and relevant climate change issues

The ten analysed projects represent a small fraction of the nationally funded aquaculture research in Europe. Consequently, the following considerations can be only considered as indicative, although relevant outcomes can be extracted for the future both at the national and the EU level. Figure 2 display a graphic summary of the *take home messages*.

All the 10 projects selected were to some extent related to the European Missions "Adaptation to Climate Change" and "Restore our Oceans and Waters". Namely, they approached blue economy climate-neutral and circular with net-zero maritime emissions and how to be prepared to deal with climate disruptions, such as global warming and infectious diseases, one of the main problems of aquaculture. However, the wide variety of approaches and methodologies among projects and, in some cases, the species-specific focus, considering their relevance for national aquaculture, made not possible to identity research and innovation gaps on the topic evaluated. On the other hand, other stages of the production system, such as trade and marketing of aquatic products were not included in the projects evaluated. Since the entire aquaculture value chain is vulnerable to climate change effect, future studies and models should have a broader focus and encompass all stages of the aquaculture value chain.

Given the broadness of the topic addressed, a greater coordination of member states within and among countries and EU Missions would benefit a common mainstream for future research and innovation projects. On this regard, European Partnerships (former ERANET), that involve common topics with national funding, could be a good opportunity to address the climate-related challenges that aquaculture faces in a coordinated way. Although climate change is a global food production risk, the associated risks on aquaculture are expected to differ across geographical or climatic zones, national economy, water environment, production systems, the scale of production, and cultured species of the aquaculture producers. Besides, the capacity of countries across EU for successful adaptation and mitigation to climate change is different. In this sense, IPCC (2018) strongly recommends international cooperation that promotes enhanced access to finances and technology and enhanced local capacities for developing nations and most vulnerable regions for effective action (Maulu et al. 2021).

Furthermore, a higher visibility of national projects at European level could facilitate the alignment of efforts among countries and better contribute to define integrated strategies to tackle climate change. For this purpose, it would be helpful to have national databases in English and even integrated at EU level that could be explored to combine national and EU research policies on aquaculture and climate change. Additionally,

some of the projects evaluated in this portfolio represent interesting models to be developed at national level, such as those retrieving information from stakeholders and producers on the impact of climate change on aquaculture production (Spanish and Norwegian projects; AQUADAPT and AquaClimate Aquaculture,Climate Change, and Knowledge: Adaptation and Innovation) the Finnish project on the Gulf of Bothnia (SmartSea) that represents a useful model to be developed at national level or integrating neighbour countries on the impact of climate change on suitable ecosystems that could be used to assess the impact on fisheries and aquaculture; and finally, those projects that address the impact of climate change on valuable national species would be important for specific EU countries, but also could provide suitable models on the impact of climate change on aquaculture that could be expanded to other species. And on the other way around, this information would be useful for adaptation strategies by the producers to shift to species that may be more resilient to the change in the climate.

Figure 2. R&I report: Take home messages

6. References

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Annex 1 Suplementary files 1-11

Please view zipped folder