# i34BLUE GROWTH

green innovation for blue growth

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## Handbook on Innovative Best Practices

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# Contents

# Acronyms and Abbreviations

| | |
|---|---|
| AEP | Annual Energy Produced |
| AI | Artificial intelligence |
| AIR | Atlantic International Research |
| ANI | Agencia Nacional de Inovacao |
| BBA | Blue Bio Alliance |
| BBA | Assosiacao Nacional Para os Biorecursos Marinhos e Biotecnologia Azul |
| BGI | Building Global Innovators |
| BSSC | Balticky Klaster Morsaki i Kozmiczny |
| CAD | Computer-Aided Design |
| CAE | Computer-Aided Engineering |
| CAM | Computer-Aided Manufacturing |
| C-ER | Clust-er Agroalimentare |
| CESTHA | Centro Sperimentale per la Tutela Degli Habitat |
| CMMI | Cyprus Marine & Maritime Institute |
| CTAQUA | Funadacion Centro Tecnologico Acuicultura de Andalucia |
| CTO | Centrum Techniki Okrętowej |
| EASME | Executive Agency for Small and Medium-sized Enterprises |
| EdM | Economia del Mare |
| EMFF | European Maritime and Fisheries Fund |
| ERDF | European Regional Development Fund |
| EU | European Union |
| FAO | Food and Agriculture Organisation |
| FER | Fakultet elektrotehnike i računarstva |
| GEO | Geonardo Ltd |
| GHG | greenhouse gas |
| GNC | Guidance, navigation and control |
| HAMAG-BICRO | Hrvatska agencija za malo gospodarstvo, inovacije i investicije |
| HUCAP | Human Capital Development Plan |
| IBYDA | Instituto de Biotecnología y Desarrollo Azul |
| ICT | Information and Communications Technology |
| IEO | Instituto Español de Oceanografia |
| IMO | International Maritime Organization |

| | |
|---|---|
| IMTA | Integrated Multi-Trophic Aquaculture |
| IoT | Internet of Things |
| ISBN | International Standard Book Number |
| JRC | Joint Research Centre |
| JRP | Joint Research Project |
| KPI | Key performance indicator |
| LLs | Learning Labs |
| LNG | Liquefied Natural Gas |
| Ltd | Limited liability company |
| MIPAAF | Ministero delle Politiche Agricole, Alimentari e Forestali |
| ML | Machine learning |
| MPA | Marine Protected Area |
| NAUSICAA | Societe d'exploitation du Centre National de la Mer |
| NSR | North Sea Region |
| OESA | Ocean Energy Scale-up Alliance |
| PET | Polyethylene Terephthalate |
| PLM | Product Lifecycle Management |
| PMBA | Pole Mer Bretagne Atlantique |
| R&D&I | Research and Development and Innovation |
| RAS | Recirculating Agriculture System |
| RDM | Rotterdamsche Droogdok Maatschappij |
| ROV | Remotely operated vehicle |
| RTG | Rubber Tyred Gantry Cranes |
| S&T | Science and Technology |
| SME | Small and medium-sized enterprises |
| STECF | Scientific, Technical and Economic Committee for Fisheries |
| STS | Science, Technology and Society |
| STS | Ship to Shore |
| SWIMS | Smart Warehousing Information Management System |
| TEN-T | Trans European Transport Network |
| TRL | Technology Rediness Levels |
| UAV | Unmanned aerial vehicle |
| UNESCO | United Nations Educational, Scientific and Cultural Organisation |
| UNIZG | University of Zagreb |

| | |
|---|---|
| VLIZ | Wlaams Instituut voor de Zee |
| VPGRA | Vice-Presidencia do Governo Regional Dos Acores |
| VR | Virtual reality |
| ZES | Zero Emission Services |

# Foreword

Blue area of the regions/countries participating in I3 4 Blue Growth project implementation encompasses numerous islands and seas which represent resource base for the establishment of new blue economy industries and the development of those existing. Although, the blue economy industry represents a significant economic sector on the EU level, and especially in the regions geographically covered by the project, a certain underdevelopment and insufficient level of R&D&I activities calls for further enhancement and exploitation of blue economy potentials and resources.

A sustainable approach to the exploitation of maritime and coastal resources is necessary to ensure the survival of our seas and maritime natural resources. The exploitation of the fish stock by overfishing, excessive use of fossil fuels, sea transport and climate change endangering marine habitats and indigenous species call for comprehensive and urgent actions to develop new policies, methods, legislative documents and technologies fostering clean blue industries and environmentally acceptable projects.

A quadruple helix approach is highly important to face the challenges of finding new sustainable ways for food and energy production reducing greenhouse gases emission, sea, land and air pollution, waste disposal and biodiversity preservation. Cooperation among international partners representing different European regions can contribute to achievement of goals by setting new collaborative groups of experts, research and educational institutions, public, private sector and non-governmental sector focusing on exchange of knowledge, experience and best practices, recognising positive initiatives, good investment examples and financing options.

# Acknowledgments

The Handbook on Innovative Best Practices is the result of the collective and cooperative engagement of all I3 4 BLUE GROWTH project partners. The task was led by the Croatian Agency for SMEs, innovation and investments which was a coordinator in drafting the handbook while other project partners contributed by identifying and collecting data on innovative blue projects and investments geographically located in their regions, being implemented or still under implementation.

The questionnaire was developed and used among project partners to gather information and identify pipelines of innovative investments. It was delivered to previously identified stakeholders from public sector, SMEs & industry, research and educational institutions etc. who were or still are performing

activities on the most interesting and prominent blue innovative practices undertaken in area of two specific value chains the I3 4 BLUE GROWTH is focusing on (sustainable fisheries, aquaculture and valorisation of blue resources; Renewable Marine Energy and maritime decarbonisation) and other blue economy sectors. The question sets were designed to gather fundamental project details, including descriptions of project activities, objectives, results and outcomes, implementation methods, challenges, and lessons learned.

This handbook is to be considered a living document and will be used by project partners in further project tasks/activities implementation and project deliverables achievement. However, public availability and further use of this handbook by subjects engaged in the blue economy could hopefully generate new ideas and good practices in European regions and countries. It is also envisaged to be used as a guideline for decision makers and other stakeholders in creating blue economy strategies and policies dedicated to further relationships development and strengthening knowledge and expertise to build together a more competitive, innovative and sustainable maritime blue bioeconomy.

# Disclaimer

The designation of geographical entities in this publication, and the presentation of the material, do not imply the expression of any opinion whatsoever on the part of HAMAG-BICRO or other participating organisations concerning the legal status of any country, territory, or area, or of its authorities, or concerning the delimitation of its frontiers or boundaries.

The views expressed in this publication do not necessarily reflect those of HAMAG-BICRO or other participating organisations.

All representatives of Best Practices have provided consent for their contact information to be made public. For further information about the best practices in this document please contact the relevant contact.

All views expressed are those of the authors and not necessarily reflect the views of the European Commission.

# Introduction

The implementation of the I3 4 BLUE GROWTH Project: Unlocking the potential of Sustainable Blue Economy started in January 2024. The project activities were split among ten project partners from different EU countries and regions. The main objectives of the project are to enhance capacities of less-developed coastal and insular European regions, to build and to reinforce innovative ecosystems, to transfer knowledge and good practices to support interregional collaboration, to identify innovative projects and investments and to promote a sustainable growth in blue economy specific value chains: 1) Sustainable fisheries, aquaculture and valorisation of blue resources; 2) Renewable Marine Energy and maritime decarbonisation.

The project aims to build up on regional stakeholders and SMEs technical readiness, business expertise and matchmaking and investment opportunities towards join interregional innovative projects. Implementation on project activities will be provided through scanning of interregional examples of policies, best practices and investments, study field trips and establishment of Q-helix expertise working groups to foster interregional knowledge, exchange experience and to connect with key European stakeholders in specific blue economy sectors.

This handbook is produced as a project deliverable in cooperation with all partners. As a publicly available document it can be used not only by project participating stakeholders but also by all interested entities from business, educational, research, governmental, and non-governmental area involved in respected blue economy sectors covered. Its purpose is to showcase various examples of new technologies and innovative blue economy projects primarily in the scope of two targeted value chains and secondary in other blue economy sectors. In the first phase, it's going to serve to all I3 4 BLUE GROWTH project stakeholders as an input to provide current overview into last technologies and regional/interregional European initiatives. It is also going to be used to help build a training and capacity building program and later to stimulate interregional investments among regional actors and blue economy SMEs.

The Handbook includes an introduction and three sections dedicated to different blue economy sectors. The first two sections focus on value chains targeted by I3 4 BLUE GROWTH: Part I covers sustainable fisheries and aquaculture, and Part II addresses maritime decarbonization and renewable energy. Part III explores other blue economy sectors and technologies.

This Handbook is intended for European coastal regions participating in the I3 4 BLUE GROWTH project. It presents examples and showcases best practices and innovative projects from six less developed regions in Portugal, Spain, Croatia, and Poland, as well as two more developed regions in the Netherlands and Italy, and two transition regions in Finland and France.

# Part I: Sustainable fisheries and aquaculture

## Sector analysis

Despite all its benefits, aquaculture production and consumption in the European Union (EU) has not grown at the same pace as in other parts of the world. Of the total consumption of fish and seafood by the average EU citizen, only 25% originated from aquaculture in 2022. EU aquaculture production only covered 10% of the seafood consumed in the EU and accounted for less than 2% of world production.[1]

In 2020, the EU aquaculture sector reached 1.2 million tons in sales volume and €3.9 billion in turnover value and directly employed around 57,000 people working for approximately 14,000 enterprises. The enterprises are primarily small, and family owned.

67% of the aquaculture production in the EU is concentrated in four countries: France, Greece, Spain, and Italy. More than half of the total aquaculture production volume focuses on shellfish, while marine and freshwater fish account for around 21% and 28% of the total volume. The most farmed species are mussels, trout, oysters, seabream, seabass, carp, and tuna. Algae production is still limited in the EU but is increasing. Related to production volume Spain with annual production of 276 562 tonnes is the biggest producer in EU.

On the other hand, if we consider annual production value, 42% of the value refers to marine aquaculture, while shellfish and freshwater take part of 30% and 28% of the total value. France with total annual income of €878,6 million is No. 1 producer in EU by production value.

In 2020, the EU aquaculture sector reached 1.2 million tons in sales volume and €3.9 billion in turnover value and directly employed around 57,000 people working for approximately 14,000 enterprises. The enterprises are primarily small, and family owned.

[1] European Commission, Directorate-General for Maritime Affairs and Fisheries, *A new strategic vision for sustainable aquaculture production and consumption in the European Union – Blue farming in the European Green Deal*, Publications Office of the European Union, 2021, **https://data.europa.eu/doi/10.2771/961425**

Top nine European aquaculture production spices include: Rainbow trout, Gilthead seabream, European seabass, Common carp, Atlantic bluefin tuna, Pacific cupped oysters, blue mussels, Mediterranean mussels and Sea mussels.[2] The most represented species in production in terms of quantity are Sea mussels with a share of 19% in total production. The European production structure in weight is presented in chart below.

Taking in consideration production by sales value current structure on European market is presented in chart by total production by value. Top five spices are: Rainbow trout, Gilthead seabream, European seabass, Atlantic bluefin tuna and Pacific cupped oysters. Rainbow trout is the most represented with a share in sales of 17%.

## Challenges

Challenges related to climate change, environmental protection and food production for the growing world population represent a global problem. The increase in average temperature, more and more frequent weather disasters such as floods, droughts and storms are causing global problems in food production, rising prices of food products and food availability for the growing world population. As for the seafood that is provided by fishing, this sector has been faced for a long time with significant problems, primarily the reduction of the fish stock population, which is caused by overfishing, but also other factors such as pollution of the sea and ocean, migration of fish species, destruction of fish habitats etc. The fishing sector is struggling with a series of problems and challenges to maintain the quantity of catch and the level of income and productivity that it achieved in past.

As for the aquaculture sector, there are also problems caused by the global changes, which put pressure on the sustainability of production and increase the risks for the efficient production of fish and shellfish. Despite this, the aquaculture sector, especially the cultivation of marine species, has not yet reached its peak, both in the valorisation of areas that can be used for the cultivation of various types of fish and shellfish, and in the development of new technologies and cultivation techniques that can potentially ensure higher levels of production either by solving current problems related to safer farming, reducing losses and increasing productivity or increasing production capacity in an ecologically sustainable and acceptable way, such as the possibility of farming in more remote locations and in the open sea.

[2] Scientific, Technical and Economic Committee for Fisheries – Economic Report on the EU aquaculture (STECF-22-17), Nielsen, R., Virtanen, J. and Guillen Garcia, J. editor(s), EUR 28359 EN, Publications Office of the European Union, Luxembourg, 2023, ISBN 978-92-76-99317-9, doi:10.2760/51391, JRC132648

Aquaculture can contribute to the substitution of food production that uses significant amounts of fossil fuels and artificial fertilizers and thus help in limiting the accelerated climate changes and the increase in the global temperature of the seas and oceans as well as the temperature of the atmosphere. According to FAO we need to increase sustainable aquaculture production by at least 75% by 2040 if we are going to limit global warming to 1.5C. Conclusion can be made than the main challenge of aquaculture is how to increase supply and at the same time reduce the environmental footprint.

## Opportunities

Aquatic food is a major component of our food future, and Blue Food from all species in marine and freshwater production, is rightly in the spotlight for its potential to provide healthy, tasty and highly nutritious food for the planet. Food systems transformation is a crucial requirement to mitigate climate impacts, reduce footprint, and offer enhanced food safety and security to billions. Aquaculture has demonstrated its resilience to change and is increasingly recognised for its environmental responsibility, reduced footprint and high efficiency in protein transformation and provision. As our knowledge increases, so does our potential ability to offer Green Solutions throughout the aquaculture (and seafood) value chain. These solutions need not only to be financially feasible, but they must also be based on the intelligent and sustainable utilisation of resources to maintain a measurable and limited footprint.[3]

During the past three decades, European aquaculture has expanded, diversified, intensified and made technological advances. The potential of this development to enhance food security and provide top quality animal protein for human consumption has been well recognized. Aquaculture will be able to provide food for the world's population in the future although this will depend on the capacity to expand and grow in a sustainable manner; on climate-driven changes in ecosystems productivity; and on the aquafeed industry reducing its reliance on wild fish. An important parameter for the cultured species is the development of sustainable cost-effective and nutritionally complete feeds, along with efficient feed management systems. Aquaculture "the farming of waters" is rightly viewed as an important contributor to the European economy and to the wellbeing and health of communities throughout Europe and in the more remote and rural areas. It has the potential to take the pressure off wild fish stocks whilst meeting the dietary needs of the population for omega 3 fatty acids, essential amino acids and other key

[3] BLUE FOOD, GREEN SOLUTIONS; AQUA 2024; European Aquaculture Society and World Aquaculture Society; www.was.org; www.aquaeas.org

nutrients such as vitamin D. The need to achieve sustainable aquaculture production to provide products for the expanding export market demand and for European consumers has never been greater.[4]

John Bostock, Alistair Lane, Courtney Hough and Koji Yamamoto conclude that an overall increase in production by 55 % is possible by 2030 based mainly on expansion of marine cage-based farming using larger systems in more exposed sites and similarly shellfish farming using larger-scale suspended systems.[5]

## Best practice examples

## Example 1: Management and recovery of waste from mussel farming (mitilicoltura)

***Company/Institution:*** M.A.R.E. Soc. coop. a r.l
***Location:*** Italy/Emilia-Romagna/Rimini
***E-mail:*** info@coopmare.com
***Web page:*** http://www.coopmare.com/

***About Coop Mare:*** Coop Mare is involved in scientific research and technical assistance for fishing, aquaculture, and the environment. The specific projects and research activities undertaken by Coop Mare are aimed at supporting and enhancing the blue bio value chain. This involvement includes the development and implementation of projects related to sustainable fishing practices, aquaculture, and environmental conservation within the marine ecosystem. The organization's focus on research and assistance in these areas contributes to the broader goals of sustainable exploitation and preservation of marine biomasses, which are crucial components of the blue bio value chain.

***Project description:*** This project is highlighted as a best practice example due to its comprehensive approach towards sustainability and environmental protection within the mussel farming industry. The initiative aims to promote the use of good practices in the handling of processing waste from mussel farming, specifically targeting the research and development of systems for the recovery of plastic materials and their subsequent recycling and reuse. The project aims to enhance the sustainability of mussel farming practices by addressing the issue of waste management, particularly the disposal and recycling of materials used in the process; To develop and implement systems for the recovery of plastic materials used in mussel farming. This includes the recycling and reuse of these materials, thereby reducing the environmental impact of the industry. The project intends to share its findings and best practices with other production realities along the regional and national coast, contributing to the reduction of plastic waste dispersion by farmers.

[4] Mente, E., Smaal, A.C. Introduction to the special issue on “European aquaculture development since 1993: the benefits of aquaculture to Europe and the perspectives of European aquaculture production”. Aquacult Int 24, 693–698 (2016). https://doi.org/10.1007/s10499-016-0003-3

[5] Bostock, John & Lane, Alistair & Hough, Courtney & Yamamoto, Koji. (2016). An assessment of the economic contribution of EU aquaculture production and the influence of policies for its sustainable development. Aquaculture International. 24. 10.1007/s10499-016-9992-1.

*Challenges:* The project encountered technical difficulties with the prototype machine designed for the treatment of polypropylene mussel nets. The machine, which was intended to separate the plastic component from organic matter, required several modifications to improve its efficiency and to prevent the generation of microplastics during the cutting process. The project aimed to simplify the management of special waste from mussel farming by proposing a management system analogous to that used in agriculture. This required navigating complex regulations and potentially changing the classification of the waste to allow for more straightforward management by cooperatives or consortia, reducing bureaucratic burdens on operators. There was a need to address the environmental impact of the project, particularly the potential generation of microplastics during the treatment process. If confirmed, this would necessitate rethinking the on-board treatment methods used by mussel farmers and exploring more traditional system. These challenges were addressed through a combination of iterative testing, collaborative efforts with various stakeholders, research into alternative solutions, engagement with regulatory bodies, and environmental risk assessments.

*Impact:*

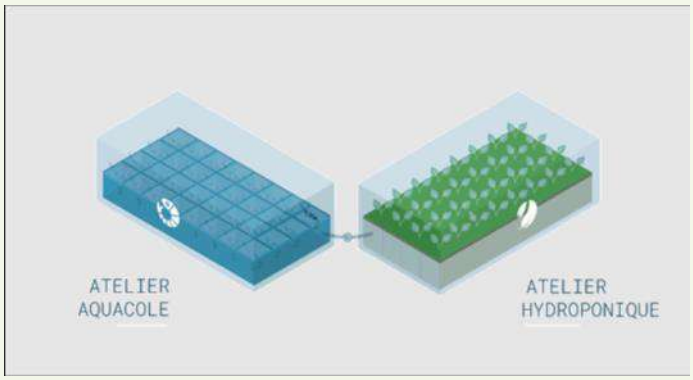
1) Collaborative Relationships: The project strengthened the collaboration between the productive sector and various waste management entities, initiating the process of recovery and recycling of plastic materials involved in mussel farming.
2) Waste Management Proposal: An interesting proposal for the management of special waste from mussel farming was advanced. This proposal envisioned a more simplified management of this type of waste, potentially relieving operators from certain bureaucratic obligations.
3) Operational Waste Management Methods: The project identified operational methods for managing waste from mussel farming that would facilitate onboard management and subsequent phases after landing.
4) Environmental Sustainability: The activities carried out by the project fully met the expectations in terms of environmental sustainability for the mussel farming sector.
5) Machine Prototype Development: Although the prototype machine for treating polypropylene nets faced technical challenges, it provided valuable information for future evaluations and projects on the topic.
6) Recycling and Reuse Trials: The project conducted trials for the recycling and reuse of polypropylene derived from treated nets, evaluating the technical characteristics of the resulting plastic material and identifying the best forms of reuse.
7) Good Practices for Waste Management: The project defined good practices for managing waste from mussel farming, aiming to limit accidental loss of nets during the breeding cycle and to manage plastic nets once they become waste.
8) Outreach and Training: Meetings were held with operators to disseminate the results and good practices, ensuring that the knowledge gained from the project was shared with a wider audience.

The initiative had a multifaceted impact on the blue bio value chain and related stakeholders by fostering collaboration, advancing innovative waste management proposals, involving sector operators, disseminating results, and contributing to environmental sustainability. These outcomes demonstrate the project's significant contribution to improving the sustainability and efficiency of mussel farming practices and the broader blue bio value chain.

*Lessons:* The project provided valuable lessons on the importance of collaboration, innovation in waste management, environmental sustainability, and the potential for recycling and reuse within the aquaculture sector. These insights can serve as a guide for other projects and stakeholders aiming to address similar challenges and promote sustainability in their operations.

## Example 2: Aquaponics for Prawn Cultivation in Saltwater

***Company/Institution:*** Agriloops
***Location:*** France/Brittany/Rennes
***E-mail:*** europe@polemer-ba.com
***Web page***: www.agriloops.com




***About Agriloops:*** Company aims to produce French-grown jumbo shrimp that are never frozen, are sustainably raised without antibiotics and near the end-consumer.

***Project description:*** The company conceives unique farms that combine shrimp production with market gardening. Deploying an aquaponics system, they are able to cultivate crustraceons and vegetables within a single system. The particularity of the system is that it represents the first time that mastery of the technique has been achieved while using saltwater. The jumbo shrimp market in France represents around 100,000 tonnes a year, mostly from Central America and South-East Asia. As tropical shrimp production is the number one cause of mangrove deforestation, threatening these carbon sinks, the ecological stakes of relocating production are high. The company's aquaponics model aims to produce local and premium premium prawns that are ultra-fresh because they are guaranteed never frozen and free of Antibiotics. After several years of research and development, a pilot farm was established to establish proof of concept. Agriloops built ties with wholesalers and restaurateurs. Consumer demand confirmed the viability of the concept. The company's unique patented aquaponics technology transforms effluent from prawns into fertiliser to co-produce fruit and vegetables with exceptional nutritional and taste qualities. With support from a variety of public and private investors as well as a successful crowdfunding campaign, a commercial demonstration site is currently under construction. When completed, it will be one of the largest aquaponics farms in Europe. It will be capable of producing over 100 tons of prawns and fresh vegetables per year.

***Challenges***: While aquaponics has been used with freshwater species, the challenge at the heart of this initiative is applying the principles of this mode of cultivation while using saltwater. Extensive research and development resulted in a patented process that has proved highly successful.

***Impact:*** The process has proven successful in biological, environmental, culinary and economic terms. Its application results in a large reduction in the use of fertilizer and a 90 percent decrease in water consumption compared to more traditional methods of cultivation. Successful fundraising and high consumer demand suggests promising long-term prospects for the company. Restauranteurs and wholesalers report high levels of satisfaction with the quality of the shrimp and of the market vegetables produced by the system. The freshness and sustainability of the system are marketable qualities that are appreciated by consumers.

***Lessons:*** Environmental sustainability and economic viability are not mutually exclusive and the former can serve as a driver of the latter. Through R&D, the company managed to innovate, bringing unprecedented to success to a process previously limited to freshwater. Businesses and end consumers are receptive to processes that bring production closer to them and which reduce the environmental impact and enhance the quality of the end product. Financial backing was secured from national and regional authorities, private investors, but also members of the broader public. The use of a pilot farm enabled the company to establish key ties with other businesses in their value chain and build confidence in the viability and the promise of their process.

## Example 3: The short supply chain of "forgotten" fish species

***Company/Institution:*** Economia del Mare
***Location***: Italy/Emilia-Romagna/Forlì-Cesena
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***Web page***: https://www.ecopesce.com/
***Phone:*** *+39 0547 1908 340*

***About Economia del Mare:*** EdM is a company focused on a zero-waste retrieval project for "forgotten" fish species. These are fish species of low economic value or surplus that are usually discarded back into the sea. In Italy, out of 700 fish species, only 25 are commercially used. Economia del Mare aims to utilise 100% of the catch, promoting the catch of the day and transforming surplus rejected by wholesalers. The company also focuses on teaching about seasonal fishery products and has opened an outlet called **Ecopesce**, which sells local catch fresh and prepared ready to eat, employing 15 people and offering quality products under a circular economy mode.

***Project description:*** Ecopesce is a project that focuses on the recovery and valorization of "forgotten" fish species, which are fish of low economic value or surplus that are typically discarded back into the sea. In Italy, out of 700 fish species, only 25 are commercially used, and aims to utilize 100% of the catch, promoting the catch of the day and transforming the surplus rejected by wholesalers. Under the principles of the circular economy, Ecopesce has enhanced the use of fish scraps, such as fish heads and bones, which are used not only for pet food but also for top market catering to create original dishes. Additionally, the company has adopted the use of fully recyclable packaging, using only PET containers and bags. This initiative is recognized as a good practice because it addresses food waste, promotes local traditions, and contributes to the sustainability of the aquaculture industry by creating a fair local supply chain that provides employment and offers quality products under a circular economy model.

***Challenges***: One of the main objectives of Ecopesce was to make people aware of "forgotten" fish species and to focus on local traditions linked to these products. This implies a challenge in changing consumer habits and preferences, which often favour well-known and popular fish species. Addressing this challenge likely involved educational efforts, such as teaching about seasonal fishery products and promoting the nutritional and environmental benefits of consuming a wider variety of fish. The initiative involved setting up a small workshop and later a new small plant in Cesenatico equipped with innovative machinery for processing fish. This step suggests challenges related to sourcing and implementing technology suitable for processing "small" Adriatic fish such as sardines, herring, and anchovies. Addressing these challenges involved securing funding from EU projects for the necessary infrastructure and machinery, which allowed the company to experiment with new food products and enhance the value of the fishers' work.

***Impact:*** By utilizing 100% of the catch, including "forgotten" fish species of low economic value or

surplus, the initiative significantly contributes to reducing food waste in the aquaculture and fisheries sector. This initiative encourages a more balanced ecosystem by preventing overfishing of certain species and supporting the use of a wider range of species, in addition, minimize waste and promote the responsible use of resources. Ecopesce has positively impacted the local economy by creating jobs and establishing a fair local supply chain. The initiative provides employment for 15 people and offers quality products, which supports the livelihoods of local communities and stakeholders involved in the fishing industry. Efforts to educate consumers about seasonal fishery products and promote the catch of the day have likely influenced consumer behaviour and demand within the blue bio value chain.

***Lessons:*** The benefits of a short supply chain, where the local catch is sold fresh and prepared ready to eat. This approach supports local fishermen, reduces transportation emissions, and ensures product freshness, which can be a model for other businesses aiming to promote sustainability and local economies. Ecopesce demonstrates that there is commercial and environmental value in "forgotten" fish species. By utilizing species that are typically discarded, the initiative shows that diversifying the types of fish caught and consumed can lead to a more sustainable fishing industry and can also open up new market opportunities. The project serves as a practical example of how circular economy principles can be applied to the aquaculture industry. By enhancing the use of fish scraps for pet food and top market catering, and adopting fully recyclable packaging, Ecopesce illustrates how businesses can minimize waste and create value from by-products.

## Example 4: Managing the clam farming process through monitoring the size of clam stock (SACCA DI GORO)

***Company/Institution:*** Consorzio Pescatori di Goro Soc. Coop. O.P
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***About Sacca di Goro:*** Sacca di Goro is a saline lagoon of 2.600 hectares where the main activity is clam farming. Founded in the 1930's by fishers from Goro, the COPEGO has since 1970 became the present uniting the different local cooperatives. Today, the clam farming is carried out over 620 hectares and the mussel farming over about 1.100 hectares. COPEGO deals with all the phases of the product supply chain and from 1983 has managed the new whole-sale fish market for the Municipality of Goro.

***Project description:*** COPEGO, supported by the Department of Biology of Ferrara University, organises at least three times a year a monitoring to determine the size of its clam stock. The data is used in managing the farm and selecting the periods and best areas for juvenile seeding. COPEGO has undertaken an intensive campaign for manila clam seeding along the natural selection. The main initiative objectives are open-circuit installation and sustainable packaging. The open-circuit installation for the depuration of molluscs in sweater has undergone innovative modifications allowing for timely intervention regarding water parameters. which can become critical for the survival of the live shellfish during the year. COPEGO uses sustainable packaging fostering reuse, recovery, and recycling. For the packaging of the live bivalve shellfish, the cooperative has replaced the traditional tubular net sacks with a system of heat-sealed vacuum packaging, that by removing the air eliminates the pollution elements and inhibits aerobic microorganism activity.

The seeding is mainly divided into two distinct phases: a direct seeding method, in nurseries, with juveniles coming from hatcheries or juveniles from wild stock acquired from third parties or from member; and the transferring juveniles from high density zones to nurseries held to be more ideal for growth. Regarding packaging, it consists of different sized thermoformed plastic trays for the live bivalve shellfish and hermetic locked plastic fil.

*Challenges*: The high reproductive capacity of the Manila clam has always resulted in high yields of natural seeds, even if these have not always been constant over the years. For this reason, COPEGO started the seeding.

*Impact:* There are many advantages thanks to their sustainable packaging: longer-life fresh foodstuffs in the store's perishable good's section, in the home, and during transportation; an increased hygiene level; maintaining the product organoleptic and nutritional properties; self-service packaged goods, more attractive and lighter, easier to store and transport. Also, COPEGO is able through his precision aquaculture to monitor the size of its clam stock. In this way, the growth of the cultivated species- Manila Clams- takes place in the most suitable areas. The packaging plant is at the forefront for its technological knowhow, innovation, sustainability and has an excellent production potential with more than 10.000 tons packaged per year, mainly involving bivalve shellfish and gastropods.

*Lessons:* It is essential for a consistent seeding that it takes place in the periods and areas considered most suitable according to water parameters such as temperature and salinity; and that the natural selection is combined with intensive seeding operations. In addition, using sustainable packaging not only protects the environment but it also benefits the preservation of the product itself.

## Example 5: Blue Azores

*Company/Institution:* Governo Regional dos Açores, Fundação Oceano Azul, Instituto Waitt
*Location:* Portugal, Azores
*E-mail:* mjoao@blueazores.org
*Web page:* https://www.blueazores.org/
*Phone:* +351 966 511 232

*Project description:* Led by the Regional Government of the Azores in partnership with the Oceano Azul Foundation and the Waitt Institute, with the involvement of the University of the Azores and numerous regional and international partners, Blue Azores serves as the program that aggregates the existing capabilities in the region, focusing on solutions for marine conservation and sustainability.
The Blue Azores Program contributes to the protection, promotion, and valuing of the marine resources of the Azores, creating new avenues for the sustainable economic development of the region and the valorisation of the natural blue capital. Blue Azores program stands out as an innovative best practice example due to its comprehensive approach, focus on knowledge creation, collaborative nature, emphasis on innovation, and its goal of promoting a paradigm shift in valuing the ocean. The main project objectives:

1. Protect 30% of the Azores Sea through marine protected areas with at least 15% of fully protected marine areas;
2. Prepare and implement management plans for all marine protected areas, including existing ones and those to be designated;
3. Contribute to marine spatial planning;
4. Support the restructuring of the fishing sector.

***Challenges***: The main challenge regarding fishing sustainability is to provide solutions that could address the need to reduce fishing effort and at the same time increase the value of the catches and distribute profit equitatively across the chain value.

***Impact:*** The Blue Azores program provided estimes of the economic value of the marine ecosystem in the Azores. To guide conservation policy, we analyse how MPAs (fully protected marine areas) might impact these values. We consider expert views and literature to score each service (e.g., fisheries) as "strong benefit," "moderate benefit," or "variable/minimal effect" based on current threats and how MPAs might address them. This helps decision-makers understand the economic value of these services and how MPAs can influence their future. Blue Azores program is likely to have a positive impact on the blue bio value chain. It supports sustainable fishing practices promoting greater stability and potentially higher value for fishers. Also encourages innovation that could lead to the development of new, high-value products derived from marine resources. Some stakeholders might be impacted in the short term as sustainable practices are implemented. Although in the long term, these changes are meant to ensure the viability of the blue bio value chain for future generations.

## Example 6: Offshore IMTA (Integrated Multi-Trophic Aquaculture) Farm- Oysters and winkles

***Company/Institution:***
***Location:*** France/Brittany
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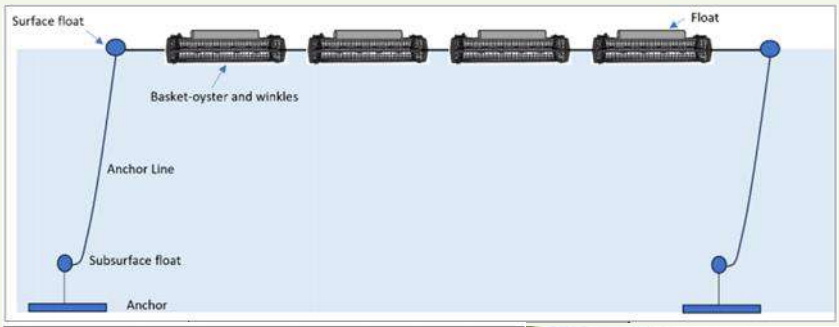
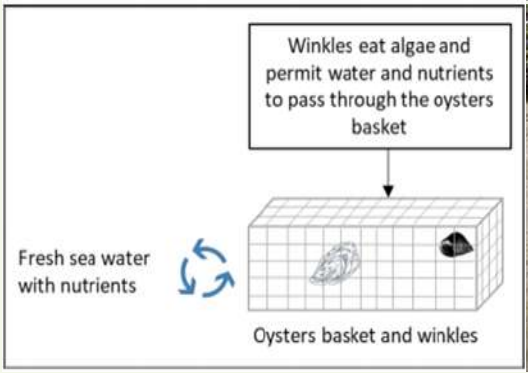
***Web page:***




***About:*** The company is focused on spats and high value half-breed oysters. For five years, it has been growing oysters in an IMTA offshore farm, collaborating with private companies and research organisations through innovation projects. After three years, the company aims to maintain profitability through oyster production.

*Project description:* The aim of this IMTA commercial site is to secure oyster production and diversify its production. They lead several innovation projects focused on the IMTA system to develop a more sustainable and profitable aquaculture. The farm produces species from two trophic levels: oysters and winkles. They are using an offshore IMTA system. With this approach, species at a lower trophic level (winkles) use uneaten feed from the higher trophic species (oysters) as a nutrient input. The lower trophic species can then be harvested in addition to oysters to diversify farmers' revenues. The main project's objective is to secure oyster production and its diversification by mitigating production losses from pathogens, reducing labour required to maintain oyster bags, optimizing production in the face of limitations on expansion.
In production process oyster bag farming is used with the help of periwinkles to reduce the fouling on bags. The winkles feed on this fouling allowing better aeration of bags and more effective water and nutrients circulation. This has a direct impact on the growth of oysters by increasing the growth rate by 15% compared with a farm growing only oysters. On the other hand, the winkles increase the survival rate of oysters by eating dead oysters and thus decreasing the bacterial load. Moreover, the use of the fouling by winkles as a feed reduces the manual work needed to clean the oyster bags.

*Challenges*: Reliability on robust equipment because of an open sea system; Complex and long regulatory process for setting up aquaculture farms (minimum 12 Months) and for sanitary authorisations to be able to sell their own products resulting from their innovation; Need to buy winkles spat (from Ireland) and risk of price fluctuation.

*Impact:* The methods used for growing the periwinkles and oysters does not require any artificial feeding or antibiotics and does not have any negative impact on the surrounding environment. The farm produces high-quality oysters and winkles: in 2023, they produced 200 tons of oysters (Crassostrea gigas) and 8 tons of winkles (Littorina littorea). The winkle production has doubled between 2021 and 2023. This process enhanced the growth rate by 15% compared with a farm growing only oysters. The company also produces spats and semi-rearing oysters (18 months) targeted for oyster farmers. Winkles are raised to jumbo size (maximum size is around 3-4 cm), a rare size for these products: they do not reach this size on natural conditions (or they have been harvested before to reach this size).

*Lessons:* IMTA has reinforced their business model, especially as this type of farming should enable them to fight against oyster mortality. Offshore system reduces the pollution risk from coastal areas (agriculture effluents discharged into the sea…) and optimising farming. This practice confers a competitive advantage on the farm: winkles are a high-value species, but not many farms invest in R&D to produce them at large scale + an open sea oyster production = rare + high quality and distinctive taste. The use of an IMTA system has proven positive for their image and their dynamism.

## Example 7: Sustainable production of Dutch Yellowtail

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*Phone:* +31 6 21548225

*About Kingfish:* The Kingfish Company is dedicated to advancing its leading position in technology-driven aquaculture, focusing on the sustainable production of high-value marine seafood. Their commitment encompasses sustainability and respect for both the fish and the environment, which are central to the company's values. They produce Dutch Yellowtail, a sustainable high-grade sashimi, recognized as a "Green Choice" by the Good Fish Foundation

*Project description:* The Kingfish Company's innovative project focuses on the sustainable production of Dutch Yellowtail, a high-quality fish recommended as a "Green Choice" by the Good Fish Foundation. This initiative leverages advanced aquaculture technologies to ensure environmentally friendly practices, emphasizing fish health, welfare, and minimizing ecological impact. Through these efforts, The Kingfish Company sets a benchmark in sustainable seafood, aligning with global sustainability goals and providing a model for responsible aquaculture in the industry. The main objectives of The Kingfish Company's initiative focus on sustainable aquaculture practices for producing Dutch Yellowtail. They aim to lead in technology-driven aquaculture, establish market leadership in sustainable marine seafood production, and prioritize environmental respect and fish welfare. Their goals align with global sustainability targets, emphasizing eco-friendly operations and promoting Dutch Yellowtail as a sustainable seafood choice.

*Challenges*: The big scale on which this type of Fish farming is needed to be sustainable makes the implementation and funding difficult.

*Impact:* Major outcomes are the rapid expansion both in the Netherlands but also abroad in Sout America. The proof that cultivated fish in a sustainable way can we tasteful and economic valuable is very important to get to sustainable fish farming. The Kingfish Company's initiative significantly impacted the blue bio value chain by setting a benchmark in sustainable aquaculture, demonstrating a scalable model for producing high-value marine seafood with minimal environmental footprint. It influenced stakeholders by promoting sustainability certifications and practices within the industry, thus encouraging broader adoption of eco-friendly operations. The project has likely spurred innovation and set new standards for responsible seafood production, benefiting the environment, community, and the aquaculture industry at large.

*Lessons:* As fish is fish, the value of marketing and branding is very important to get this project on a large scale, you need to create the demand for it. Making cultivated fish attractive is something that made the difference for the growth of this company.

## Example 8: Valorising Coproducts from Fishing and Shellfish Farming for Human and Animal Health and Nutrition

*Company/Institution:* Phosphotech
*Location:* France / Pays de la Loire / Saint Herblain

*E-mail:* europe@polemer-ba.com
*Web page*: www.phosphotech.com

***About Phosphotech:*** Company was founded 20 years ago by a researcher specialized in valorising coproducts from the fishing industry, with the conviction that the whole fish could be used and applied to health and nutrition of humans and animals. The company produces oil, powders, and soft capsules that sell worldwide. They are increasingly positioned toward the health market, recognizing the potential of molecules of interest to human health. Current R&D focuses on products that could contribute to preventing pathologies such as arthritis, diabetes, cardiovascular disease, etc.

***Project description:*** Phosphotech has successfully introduced a number of products sold around the world. Their efforts have allowed to diminish waste in fishing and aquaculture industries while creating value for firms further up the value chain. This success has allowed the firm to explore new and promising R&D activities using new raw materials and addressing ecological, economic and health challenges in their local area and around the world. In addition to the final goal of improving human health, these activities encourage circularity, short circuits of production and ensure that the economic potential of historical industries such as fisheries and oyster, mussel farming are fully realized. Fishermen and farmers are able to find buyers for biomass previously thought to be without value.

*Challenges*:

- Historic fishing activity, limited exploitation of the potential of biomass beyond the filet – outreach to producers to promote added value;
- Climate change: changes in the T° of the water had impact on the development of some crops;
- Norovirus threat to oysters: the company is currently positioning itself to find ways to valorise contaminated oysters

*Impact:*

- *By developing partnerships with other companies, support health of those businesses and drive employment indirectly;*
- *RandD will be developed internally and staff expansion foreseen, plan to establish a factory in 2 to 3 years*
- *Ensuring local points of sale are aware of the company's products which are designed to contribute to the health of humans and animals;*
- *Valorising usually unused coproducts by exploiting knowledge of market and ability to guarantee quality, creating a short circuit and thereby reducing CO2 emissions and waste*

***Lessons:*** The potential for exploiting traditionally underutilized coproducts in the aquaculture and fishing sectors is vast. However, there is a key need for deep knowledge on the resources you are

working on to be able to analyse potential applications. Research and collaboration may allow to identify applications that contribute to the resilience of fishing and shellfish farming by diversifying revenue streams and exploiting value of stock that would be considered undesirable or unsafe for traditional modes of consumption. There is considerable promise in using the raw material in our oceans and aquaculture farms to formulate novel medical and nutritional ingredients.

## Example 9: Heterogeneous autonomous robotic system in viticulture and mariculture – HEKTOR

***Company/Institution:*** University of Zagreb Faculty of Electrical Engineering and Computing (UNIZG-FER)
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***Project description:*** HEKTOR is conceived as a modular and autonomous robotic system, adapted for various missions in viticulture and mariculture with the anticipated possibility of human intervention while performing various work, inspection, and intervention tasks. The main objective of HEKTOR project was to provide a systematic solution for the coordination of smart heterogeneous robots/vehicles (marine, land, and air) capable of autonomously collaborating and distributing tasks in open unstructured spaces. For mariculture use-case, an autonomous catamaran Korkyra was developed with full GNC stack. It was integrated with an ROV and its acoustic localization system. Furthermore, a tether management system for the ROV and a landing platform for a UAV were developed for the catamaran. Fish cage inspection mission planning and biofouling estimation algorithms were developed.

***Challenges***: Apart from challenges stemming from a big number of subsystems that needed to be developed and integrated, COVID-19 pandemic and its effect on supply chains was a significant challenge during the implementation phase. This was addressed with planning things ahead of time as much as possible and diversifying our suppliers list.

***Impact:*** All robots and algorithms were tested in simulation environment and then thoroughly validated in several sea trials. 15 conference and 12 journal papers were published. The catamaran was awarded with grand prix award of 2 innovation fairs. A part of the project results is awaiting patent application review. UNIZG-FER team closely collaborated with a well-known Croatian mariculture company named Cromaris. They were very interested in the application of such advanced technologies at their fisheries.

***Lessons:*** HEKTOR was a really challenging project that tried to push the edge of the state-of-the art. Apart from the engineering and research, it offered us a chance to start thinking about and ultimately applying some of the results of the project for patenting.

## Example 10: ASTRAL- All Atlantic Ocean Sustainable, ProfiTable and Resilient AquacuLture

***Company/Institution:*** AIR Centre- Atlantic International Research Centre
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***Web page:*** https://www.aircentre.org/natalia-ospina-alvarez/
***Phone:*** +351 910 275 590


***About AIR Centre:*** The Atlantic International Research Centre is an international collaborative framework to address global challenges and local priorities in the Atlantic Ocean. It promotes an integrative approach to climate and ocean issues in the Atlantic, supported by emerging technological innovations and advances in space, renewable energy and data science, and through international cooperation. The AIR Centre hosts the Atlantic Aquaculture Network of the ASTRAL project which aims to be a Collaborative Ecosystem for Aquaculture in the Atlantic fostering international collaboration and capacity building oriented to the growth of the sector with a sustainable approach.

***Project description:*** *ASTRAL is a H2020 project financed under the Blue Growth programme ending in late 2024.* ASTRAL aims to develop new, sustainable, profitable, and resilient value chains for integrated multi-trophic aquaculture (IMTA) production within the framework of existing, emerging, and potential Atlantic markets.
The main project objectives are:

1. Develop and validate IMTA labs in different Atlantic regions and deliver a catalogue of "Atlantic species for the future" and best practices to implement IMTA.
2. Increase profitability, circularity, and work towards zero waste in aquaculture.

3. Develop innovative technology and reinforce capacity development and provide key economic and business tools for IMTA.

***Challenges***: Represent the needs of the different Atlantic stakeholders, which was tackled by using a regional challenge-based perspective.

***Impact:*** Key milestones of the project are:

- The implementation of the IMTA concept in four established IMTA labs in Ireland and Scotland, South Africa and Brazil and a prospective IMTA lab in Argentina.
- Creation of the ASTRAL Atlantic Aquaculture Network.
- The delivery of an ambitious and gender-sensitive human capital development plan (HUCAP) to improve professional skills and create a highly trained workforce in aquaculture in the Atlantic.

***Lessons:*** One of the main problems faced within the project is related to the stakeholder's fatigue. The lack of interest or engagement comes from the fact that several similar projects and initiatives approach the same kind of stakeholders. It was necessary to identify synergies with other projects and work together on similar tasks to maximise the interest and feedback of stakeholders.

## Example 11: ALFIL Project- Algae for an ecological transition in aquaculture

***Company/Institution:*** Andalusian Institute of Biotechnology and Blue Development (IBYDA).
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***About IBYDA:*** The University Institute of Biotechnology and Blue Development (IBYDA) was born within the University of Malaga by researchers from very diverse areas of knowledge. IBYDA's mission focuses on the development and transfer of knowledge about Biotechnology and Blue Development. IBYDA wants to make research in Science, Technology and Society (STS), and Blue Development, more useful to society in the face of major environmental challenges by working in a cooperative and transdisciplinary way. Our vision is to become a transdisciplinary instrument of the Public Administration, a qualified voice that advises the administration and companies on aspects related to blue development.

***Project description:*** The ALFIL project focuses on two key problems in aquaculture: the use of fishmeal and fish oil for fish feed and the generation of highly polluting waste rich in ammonium that is discharged into the sea, making the current production model unsustainable. We propose a sustainable model of bioremediation of fish farm effluents by cyanobacteria, macro and microalgae and the utilization of this nutrient-rich biomass to replace 100% of fishmeal and fish oil. The project will evaluate the bioremediation capacity of different species, characterize the biomass generated, formulate and produce a feed that will be evaluated in vitro and in vivo.
Main project objectives are:

1) Establish a circular system in which the biomass of cyanobacteria and algae cultivated in fish farm effluents (bioremedial work), is used for the production of feed with a 100% substitution of fishmeal and fish oil;

2) To evaluate the bioremediation capacity of different species, characterize the biomass generated, formulate and produce a feed;
3) To evaluate in vitro and in vivo the feed, both the effect on fish growth and on its composition, metabolism, microbiota and resistance to diseases.

***Challenges***: Main challenges addressed through the experimentation proposed by the project were sustainability in aquaculture and production a feed without fishmeal and fish oil. Also, we have applied for an infrastructure for the IBYDA institute in the Ministry's call for proposals. If we get this equipment, it will significantly increase our development capacity because of the experiments that can be carried out in our facilities. We have other projects underway and will continue to apply for projects related to improving aquaculture sustainability and disease resistance.

***Impact:*** Algal biomass has been obtained. It has been characterized. Several treatments have been applied and the one with the best results has been chosen to formulate the feed. Now the in vivo experiments are being designed. The project has not yet been completed, but its impact will be related to improved sustainability through better water use, pollution control and the consequent protection of the biodiversity of aquatic ecosystems, as well as the implementation of a circular economy system.

## Example 12: Fish n' Greens

***Company/Institution:*** Aquaponics Iberia
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***Web page***: https://www.aquaponicsiberia.com
***Phone:*** +351 918 784 620


***About Aquaponics Iberia:*** We are a professional aquaculture and aquaponics firm based in Portugal with a passion for creating and operating innovative and sustainable recirculating aquaculture systems. We work with businesses and people to create a more sustainable, circular and healthy food system. We develop technologies for aquaponics, do R&D, implement aquaponics systems and test new species, including finfish and algae.

***Project description***: Fish n' Greens is a pioneering company using lean principles, agile practices, and innovative technology to establish commercially viable aquaponic units near cities. Imagine fresh fish and vegetables grown together sustainably, right in your city. We leverage SWIMS technology to create these urban farms, minimizing transport and environmental impact. Our mission is to revolutionize aquaculture by providing fresh, local, and sustainable seafood while promoting a secure food system for the future. By supporting Fish n' Greens, you're not just getting delicious fish, you're investing in a healthier planet and a brighter future. This project aimed to revolutionize aquaculture by creating commercially viable urban aquaponics using lean, agile practices and SWIMS technology. This approach provides fresh, local, sustainable seafood while reducing environmental impact.

***Challenges***: There was a considerable amount of investment during the last years in technology development, legal issues (licensing, fish species), engineering, partnerships, location and fundraising, being this last one the main challenge we are facing. Technical challenges were faced with R&D, testing and validation using client's projects. Legal challenges were solved with meetings with public institutions, publishing some papers with universities and adopting alternative species. Also, municipal partnership and support was crucial.

***Impact:*** For now, we have developed and validated very relevant technologies for aquaponics that will allow aquaculture to become a sustainable and economically viable activity. When invested, this will allow to reach several cities in Europe, contributing to food security through a circular and farm to fork approach.
1 year impact (1st large-scale unit):

- Reducing 740 tons of carbon emissions (for the equivalent amount of fresh food produced)
- less overfishing, reducing fish catches by 420 tons;
- Reducing water waste/consumption by 32,500 cubic meters (for the equivalent amount of fresh food produced);
- ZERO organic waste/wastewater, synthetic fertilizers input, inorganic pesticides input and medication input;
- Providing educational tours and sustainable content events to 2,640 students;
- Daily supplying 11,000 local students (school canteens, in partnership with the local municipality) with sustainably and organically produced fresh food;
- Providing 4,000 families (in a market of over 2 million consumers) with 100 tons of fresh fish and 480 tons of fresh organic vegetables.

***Lessons:*** Despite solving technical, legal and market challenges and presenting to society a disruptive solution that addresses sustainability (at several levels), has a positive social impact (on food security, organicity and education) and shows high profitability and replicability, fundraising is still a major challenge. Apparently, investors are more interested in potentially highly scalable trending projects than in projects that are normally profitable and contribute strongly to the greater good.

## Example 13: Advancing European bivalve production systems- BIVALVI

***Company/Institution:*** Naturedulis s.r.l.
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***Phone:*** +39 3338 390559

***About Naturedulis:*** Naturedulis s.r.l. since 2015 has been involved in the reproduction and maintenance of juveniles of bivalve molluscs in a land-based hatchery and nursery, located on the coast of Goro lagoon, in the Adriatic Sea. The company has the Organic product certificate for activities in accordance with reg. CE 834/2007. Naturedulis s.r.l. is also registered in the National Research Registry (Art. 64, paragraph 1, DPR 11 July 1980 n.382. Code 62205QCJ) and it is included in the list of Institutes who carry out direct scientific fishing activities for study, research and experimentation purposes, recognized by Italian Agricultural Ministry.

***Project description:*** BIVALVI is addressed to promote the importance of bivalve species for sustainable aquaculture production in Europe. The technological development of these low-trophic production sectors lies far behind other well-developed aquaculture sectors. BIVALVI focuses on blue mussel, Manilla clamsand Pacific oysters, the bivalve species with the highest production in Europe. BIVALVI will increase the sustainability of these sectors by adapting and integrating technological developments of large parts of their value chains (seed quality, re productive health and control, production management, immunity and pathogen and disease control, and product quality). Activities involve close collaboration with R&D and industry partners (including SME) from Ireland, Italy and Norway. The R&D partners are specialists in their fields of shellfish health and immunity, genetics and farming technologies and the industry partners represent the national production sectors of their respective species. Naturedulis s.r.l. is involved in the project in particular for: The development of a selective breeding programme, Testing new solution for pre-fattening of Manila clam seed. The project duration is 2022-2025 and, since bivalves have complex and quite long lifecycle, results and milestones could be reached at the end of the project.
Milestones to reach are: 1) Choosing of the best farming systems, 2) Establishment of first stocks of genetic selected bivalves.

***Challenges***: The most impactful challenge concerns the rapid response to climate change. In particular, the development of breeding systems and bivalve breeds adapted to the attack of exotic species (for example blue crabs) and extreme environmental conditions represent the most important
challenges to face.

***Impact:*** The expected overall contributions of BIVALVI to the European bivalve production sector are increased survival, improved productivity, improved quality and social acceptability.
In particular, final results will assess: manila clam spat welfare response to different temperatures, salinities, pH, currents of the sea, rains and storms, a comparison of farming technologies for Manila clam spat. The aim of the project is to implement marine resources and consequently increase productivity in the aquaculture production chain, through sustainable practices.

## Example 14: Croatia-Cyprus Excellence Hub on Eco-Innovative Technologies for Healthy and Productive Seas – SeaTecHub

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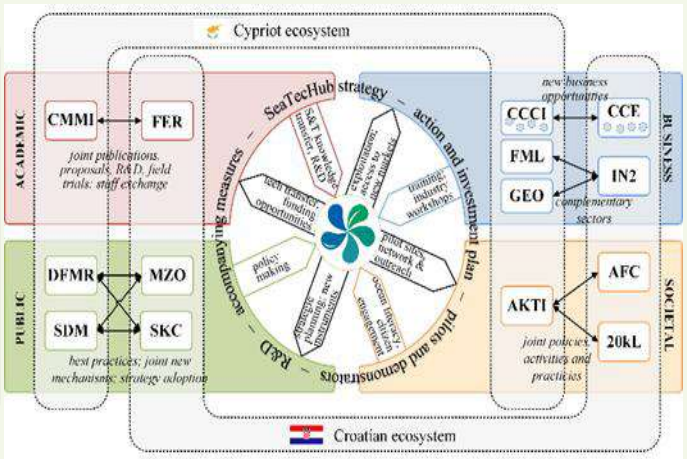


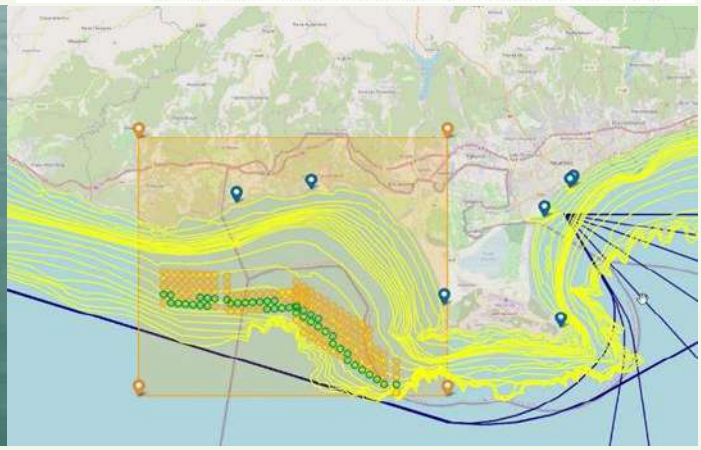

***About AgriFood:*** AgriFood Croatia is an innovation hub that brings together research, business and public stakeholders in Croatia for the common pursuit of digital transformations in the aquaculture, agriculture and food related sectors. The mission of AgriFood Croatia is to contribute towards achieving the vision outlined in the EU Declaration of 'A smart and sustainable digital future for European agriculture and rural areas' and strengthen the national and European technological infrastructure.

***Project description:*** The main goal of the SeaTecHub project is to strengthen Croatian and Cyprus place-based innovation ecosystems and improve access to excellence for R&I actors by cross-border collaboration on a common strategy and alongside value adding chains within the area of ecoinnovative technologies for healthy and productive seas, focusing on sectors 1. Aquaculture and fisheries, 2. Smart ports, 3. Maritime security and protection, 4. Research and Education, and 5. Maritime technologies. The objectives of the SeaTecHub project are:

1) to facilitate long-term cross border and inter-sectoral collaboration to advance eco-innovative technologies for healthy and productive seas;
2) to perform joint research work to close knowledge gaps, consolidate and reinforce quadruple-helix linkages, and validate strategy and action and investment plans (AIPs);
3) to implement a set of mutual learning and skills development measures;
4) to raise visibility of Croatian-Cyprus innovation ecosystems by implementing strategic measures in the form of organizing networking, knowledge and experience transfer events.

***Challenges***: The large number of sectors (5) being processed requires a large investment in data processing. Some of the sectors do not have adequate public data sources.

*Impact:* KPI 4.1: Joint research projects (JRPs) carried out within SeaTecHub up to TRL 3-4 (At project start, there has been only one R&D joint project between CMMI and FER). 2 (Marine Spatial Planning and Maritime IoTs). KPI 4.2: Number of pre-planned R&I pilot and demonstration projects within the framework of SeaTecHub. (baseline: 0 at proposal stage)>5.

## Example 15: AquaLit- Preventive Measures for Averting the Discarding of Litter in The Marine Environment from The Aquaculture Industry

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*Project description:* Funded under the European Maritime and Fisheries Fund, the AQUA-LIT project worked together with the aquaculture stakeholders from the Mediterranean Sea, the Baltic Sea and the North Sea over two years to develop a toolbox to help tackle marine litter, aiming at further making the aquaculture industry a leading sector on addressing this global and escalating issue. The project was implemented through funding provided by EASME-EMFF (2019-2021). The project was organised in 6 work packages:

- WP1 Project management (Leader: GEO)
- WP2 State of Play (Leader: VLIZ)
- WP3 Learning Labs (Leader: NAUSICAA)
- WP4 Toolbox for integrated approaches (Leader: IEO)
- WP5 Scaling up the tide (Leader: EurOcean)
- WP6 Communication, engagement and dissemination (Leader: GEO)

*Challenges*: COVID-19 had an impact on the organisation and delivery of some of the project activities, which required additional efforts from the partners. For example, the partners had to struggle more in order to engage the stakeholders for acquiring information regarding the port facilities, for the transferability process and for reviewing the toolbox. Challenges were managed by redirecting unspent travel budget into human resources allowing for greater effort on the desk studies.

*Impact:* Aqua-Lit created the "Tide against marine litter toolbox", available online (www.aqua-lit.eu/toolbox) and as an app, which provides more than 400 ideas, best
practices and solutions to tackle marine litter at sea, and which is open for people to feed with more innovative ideas. AQUA-LIT's toolbox also includes information on which ports have the facilities to receive waste, a database of funding opportunities to create a project on marine litter, the marine litter inventory mentioned before, a set of 58 policy recommendations to improve decision-making and overcome the existing gaps in marine litter management and specific action plans for outermost regions. Lastly, to leave some legacy behind, Aqua-Lit provided a forecast of the potential impacts the sector could face by 2025, so other European projects could use our findings and build on our outcomes.
Aqua-lit successfully engaged with 12 different groups of stakeholders through 120 participants in 4 Learning Labs (LLs) and 46 interviews from the Baltic Sea, the Mediterranean Sea and the North Sea basins. The work focused on firstly, understanding the barriers faced

and needs to have a good marine litter management. And secondly, the focus during the LLs was on co-developing solutions and brainstorming ideas that could help tackling such identified barriers and needs, as well as collect best practice examples. The more than 400
ideas and solutions compiled fed the 'Solutions & measures' section of AQUA-LIT's toolbox.
Stakeholder mapping included the development of country profiles compiled for the two most extensively studied countries in each of the studied sea basins. The AQUA-LIT country profiles present a description of the different aquaculture stakeholders, categorised by the four different stages in the life cycle of an aquaculture farm: 1) Initiation, 2) Development, 3) Operation and 4) End of life. All further information is available from the project website: https://aqua-lit.eu

***Lessons:*** A series of best practices factsheets were released to build on lessons learned and to provide advice for others. These can be found here:
https://aqualit.eu/assets/content/Best_Practices_Factsheets_final.pdf

## Example 16: Eco-design of clams aquaculture

***Company/Institution:*** University of Ferrara – Laboratory Terra&AcquaTech
***Location:*** Italy – Emilia Romagna- Ferrara
***E-mail:*** psu@unife.it
***Web page:*** https://tatlab.tecnopolo.fe.it/

***About Terra&AcquaTech:*** The Terra&AcquaTech Laboratory is part of Ferrara Technopole and of the High Technology Network of the Emilia-Romagna Region. It focuses on the development of innovative solutions for the environmental, agrifood and green economy sectors, capable of saving the use of resources (raw materials and energy sources), reducing waste, also through its transformation, according to a circular economic perspective, and making resource management and remediation in industrial processes more efficient and sustainable. The Terra&AcquaTech Laboratory focuses on the development of innovative solutions for the environmental, agrifood and green economy sectors, capable of saving the use of resources (raw materials and energy sources), reducing waste, also through its processing, according to a circular economic perspective, and making resource management and remediation in industrial processes more efficient and sustainable. Thanks to its specialisation and versatility in several domains, ranging from biology to chemistry, physics, engineering, and geology, the Terra&AcquaTech Laboratory delivers integrated services, such as the planning and implementation of monitoring plans, the reduction of greenhouse gas emissions and production of power from renewable energy sources, the valorisation of waste for the production of chemical compounds, materials of interest for various industrial sectors, such as construction, as well as agri-food and/or cosmetic supply chains, the development of sustainable and precision technologies to be applied in agriculture, animal husbandry, aquaculture and fishing.

***Project description:*** Projects activities are directed to implementation of ICT in aquaculture an innovative automated system able to control water quality and operational routines, valorisation of sea waste, particularly seashells and algae and to productive recovery of native species of bivalves. The main project objectives are:

1. Promotion and development of sustainable aquaculture through ICT; Mitigating environmental impact of aquaculture activities in coastal ecosystems, reducing energetic costs and GHG emissions; Improving aquaculture productivity to meet the increasing future food demand through the employment of intelligent and technological solutions;
2. Reusing marine waste and waste/by-products from fish processing to improve environmental conditions and mitigate the effects caused by the increase in atmospheric carbon dioxide;

3. Providing integrated services aimed at conserving the natural balance of coastal areas and enhancing the socio-economic well-being of communities.

***Challenges***: Currently, the issue that most impacts the productivity of regional aquaculture companies is due to the massive presence of the blue crab.

***Impact:*** Number of fish farmers informed about ICT solutions for their production is increased of about 10% as well as the number of SMEs aware of circular economy concepts.

***Lessons:*** The inclusion of environment monitoring within the routine and "daily practice of work" and as a tool to improve production and animal well-being. This represents a profound change in viewpoint, generating the awareness that quality of products strongly depends on the protection and care of the environment.

## Example 17: COOL BLUE BALTIC- COmmunity Ocean farms and Local Business cLUstErs in the BALTIC sea

***Company/Institution:*** Maritime Institute of Gdynia Maritime University
***Location:*** Poland/Pomorskie/Gdańsk
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***Phone:*** +48 609 322 929

***About:*** "Regenerative Ocean Farming" is a way of growing things like seaweed and shellfish in the ocean that doesn't need extra elements like medicine or food for the plants and animals. This is good for the environment, as it helps clean the water, store carbon, and supports a variety of sea life. COOL BLUE BALTIC (CBB) wants to show how this can be profitable business and help the environment at the same time. Its aim is to teach fishermen and farmers how they can earn money from this new way of farming.

***Project description:*** COOL BLUE BALTIC would hold workshops where different groups can discuss and plan. Its aim to set up six key plans to help make regenerative ocean farming easier to start and maintain. The project will also hold eight special events in countries around the Baltic Sea. These events will use the six key plans to inspire more people to get involved in the process. The goal is to make it easier for local communities to use ocean areas for regenerative ocean farming, especially in places that are protected for their natural value. The main objectives of the COOL BLUE BALTIC is to collect data on the impacts of regenerative ocean farming, develop training materials, demonstrate technical and socioeconomic feasibility, mobilise communities through awareness-raising campaigns, participate in multiple annual events and work with public authorities to combine MPAs with regenerative ocean farms.

***Impact:*** COOL BLUE BALTIC will support future fisher/farmers and other stakeholders in assessing interest and feasibility in setting up new regenerative ocean farms or restoring coastal marine ecosystems. This support will come via testing approaches, preferably in connection with marine protected areas. COOL BLUE BALTIC will provide concrete examples of regenerative aquaculture and ecosystem restoration, reorienting fishers from extraction to ocean regeneration activities and stewardship of Marine Protected Areas (MPAs). It will support fishers and other interested stakeholders in setting up new regenerative ocean farms, demonstrating positive impacts on coastal marine ecosystems through technologically and socially innovative data collection methods. The

project represents an ambitious step towards restoring the Baltic marine environment while providing socioeconomic co-benefits through self-sustaining social enterprises and cooperative business clusters.

## Example 18: GEEBovMit – GHG emissions mitigation on beef cattle production – pastures, forages and natural additives

***Company/Institution:*** seaExpert, Fisheries Services and Consultancy, Ltd.
***Location:*** Portugal, Azores, Faial island, Horta
***E-mail:*** Artur.oliveira@seaexpert-azores.com
***Web page:*** www.seaexpert-azores.com
***Phone:*** +351 913 309 568

***About seaExpert:*** An Azorean fisheries consultancy company with a commercial division based on wild seaweed harvest and supply to several industries. Founded in FAIAL – AZORES in 2003, seaExpert experiences fishing in its most varied aspects. Created with the aim of supporting Azorean ARTISANAL FISHING, we quickly extended our activity outside the Region. We carry out long-distance and continental fishing, operating throughout the Atlantic. With a strong scientific component, we have been accumulating experience over the years with competence, rigor and entrepreneurial spirit.

***Project description:*** GEEBovMit project intends to demonstrate the existence of natural feed additives that allow the decrease of methane emission in vitro and in vivo. One of the main objectives is to test the anti-methanogenic effect of a specific seaweed (Asparagopsis taxiformis) oil extract when used as a natural additive in calf's normal diet. After getting to know each partner's field of expertise and current work, we planned to do a very small-scale experiment at each other's own expenses in order to prove the potential and find out if this could turn into a bigger and wider project with much more partners involved.

***Challenges***: To manage 14 consortium members in a big project can be tricky and challenging, but this was surpassed through constant and fluid communication between project leadership and the other members (vertical communication) and with each other (horizontal communication). Keeping in mind the main focus of the project, adapting to mid-results and conclusions and putting together scientific teams from universities and private companies from multiple supply chain stages are also main factors for a successful project.

***Impact:*** The referred project is still ongoing, but there are good results in terms of methane emission cuts and beef cattle external behaviour when being fed with the new diet. The current is to seek ways to improve these anti-methanogenic values. Since the beginning, this project already published 2 very important papers to Science, namely to the Animal Production field. The expected

impact is to release a totally groundbreaking study by the end of the project and, simultaneously, create a viable commercial product for market release, so this project is meaningful to the blue bio value chain at the very least.

***Lessons:*** It is mandatory to put everyone on the same page and setting the focus of the different teams to their specific role, with the idea of working towards a bigger picture.
To cover the entire supply chain (if there is a potential product involved) for stress tests and results discussion along the project work. It is mandatory to put everyone on the same page and setting the focus of the different teams to their specific role, with the idea of working towards a bigger picture.
To cover the entire supply chain (if there is a potential product involved) for stress tests and results discussion along the project work. When referring to a big project, it is important to have a good national coverage regarding each partner's origin and field of expertise.
Flexibility: Many times, there are initial perspectives and somewhat expected results, but the project can receive twists and turns and it is extremely important to adapt the plan according to the middle term results and discussions.

## Example19: AmplIAqua

***Company/Institution:*** BGI S.A
***Location:*** Portugal / Lisbon
***E-mail:*** goncalo.amorim@bgi.pt
***Web page:*** www.bgi.pt/ampliaqua

***About BGI S.A:*** BGI is a sustainable venture builder focused on promote innovation and supporting startups in leading sectors such as Agrifood, Climate, Mobility, Digital and Health.

***Project description:*** AmpliAqua is a precommercial unit of an innovative approach to Aquaponics, promoting circularity through the integration of fish, algae and vegetable production, optimizing the use of nutrients and water resources. AmpliAqua will demonstrate and optimise the technical and financial feasibility of this innovative approach to Aquaponics, to leverage its scaleup and replication

to a fully commercial dimension. The initial stage includes the selection and research validation of the technology and the installation of the precommercial production unit.

***Challenges***: The main challenges included the selection of a suitable site and the associated legal and bureaucratic licencing process of the operation, site licencing and construction.

***Impact:*** Further from the optimization of use of nutrients and water resources for the production of fish (10t/year), algae (0,25t/y) and vegetable (2t/y) in 500m2, AmpliAqua will develop a digital platform for integrated management of all production cycle, including the over 20 parameters. AmpliAqua will also serve as test bed for validating third party innovation for soilless farming (fish & vegetables). The ongoing project will demonstrate the feasibility of such an integrated high yield food production facility, with a small land and environmental footprint, enabling its replication in other locations, near the consumption areas, hence reducing GHG emissions in the food chain.

***Lessons:*** The challenges imposed by legal and bureaucratic licencing process of the operation, site licencing and construction, represent a significant challenge that should not be undermined.

## Example 20: SEA2SEE

***Company/Institution:*** SEAentia
***Location:*** Peniche, Portugal
***E-mail:*** nuno.leite@seaentia.pt
***Web page***: https://sea2see.eu; https://www.seaentia.pt
***Phone:*** +351 262 782 255


***About SEAentia:*** SEAentia focuses on sustainable aquaculture, specifically the production of corvina (also known as meagre) using a recirculating aquaculture system (RAS). This aligns with the blue bio value chain in several ways: Sustainable seafood production- by focusing on responsible aquaculture practices and minimising environmental impact, SEAentia contributes to the production of healthy seafood while conserving marine resources; and Innovation in aquaculture - the use of RAS technology represents an innovative approach to fish farming, potentially leading to more efficient and environmentally friendly methods within the blue bio-economy.

***Project description:*** SEA2SEE is an innovative European project aiming to make seafood value chain actors with sustainable practices more visible to consumers, thus giving them a competitive advantage. SEA2SEE comes to fill in existing seafood traceability gaps through the development of an innovative end-to-end blockchain-based platform, along with professional and consumer applications to increase trust and social acceptance of sustainably fished and farmed seafood.

SEA2SEE's ambitious goal will be achieved with the development, implementation and validation of a blockchain-based platform that consolidates and analyses data from the seafood value chain, in a system that is flexible enough to adapt to changes in the value chain and brings transparency to end-consumers at its end. An existing small-scale platform will be extended with new, industry-specific algorithms powered by AI and additional platforms so that it is effectively functional for the European seafood industry. The main objective of SEA2SEE is to significantly increase consumer trust and acceptance of sustainably fished or farmed seafood in Europe through the development and demonstration of an innovative end-to-end blockchain traceability model throughout the seafood value chain and the implementation of societal and sectoral strategies for co-creation, communication and awareness raising about the benefits of sustainably fished or farmed nutritious seafood. SEA2SEE holds significant potential to increase the consumption of sustainably fished or farmed seafood among European consumers by engaging them in providing trustworthy traceability information through participatory demonstrations of the use of web-based and digital tools.

***Challenges***: The project began in 2022 and will end in 2026. The first step in implementing the project, which required the involvement of stakeholders, was challenging, but by sharing the project on social media and through partners, greater involvement was achieved. As the project is still ongoing, there are no further considerations.

***Impact:*** Traceability blockchain data deployment model, Aquaculture production management software integrated and Blockchain consumer-engagement tools will be deployed to 5 specific case studies in 2 types of demonstrators (fishery and aquaculture). This focus on case studies is crucial for the project as it would allow the demonstration of Sea2See technology with real life data inputs towards traceability from end-to-end of each value chains involved. The collaboration with demonstrators will allow to optimise the blockchain model, to draw conclusions on Life Cycle Assessment and hazardous contaminants of seafood products and to prepare the replicability of methods and tools to other contexts and scales.

*Lessons:*

1) Importance of Stakeholder Engagement: SEA2SEE emphasizes collaboration between various players in the seafood industry (researchers, technology providers, fishers, and consumers). This highlights the value of a comprehensive approach for achieving sustainable practices.
2) Transparency and Traceability: The project focuses on making sustainable seafood practices visible to consumers. This suggests a potential emphasis on developing reliable traceability systems to build trust with consumers who are increasingly interested in ethical sourcing.
3) Technology for Sustainability: SEA2SEE's development of tools and algorithms suggests a focus on leveraging technology to improve efficiency and sustainability in the seafood sector.

## Example 21: Implementation of flying doors on trawlers

***Company/Institution:*** Almeria Fish Producers' Organization OPP-71
***Location:*** Almería (Spain/Andalucia)
***E-mail:*** elvira@delbarcoalamesa.com
***Web page***: www.oppalmeria.com

***About OPP-71:*** The OPP-71 is recognized by the Government of Andalusia as an Organization of Fisheries Producers, and complies with the regulations of the Common Fisheries Policy and the Common Organization of Markets. Each year we plan our activities based on fundamental objectives such as promoting sustainable fishing, reducing unwanted catches, contributing to traceability and

clear product information. We also promote the improvement of fishing marketing, the profitability of our associates, etc.

***Project description***: The producers' organization intends that the largest number of trawlers fishing in this area of the Mediterranean Sea install doors that do not contact the seabed without damaging the native flora. At the same time, this incorporation also leads to savings in the vessel's fuel. We are supporting the migration of classic trawl doors in our trawl fleet to flying doors that do not contact the seabed, and consume less fuel, improving the carbon footprint of the fish products caught. Each year we finance the equipment of 2 or 3 trawlers. Our main objective is related to environmental sustainability.

***Challenges***: It was questionable if it would be viable for the boats that do more coastal fishing, where there is more sediment and more species.

***Impact:*** Main outputs were: diesel consumption decreased by 7%, catches cleaner of sediment and in better condition and Improved net profitability of the activity on these vessels.

***Lessons:*** Implementing this project, we manage to improve seabed conservation and reduce the carbon footprint of fishery products which contributed to the fight against climate change.

## Example 22: Quality labour certification

***Company/Institution:*** CESTHA CENTRO SPERIMENTALE PER LA TUTELA DEGLI HABITAT
***Location:*** *Ravenna, ITALY*
***E-mail:*** Direzione.cestha@gmail.com
***Web page***: www.cestha.it
***Phone:*** +39 328 740 278
***About CESTHA:*** Experimental Center for the Protection of Habitats is a non-profit research body whose aim is environmental protection. CESTHA is a private Research Centre, accredited by MIPAAF as a Scientific Institute pursuant to the Presidential Decree. n. 1639 of 2 October 1968. CESTHA is a member of the Emilia-Romagna Agrifood Cluster and deals with conservation programs for species at risk of extinction and promotion of sustainable management activities, working in close collaboration with public and private bodies, universities and others Research Centers. The staff is made up of researchers and specialists in natural sciences, marine biology and veterinary medicine. CESTHA works to ensure that production activities and the protection of marine and coastal ecosystems coexist. CESTHA is a non-profit organization and a scientific institute and is committed to developing sustainable fishing by collaborating closely with industry professionals and promoting responsible exploitation of resources.

***Project description:*** CESTHA has worked on various projects to create quality brands for seafood products that reflect certain sustainability standards. Specifically, THE WILD MUSSEL OF MARINA DI RAVENNA, a product of the corresponding local fishery, CUTTLEFISH RESPONSIBLE FISHERY, related to the artisanal fishing of cuttlefish, and SHARK FREE, a brand under development for the qualification of low-impact fishing products on sharks. The main project objective is making seafood products with greater sustainability recognizable to the consumer. The initiatives were carried out through various European funds and programs (Interreg IT-HR and FEAMP funds, ongoing LIFE). The validation process is the same, namely the analysis of the sustainability of production systems, their implementation and updating, and the drafting of regulations and specifications.

*Impact:* The projects have increased the economic value of the product at sale, resulting in higher returns for the producers. Among the mentioned projects, the qualification of the Wild Mussel has generated the greatest impact on both the value chain and the stakeholders. The certification has indeed "secured" the product against potential fraud and has helped to create a territorial identity for the location.

# Part II: Maritime decarbonization and renewable energy

## Sector analysis

Maritime decarbonization and renewable energy are crucial sectors in the global effort to combat climate change. The maritime industry significantly contributes to greenhouse gas emissions, and transitioning to renewable energy sources is vital for reducing its carbon footprint.

According to the EU Blue Economy Report, marine renewable energy is the fastest-growing sector in relative terms and is likely one of the fastest-growing sectors in the entire EU economy. The sector's turnover increased from €91 million in 2009 to €3.4 billion in 2021 in nominal terms.[6]

While maritime transport is a vital component of the EU economy and one of the most energy-efficient modes of transport, it remains a significant and growing source of greenhouse gas emissions. In 2018, global shipping emissions amounted to 1,076 million tonnes of CO2, accounting for approximately 2.9% of global emissions from human activities.

Projections indicate that these emissions could increase by up to 130% of 2008 levels by 2050. Such a rise would undermine the goals of the Paris Agreement, which aims to limit global warming to well below 2°C and pursue efforts to keep it to 1.5°C.

At EU level, maritime transport represents 3 to 4% of the EU's total CO2 emissions, or over 124 million tonnes of CO2 in 2021.

[6] European Commission, Directorate-General for Maritime Affairs and Fisheries, *The EU Blue Economy Report 2024.* Publications Office of the European Union. https://op.europa.eu/en/publication-detail/-/publication/ef90077b-1e82-11ef-a251-01aa75ed71a1

In order to significantly reduce greenhouse gas (GHG) emissions from international shipping, effective global measures are desirable. In July 2023 the International Maritime Organisation (IMO) made a step on this path committing to new targets for GHG emissions reductions and to develop and adopt in 2025 a basket of measure(s), delivering on these reduction targets. The next years to come will show which measures will be adopted and become applicable and whether they will be commensurate with achieving these targets and the objectives of the Paris Agreement. [7]

The EU's action to ensure that maritime transport contributes to achieving climate neutrality in Europe by 2050 is a crucial step in incentivizing the necessary emissions reductions. As part of the Commission's Fit for 55 legislative packages, adopted in July 2023, the FuelEU Maritime Regulation (Regulation (EU) 2023/1805)[8] promotes the use of renewable, low-carbon fuels and clean energy technologies for ships, essential for supporting decarbonization in the sector.

FuelEU Maritime sets maximum limits for the yearly average greenhouse gas (GHG) intensity of the energy used by ships above 5,000 gross tonnage calling at European ports, regardless of their flag. Targets will ensure that the greenhouse gas intensity of fuels used in the sector will gradually decrease over time, starting with a 2% decrease by 2025 and reaching up to an 80% reduction by 2050. Those targets will become more ambitious over time to stimulate and reflect the necessary developments in technology and the uptake in production of renewable and low-carbon fuels. The targets cover not only CO2 but also methane and nitrous oxide emissions over the full lifecycle of the fuels used onboard, on a Well-to-Wake (WtW) basis.

## Challenges

Maritime decarbonization and the adoption of renewable energy face several challenges. High initial costs and technological limitations hinder the widespread adoption of new technologies such as hydrogen fuel cells and battery-electric power. Infrastructure development is essential, yet currently lacking, for supporting alternative fuels. Regulatory and policy challenges require international coordination, complicating uniform implementation. The economic impact on global trade, especially

[7] International Maritime Organization *2023 IMO Strategy on Reduction of GHG Emissions from Ships* https://www.imo.org/en/OurWork/Environment/Pages/2023-IMO-Strategy-on-Reduction-of-GHG-Emissions-from-Ships.aspx

[8] The text of the FuelEU Maritime Regulation: *Regulation (EU) 2023/1805 of the European Parliament and of the Council of 13 September 2023 on the use of renewable and low-carbon fuels in maritime transport, and amending Directive 2009/16/EC*

for developing nations, is a concern. Ensuring a reliable supply of alternative fuels involves significant production, storage, and distribution challenges. Retrofitting existing vessels is technically and financially demanding compared to building new ships. Resistance to change within the industry and the environmental and social impacts of alternative fuel production pose additional hurdles. Continuous research and innovation are needed to improve decarbonization technologies, requiring substantial investment and collaboration.

## Opportunities

Technological advancements, such as the development of more efficient propulsion systems, including electric and hybrid systems, present significant opportunities. The use of digital technologies for route optimization and fuel efficiency improvements can lead to substantial benefits.

Policy and regulatory support from global initiatives, such as the International Maritime Organization's (IMO) strategy on reducing greenhouse gas emissions from ships, provides a robust framework for decarbonization. Government grants and subsidies for adopting green technologies are also available.

There is increasing market demand for environmentally friendly shipping solutions from consumers and businesses, and early adopters of decarbonization technologies can gain a competitive edge. Collaborative efforts, including public-private partnerships and industry coalitions aimed at driving collective action on decarbonization, offer further opportunities. Long-term savings from improved fuel efficiency and reduced fuel costs, as well as job creation in the green technology and renewable energy sectors, are significant economic benefits.

Both the maritime decarbonization and renewable energy sectors face significant challenges, but they also offer substantial opportunities for innovation, collaboration, and economic growth. Addressing these challenges through technological advancements, supportive policies, and strategic investments can unlock the potential of these sectors to drive sustainable development and combat climate change.

# Best practice examples

## Example 1: Developing and production of solar powered boats based on a modular scalable powertrain technology (Amber)

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*Location:* Finland/Österbotten/Jakobstad
*E-mail:* emil@elveneboats.com
*Web page:* www.elveneboats.com
*Phone:* +358 44 7777 269

*Project description:* Amber is currently flagship model, and at the same time a proof of concept that solar powered boating is possible, without compromising on performance or usability. Amber proves that it is possible to build self-sufficient electric boats, that runs in planning speeds, without the need for any infrastructure. This makes emission free boating possible anywhere, without any further investments. Main objectives of the project are to prove that it is possible to develop emission free boating without the limitation of charging/fuelling infrastructure and to Make the implementation of emission free boats easier, faster, less expensive.

*Challenges*: Many challenges have been faced during implementation, most of them connected to people's inclination to trust believes more than scientific facts. Amber is mainly focused on leisure boating. Next steps will include commercial applications i.a. fishing vessels.

*Impact:* 100% emission free and self-sufficient boating. That will not only benefit the environment, but also increase the profit margin for commercial users as the running costs of the boats are close to zero.

## Example 2: Zero-emission double ended ferry for inland navigation in Finland

*Company/Institution:* StoGda Ship Design & Engineering Sp. z o.o.
*Location:* Poland
*E-mail:* Wieslawa.lachowicz@stogda.home.pl
*Web page:* www.stogda.pl
*Phone:* +48 662 233 109


*About StoGda:* As a marine design office our role in blue bio value chain is connected with performing of environmentally friendly marine designs in the following types: ecological, zero-emission electric vessels; jack-up vessels to installation of offshore wind farms; wind assistance, kite retrofits; inland water cleaner unit.

*Project description:* The project was related to Finish transport company Finnferies. Their goal was to develop the best option for replacing existing, fossil fuels driven vessel. Vessel named Elektra is first battery driven vessel built in European Union, which represents a milestone on the path towards clean shipping. Battery packs are charged directly from the grid and installed diesel generators used alongside them, serve as the back-up energy source. The energy storage system is charged at each side of the crossing, using a shore-based connection to the local grid. Because of the harsh winter conditions in Finland, the ferry is able to use diesel engines to support the onboard batteries, which will serve as an extra boost travelling through ice.

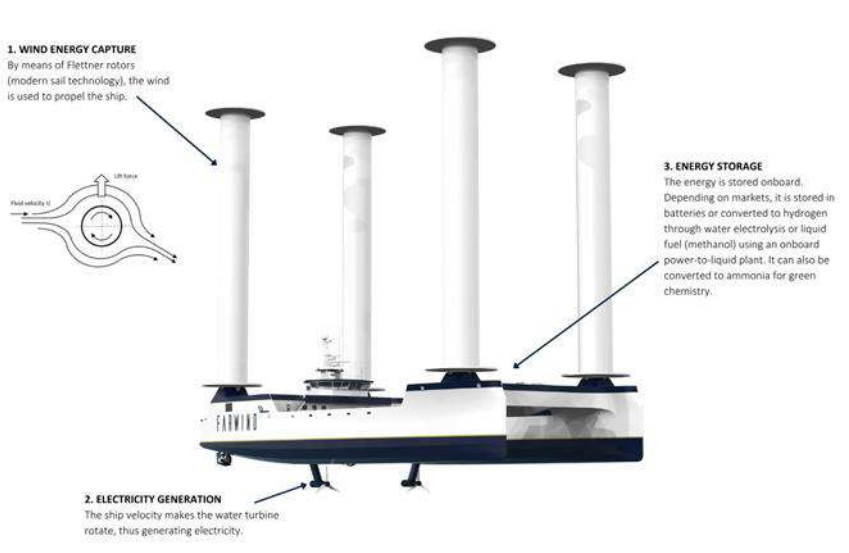
*Challenges*: Due to innovation of the project number of challenges have been faced. Following could be highlighted:
- Uniq hull form optimized during model test,
- Optimized arrangement of battery compartment. Appropriate design including 3D coordination has been performed to fulfil all requirements,
- Maximized automation of the vessel which includes charging, ro-ro operations, mooring. Proper design has been performed to address all issues connected with this subject.

*Impact:* The vessel is capable of carrying 90 cars and 375 people having top speed of 11 knots, which gives savings abt. 60% in operating costs compared with similar sized vessels that run solely on fossil fuels. The vessel is 98m-long (the biggest double ended ferry in Finland) and has 160 lithium-ion batteries on-board, with a combined total output of 1MWh. Additionally, she is fitted with several solar panels giving extra green power. As a main beneficiary, local community living on the Finnish coast could be indicated. Less greenhouse gas emission, less noise emission with improved transport capacity are natural benefits of the project. Additionally, this vessel represents new generation of vessels by being key milestone for the whole shipping industry, for vessels of that type (short voyage ferries). That project created new opportunities for number of local ferries connection across whole Europe.

*Lessons:* Developing of such an innovative project creates many design challenges. Taking this into account we have learned number of technical, design aspects (hull form design, automation solutions, safety aspects, risk analysis, etc) which could give strong benefits in upcoming projects.

## Example 3: Energy Ship

***Company/Institution:*** Farwind
***Location:*** France / Pays de la Loire / Nantes
***E-mail:*** europe@polemer-ba.com
***Web page***: https://farwind-energy.com




***About Farwind:*** Farwind Energy is a spin-off of Ecole Centrale de Nantes. Ecole Centrale de Nantes is a world-leading university for marine renewable energy research. It deployed the first floating offshore wind turbine in France in 2016. Farwind was created in July 2020.

***Project description:*** The core technology of the company's energy solutions is the energy ship, which is a disruptive technology for offshore wind energy conversion. At first, energy ships are ships propelled by the wind. In Farwind's energy ships, wind propulsion is obtained using Flettner rotors, which are vertical rotating cylinders which convert wind into a propulsion force through the Magnus effect. Energy ships are equipped with water turbines which convert the ship's kinetic energy to electricity. Energy ships being mobile, the generated electricity must be stored on-board. Depending on customer's needs, the energy is stored in battery or converted in an energy vector. Possible energy vectors include hydrogen, methanol or ammonia. They are obtained using onboard power-to-gas/liquid plants. In the case of methanol or ammonia, the necessary feedstock (CO2 or N2) is supplied from on land sustainable sources.

***Impact:*** The use of the energy ship represents a contribution to advancing wind propulsion in the maritime sector. Its exploitation of wind energy on the high seas will be an unprecedented harnessing of the second largest source of renewable energy on Earth. The vessel has significant potential to create value for a number of stakeholders. Their clients include energy companies, large energy consumers, coastal and island communities, and industry. Insular and coastal communities may be able to use the ships as a source of renewable and autonomous energy. The use of ships for producing green hydrogen responds to the objectives of the Pays de la Loire Region. The technology may also be applied to methane production. As such it is a versatile solution capable of contributing to many forms of renewable energy. Its mobility also avoids potential usage conflicts associated with on-land and coastal infrastructure.

*Lessons:* Cooperation and collaboration are key to finding solutions to the energy challenges we face today. There is a strong evidence base for the promise of far offshore wind as a powerful and reliable form of renewable energy. The technology under development is a versatile solution for the clean energy needs of a broad variety of stakeholders.

## Example 4: Aurora Bothnia- The most environmentally friendly passenger vessel in the world

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*Location:* Finland, Ostrobothnia region, Vaasa
*E-mail:* johanna.punkari@vaasa.fi
*Web page:* www.wasaline.com
*Phone:* +358 40 568 5400


Project description: The city of Vaasa and the municipality of Umeå wanted to establish a long-term sustainable transport solution between Finland and Sweden, to the alternative of 800 km road-transport with an 80 km sea transport route. The vessel will be future ready to allow for upgrades and sustainability improvements. Kvarken Link Ab was founded in 2015 and in 2019 Kvarken Link Oy was founded bythe same owners, the city of Vaasa and the municipality of Umeå to secure the funding and to run the whole newbuild project. Today NLC Ferry is a subsidiary of Kvarken Link.
The Port of Umeå is TEN-T port, port of Vaasa is not, but is really important port for the area energy related companies, to ensure easy access to low-carbon transport of products sent to the worlds need.
The City of Vaasa and the municipality of Umeå found a shipping company, NLC Ferry Ab Oy/Wasaline, together in order to ensure a reliable and sustainable ferry connection between Vaasa and Umeå. The vessel operates between Vaasa and Umeå. Poth port areas are developed towards Carbon neutrality. The vessel uses environmentally friendly fuels and the businesses involved are developing the vessel technologies in Aurora Bothnia.

Impact: The most environmentally friendly vessel operates now between the Vaasa and Umeå. The vessel serves as development platform for businesses involved. Always the latest technology used in Aurora Bothnia vessel. Both ports areas (Vaasa and Umeå) are developed as green transition areas with the good cooperation of both cities. Additionaly, in relation to blue bio value chain, companies can use the vessel for environmentally friendly transfers and can demonstrate the low climate impact of their products and transfers easily. From Vaasa to Umeå the road is carbon neutral on certain days and low-carbon rail connection continues the transfer from Umeå.

Lessons: Good and ongoing cooperation between two cities.

## Example 5: Electric Ferry Initiative

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***Phone:*** +351 292 242 000

***About Atlânticoline:*** Our involvement in the blue bio value chain is mainly focus on two initiatives. The first is the construction of two electric ferries that will transport passengers and vehicles, and the second one is a retrofit program for our existing fleet to transition the ships from conventional fuels to run on zero-emissions biofuels.

***Project description:*** Constructing two new battery-powered ferries for zero-emission transport of 250 passengers and 10 vehicles in the Azores. Key innovations:
1) Early regional adoption of battery-electric propulsion for interisland ferries;
2) Custom battery system for ranges required between Faial-Pico and Pico-São Jorge routes;
3) Installation of charging pads at terminals for shore power;
4) Battery storage at terminals.
The main project objectives are: to decarbonize Azores maritime inter-island transport, to enhance internal mobility in the Region and to reduce dependence on the outside.

***Challenges***: During the implementation phase, two main challenges have been identified. Firstly, achieving a balance between speed and autonomy of the ferries, and secondly, managing the charging time without overloading the onshore electrical infrastructure and affecting its availability to the rest of the network. To address the first concern, an initial study by an independent entity has been requested, although it requires confirmation during construction. Regarding the second issue, careful scheduling of ferry operations and port stop times, along with the provision for installing batteries at ports, has been implemented to mitigate the impact on the electrical infrastructure.

***Impact***: The project has not concluded yet, but it is anticipated to result in a 50% reduction in CO2 emissions from Atlanticoline.

***Lessons:*** Key lessons from this initiative/project include the importance of comprehensive planning, stakeholder engagement, and technical feasibility studies. Flexibility and adaptability are crucial for addressing unforeseen challenges. Monitoring and evaluation mechanisms enable progress tracking. Openness to innovation is crucial to advance as well as promoting continuous learning, and raising public awareness about the benefits of sustainable transportation. These lessons highlight the significance of holistic approaches, collaboration, and sustainability in infrastructure projects, offering valuable insights for similar endeavours in the future.

## Example 6: INCONE60 – Inland Blue Transport Connector E60

***Company/Institution:*** Maritime Institute of Gdynia Maritime University
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***Project description:*** INCONE60 stands out as an innovative best practice in the value chain of Renewable Marine Energy and Maritime Decarbonization. By integrating advanced algorithms and real-time data, the INCONE60 Cargo Flow Model optimises cargo transport, prioritising routes that minimise environmental impact. The INCONE60 model utilises advanced technologies and methodologies to assess transport costs, environmental impacts, and efficiency in transporting goods. This data-driven approach ensures informed decision-making, aligning with sustainability goals while enhancing efficiency in the maritime sector. The main objectives of the INCONE60 project were to optimise cargo transport in the South Baltic Region, promote sustainable practices, and facilitate modal shifts towards more environmentally friendly modes of transport.

***Challenges:*** During implementation, challenges such as data accuracy and stakeholder collaboration arose. These were addressed by conducting rigorous data validation processes, fostering open communication with stakeholders, and continuously refining the model based on feedback. Regular monitoring and evaluation helped identify and mitigate any emerging issues promptly.

***Impact:*** The outcomes of the INCONE60 project include the development of the INCONE60 Cargo Flow Model and the publication of reports analysing cargo flow, port development, and transport outlook in the South Baltic and North Sea regions. Furthermore, the project extended its simulation capabilities to include Norwegian ports in collaboration with the Horizon 2020 ePIcenter project, fostering international cooperation. Pilot trips along the international waterway E60 showcased the model's capabilities and facilitated collaboration between Polish and Danish ports, culminating in the signing of a Letter of Intent between Elbląg and Vordingborg ports and an Economic Agreement in Elbląg, marking significant progress towards establishing regular maritime connections. The INCONE60 project significantly enhanced the blue bio value chain by advocating sustainable maritime transport. Through the Cargo Flow Model and insightful reports, stakeholders improved route optimisation, minimised environmental impact, and fostered collaboration. Pilot trips demonstrated capabilities and promoted international cooperation, thus advancing sustainability and efficiency in the maritime sector.

***Lessons:*** Lessons learned from the INCONE60 project include the importance of stakeholder collaboration, continuous monitoring and evaluation, and flexibility in adapting to evolving needs.

Insights include the value of data-driven decision-making, the significance of international cooperation, and the potential for innovative solutions to drive sustainability in the maritime sector.

## Example 7: Wave Breaker

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***Project description***: Main objectives of the Wave Braker project is to protect sea and costal objects of waves and produce green energy. The energy is produced with wave breaker by exploitation of sea kinetic energy at the moment the wave hits the Wave Breaker. The Wave Braker was tested in the port of Rijeka and there it withstood a wave of 3.5 m height and a wind speed of 110 km measured by the Institute of Oceanography Split. The Wave Breaker is being manufactured to be tested again for electricity generation by generators. Now, we are testing on other locations (Trogir and Savudrija) how much electricity is produced and how much the wave breaks at the same time.

***Challenges***: We faced problems during testing the Wave Breaker. The algae blocked the net and stopped the sea flow through the net.

***Impact:*** It is expected that on an annual level we produce 1MW of electricity and achieve 60% wave breaking efficiency. The positive economic impact of this project is that this innovation can break the destructive sea wave that can cause damage in harbours and marinas, and also at the same time produces electricity for the marinas, electric vehicles and electric ships.

***Plans:*** Our intension is to produce generators for wave breaker and to produce robots for collection waste on the sea.

## Example 8: Wasaline- Ports Charging Solutions

***Company/Institution:*** Kvarken ports ltd
***Location:*** Finland/ City of Vaasa/Vaasa Port
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***Phone:*** +358 44 5167 224

***Project description:*** Wasaline Aurora Botnia. Ports have charging solutions 2.4 MegaWatt chargers. Vaasa port is responsible for it and the infracture. Other actors can also use it if they want this service. But main actors are Wasaline and Wartsila.
Cavotech- charging solution and Carus automatic checking for vehicles going to Aurora Botnia Vessel. They make the check-in of passenger vehicles faster. For the boat to depart earlier and optimize the cruise in order to save fuels because the loading becomes faster. Carus is also an asset of the port.
Greenshipping corridor initiative. Based on a declaration by EU countries committing to establish carbon natural carbon corridors between 2 ports before the end of the decade.Umeå-Vaasa is one potential corridor. There has been wasalines product green Corridor Fridays Wasaline launches Green Corridor Fridays – Wasaline where they are using bioenergy. Part of making the corridor is the agreement between – Wasaline and Umeä, they have signed a letter of intent Liquid Wind, Umeå Energy and Wasaline sign Letter of Intent for the supply of eMethanol – Wasaline for making eMethanol which is based in hydrogen together with the carbon. Which is a step towards carbon natural corridor. Production of e-methanol in Umeå is planned to start 2027.

***Objectives:*** Greenshipping corridor as core. The interest is that all supply chain should be environmental. All transportation, trucks etc. that come to the port must be green.
There are alternative fuels but the electrical is having the most potential, is easily scalable and looks it's going to be faster accessible than i.e. hydrogen in road transportation. Is more mature.

***Challenges***: Road map work: noticed that are a lot of people knowing the technical solutions and understanding the value chain but it is difficult to make the bigger picture. i.e. who will be operating the charging solutions, where to take it, store it or not etc. Business concept. Challenge will be finding a business case for this solution. Requirement is to offer offshore power to ships but solutions are very heavy investments. So, they try to find different supplies and solutions to make the business case more realistic.

## Example 9: Sustainable and smart port of the future (The port of Vaasa)

***Company/Institution:*** Vaasa Region Development Company

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*Project description:* The city of Vaasa has set an ambitious goal of achieving carbon neutrality by 202X (before 2030). The EU has also raised its 2030 climate target and committed to reducing emissions by at least 55% by 2030. This is also related to the national climate-neutral Finland 2035 climate and energy strategy. The port of Vaasa plays a key role not only in terms of the city's objective, but also in terms of the region's industry in achieving carbon neutrality targets. The starting point of the project is to clarify the port's ecosystem, the needs and requirements of its operators and the port's role and opportunities in achieving carbon neutrality goals. The work seeks answers to such questions as how to integrate the port into an ecosystem that is developing in an increasingly carbon-neutral direction, for example in energy concepts and solutions. The nature of the project is roadmap work, and its goal is primarily to enable long-term and planned work for the pursuit of carbon neutrality in the ecosystem. The port ecosystem needs a strong, flexible basis for the development of the port's services and the use of space to achieve its goals.

*Challenges*: The nature of the project is roadmap work, and its goal is primarily to enable long-term and planned work for the pursuit of carbon neutrality in the ecosystem.
*Impact:* The port of Vaasa plays a key role not only in terms of the city's objective, but also in terms of the region's industry in achieving carbon neutrality targets.

*Lessons:* The port of Vaasa plays a key role not only in terms of the city's objective, but also in terms of the region's industry in achieving carbon neutrality targets. The port ecosystem needs a strong, flexible basis for the development of the port's services and the use of space to achieve its goals

## Example 10: Green Terminal of the Port of Gdynia- Innovation for Sustainable Development

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*About Port og Gdynia:* As the managers of a seaport, our involvement in the blue bioeconomy value chain focuses on implementing and promoting innovative solutions aimed at sustainable development and decarbonization. We operate an electric charging point for ferry ships and a ferry terminal located close to the port entrance, which facilitates logistics and minimizes the carbon footprint of maritime transport. Innovations in our port also include ship bunkering systems that allow for the use of low-emission fuels, such as LNG, marking a step towards the reduction of greenhouse gas emissions and air pollution. Our actions are directed towards creating infrastructure that supports the green transformation of the maritime sector, thereby actively participating in the development and implementation of innovative international projects aimed at promoting sustainable development and eco-innovation in the industry.

*Project description:* The "Green Terminal of the Port of Gdynia" project is an example of innovative best practice, addressing the challenges of sustainable development, decarbonization, and the use

of renewable marine energy. It focuses on creating infrastructure that utilizes alternative fuels such as green hydrogen, methanol, and ammonia, implementing groundbreaking technologies to reduce emissions and increase operational efficiency. The initiative includes the construction of onshore power supply units, zero-emission fuel bunkering stations, and the use of renewable energy sources. The project engages local communities and international partners, promoting collaboration for eco-innovation. Started in 2022 and planned to be completed by 2030, it aims to increase the share of alternative fuels in the port's operations, aligning with EU objectives on hydrogen economy and emission reduction.

*Challenges*: Securing funding: Finding adequate sources of financing can be one of the initial challenges. This requires effective communication of the project's value to potential investors and donors, as well as leveraging available programs that support sustainable development.

Legal regulations and compliance: Navigating the complex regulatory landscape, including obtaining necessary permits and compliance with local, national, and EU environmental regulations, can pose a challenge. Collaboration with legal and environmental experts from the outset is crucial.
Stakeholder management: Engaging and managing the expectations of various stakeholders, including local communities, business partners, and regulatory bodies, requires transparent communication and trust-building.
Technical and technological challenges: Implementing innovative technologies and green solutions may encounter technical obstacles, such as adapting port infrastructure or integrating new systems. Pilot testing and a flexible approach to problem-solving will be key.
Environmental protection and sustainable development: Ensuring that all aspects of the project contribute to environmental protection and sustainable development may require continuous assessment and adjustments to the project.

*Impact:* Significant reduction in CO2 emissions and other air pollutants, thanks to the use of alternative fuels and shore-side electricity for ships – the project may aim to reduce emissions by a specific percentage relative to current levels.
Increase in the share of renewable energy sources (RES) in the port's overall energy mix, e.g., through the installation of photovoltaic panels and wind turbines.
Development of infrastructure for bunkering alternative fuels, such as green hydrogen, which could attract new business segments and types of ships to the port.

*Lessons:* The importance of early planning and stakeholder engagement: Early involvement of all stakeholders, including the local community, regulatory bodies, and business partners, is crucial for understanding diverse perspectives and ensuring support for the project.
Flexibility and adaptability to change: The world of technology and legal regulations, especially in the context of sustainable development and environmental protection, is rapidly changing. Flexibility in planning and readiness to adapt are essential to effectively respond to new challenges and opportunities.
Collaboration as a key to innovation: Multidisciplinary collaboration between different sectors and specialties can lead to innovative solutions that go beyond traditional approaches to sustainable port development.
The importance of piloting and testing: Before implementing on a large scale, it is important to conduct pilot tests of selected technologies and solutions to assess their effectiveness and impact on port operations and the environment.
Education and communication: Building awareness and understanding among port employees, users, and the local community plays a significant role in ensuring acceptance and support for the project. Effective communication about the project's goals and the benefits it brings is key.

## Example 11: EU-SCORES European Scalable Offshore Renewable Energy Sources

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*About INESC TEC:* Inesc tec involvement in the framework of the project is cantered on providing support for the development of renewable marine energies from electrical perspective and robotic-aided monitoring and inspection.

*Project description*: INESC TEC is contributing to EU-SCORES project by providing tools for the future expansion of hybrid offshore farms (Wind, wave and offshore floating PV) as well as on the development of robots for autonomous inspection and monitoring of future farms. EU-SCORES aims at investing the hybrid farms operation to ease the future deployment. It is cantered at electrical infrastructure, anchor and mooring, environmental monitoring and logistics. The initiative demands scientific research on tools and methods and simultaneously the development of two real-size demonstrators; one in Portugal (wave energy) another in Belgium (offshore floating PV).

*Challenges*: Several challenges are being faced and overcome. They range from the materials scarcity and price increase due to the Ukraine war as well as climatic scenarios that difficulted and delayed the deployment of the first wave energy converter.

*Impact:* The outcomes will be scientific, from one side, and from the other, guidelines for future projects that will culminate on a white paper for hybrid farms. The project will also have a strong impact on the part related with renewable energy generation, but it can pave the way for other developments such as fish culture at sea.

*Lessons:* The project is not yet on a phase of publicly providing the lessons learned, since we still learning every day. Nevertheless, it shall provide good insights soon, namely on the public events. Please check: www.euscores.eu for updated info.

## Example 12: Twinning for an Offshore Wind Energy Partnership (TWIND)

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***About WavEC:*** Since its foundation in 2003, WavEC has been committed to the development and implementation of marine renewables, recognizing the pressing need for a new energy paradigm. WavEC is deeply involved in the blue bio value chain, leveraging its expertise in marine renewable energies to support sustainable development in the blue economy. This involvement includes research, development, and innovation activities aimed at harnessing marine energy. WavEC's contribution to the blue bio value chain can be seen through its collaborative projects and partnerships with various stakeholders, including academia, industry, and governmental bodies, to promote the development of marine energies.

***Project description:*** TWIND stands as a pioneering venture in Portugal's marine renewable energy sector. It bridges WavEC with reputable research bodies- Tecnalia (Spain), Offshore Renewable Energy Catapult (UK), and TU Delft (Netherlands)- to foster robust Science and Technology (S&T) capabilities in offshore wind energy. This collaboration aims to enhance WavEC's research and establish it as a European hub for offshore renewable energy, promoting Portugal's supply chain development in the sector. By leveraging expertise from regions with advanced offshore industries, TWIND intended to adapt and apply these insights to Portugal's unique deep-water conditions, broadening the application spectrum of existing methodologies. TWIND focuses on the professional growth of emerging researchers and broadens the offshore wind energy dialogue with stakeholders and the public.

***Challenges***: The implementation phase of the project encountered significant challenges, most due to the COVID-19 pandemic. Obstacles that we faced, ranged from logistical disruptions to restrictions on in-person collaborations and fieldwork. The pandemic's impact necessitated a rapid and strategic adaptation of our project management and operational methodologies to ensure continuity and progress towards our objectives. Key strategies included regular virtual meetings, adapting project timelines and milestones, extending deadlines where feasible, and adapting objectives to reflect the new working conditions without compromising the project's core goals.

*Impact:* A primary objective of TWIND was to develop strong science and technology skills in offshore wind energy in Portugal. The collaboration between WavEC and international institutions such as Tecnalia, Catapult and TU Delft produced significant research and innovation outputs:

- Definition of the stakeholders' matrix, for the identification of companies interested in the offshore wind sector in Portugal – suypply chain development.
- Identification of technology gaps linked to the development of the offshore wind sector and funding opportunities to participate in the development of this sector.
- Prepration of a Technology Action Plan for Portugal.
- Organisation of short-courses material that could be replicated for other training activities on offshore wind.

The TWIND project indirectly impacts the blue bio value chain and its stakeholders in several significant ways. By advancing offshore wind energy technologies and practices, TWIND contributes to the development of sustainable energy solutions that can be applied within the blue bio value chain. For instance, offshore aquaculture operations (and other activities), can significantly reduce their carbon footprint by integrating renewable energy sources, thereby enhancing the overall sustainability of the blue bio economy.

The research and innovation fostered by TWIND in understanding and mitigating the environmental impacts of offshore wind installations can benefit marine ecosystems. This is crucial for the blue bio value chain, which depends on the health and vitality of marine environments.

TWIND's role in creating robust linkages between research institutions and the industry fosters a culture of collaboration and knowledge exchange. This collaborative framework can extend beyond wind energy, encouraging partnerships between stakeholders in the offshore wind and blue bio sectors. Promoting Portugal as a hub for offshore wind energy, TWIND indirectly supports the economic diversification of coastal and maritime regions. The development of a skilled workforce and the enhancement of local supply chains to serve the offshore wind industry can have parallel benefits for the blue bio economy.

*Lessons:* This project demonstrates the immense value of combining diverse expertise and resources to tackle complex challenges in renewable energy. Future projects can benefit from actively seeking such partnerships early in their lifecycle. The project highlights the need for continuous investment in training and education to build a skilled workforce capable of driving innovation in renewable energy. The project's experiences reinforce the significance of collaboration, capacity building, sustainability, and active policy and public engagement as cornerstones for successful renewables energy initiatives. These insights can guide future projects also across the broader spectrum of blue bio value chain.

## Example 13: Optimization of the turbine locations within the wind farm

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***About Cador:*** Cador Consulting, as an authorized commercial partner of the world leader in the industry of services and software for product lifecycle management, Siemens PLM Software, deals with the implementation of CAD/CAM/CAE software. The company's main mission is to provide manufacturers with effective tools supporting design and production. Cador Consulting's offer includes advice on the selection of software, sales, implementation and adaptation of the software to the individual needs of the user, as well as the provision of services and assistance in solving current problems.

***Project description:*** Simulation provides unparalleled insight into the complex phenomena of erosion in production and process systems aiding understanding of the actual functional life of equipment under the operational conditions experienced. Project implementation components were wind farm layout optimization, prediction of scouring & erosion, ice accretion, floater optimal design and turbine erection simulation.

***Challenges***: Scouring is the unwanted removal of the soil around the foundation of an offshore turbine due to the sea currents. At the other hand, the flow around the foundation, and in particular when it is contaminated by sand particles, can also give rise to severe erosion which can affect the integrity of the entire asset. In cold regions there is always the risk for ice deposition on the blades. Improve annual power of a wind farm Maximize Annual Energy Produced (AEP).

***Impact:*** Project outcomes during the design phase of the wind farm were acquisition and centralizing of operational wind farm data creating a Digital Twin of the wind turbine/farm and feeding it with real-time data for optimization e.g. maintenance.
The project also benefited by Reducing service costs (due to Inventory planning based on actual lifetimes and optimization of spare part logistics during service) and Reducing procurement costs (order based on real lifetime calculation and to enable customer to provide long term service agreement).

***Lessons:*** It is anticipated that by an optimal management of the smaller spare parts can increase the its availability by 5%, the outcome of the turbines by 10% and the servicing cost by 15%.

## Example 14: KvarkenData

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*About University of Vaasa:* We study and research fields that hold the key to solving the challenges of the world of today and tomorrow. We focus on sustainable business, energy, and society. Our students have the skills and attitude to do things differently and make an impact on our common future. Our people-oriented university creates an inspiring environment for impactful research. Our modern, beautiful seaside campus is working towards carbon net neutrality and enables close cooperation in our educational and research activities. Given our location at the heart of Northern Europe's largest energy and environment cluster, it is especially our responsibility to spearhead the promotion of sustainability. Also, we are responsible authority for implementing the EU Structural Funds Programme on a regional level and managing the S3 strategy and process.

*Project description:* The Kvarken Archipelago, shared by Finland and Sweden, holds the prestigious title of a UNESCO World Heritage Site. It's recognized for its exceptional geological features. The regions in the area of Kvarken, has a long history of cross-border collaboration within various areas such as business, R&D and infrastructure development. The two-year ERDF-funded KvarkenData project, managed by the University of Vaasa, explores the research and business possibilities of environmental data from Kvarken area.Aurora Botnia, a ship of Wasaline, operating between Vaasa and Umeå acts as a sensor observing the state of the environment by collecting maritime and environmental data along its route. In addition, the utilization of other data sources (for example weather and satellite data) in monitoring the marine environment is also being investigated.
The project has four main goals:

1) Find out the possibilities of using the ship's data;
2) Implement small-scale experiments based on the data;
3) Map the possibilities of using models based on ship and environmental data;
4) Build networks for the wider use of data from Kvarken area.

*The project started 1.4.2023 and will finish 31.3.2025. The project has so far focused mainly on aspects related to maritime data collection and utilization as well as starting to build the data portal and its interface.* https://kvarkendata.com/portal/

*Impact:* In the project, researchers at the University of Vaasa are developing a user interface pilot for utilizing Kvarken data. The user interface to be developed can be used, for example, in monitoring the ship's energy efficiency, the environment or ship traffic. The Kvarken Data project will show what kinds of service business models that could be associated with the data produced by the ships. The commercial potential of maritime data as well as the requirements, processes and capabilities related to its commercialization are evaluated by means of company case studies. The investigations related to the commercialization of data continue to help in the development of business networks in Kvarken area and more broadly in the entire Baltic Sea region.
The project succeeds in bringing together different types of stakeholders and organisations on a regional, national and international level in exploring new sources and applications of data. The project's business partners are Wasaline and Wärtsilä. Research collaboration is also carried out with the Finnish Meteorological Institute, the Finnish Environmental Centre and Aalto University. In addition, the project cooperates with the Baltic Sea Action Group. The project will create wider research networks, particularly between the BSR actors, but also support the development of new business networks around the utilization of new types of data in potential areas such as transport, logistics, tourism and nature values.

*Lessons:* From the Regional Council's and more specifically, an S3- viewpoint, the project adheres to the outlined need to strengthen companies' capacity to collect and utilize new forms of data as well as to develop new business models related to these. The project activities also showcase to the need of building new networks between companies but also other actors to realize these opportunities.

## Example 15: OCEAN Energy Scale-up Alliance (OESA)

*Company/Institution:* Dutch Marine Energy Cluster
*Location:* Netherlands, South Holland, The Hague
*Web page:* https://www.dutchmarineenergy.com/

*About DMEC:* Dutch Marine Energy Centre is an accelerator and knowledge centre for offshore renewable energy solutions. As a non-profit organisation, we advance innovation, support market development and further policies for offshore renewable energy development. With this integrated approach, we create multipurpose energy solutions including marine energy, offshore storage and nature-positive designs for a wide variety of use cases.

*Project description:* Ocean Energy Scale-up Alliance (OESA) aims to accelerate the development of marine energy technologies through setting up strategic partnerships & international collaboration and deploying large scale marine energy pilots. The project overall objectives of OESA are:

1) Develop, evaluate and promote a transnational Scale-up offer;
2) Deploy four scaled-up ocean energy pilots;
3) Increase stakeholder engagement to optimise conditions for future deployments.

OESA partners work together to develop new services to support accelerated deployment of ocean energy parks in NSR. This is the first project building an alliance between the Nordics and North-West Europe. It already realises the deployment of 4 pilots during the project, that will increase the installed ocean energy capacity with 30% and reduce 100.000 tonnes CO2 emission.

Next to the expertise from eight service providers, OESA also benefits from the insights into development processes and challenges in the deployment of marine energy pilots of four technology developers. They represent a diverse group of companies with activities in 6 different NSR countries and cover in their expertise the fields of floating wind energy and wave energy. At the same time, they represent a variety of different challenges, which contributes to a scale-up offer covering an equally various field of services (Seabased AB; NEMOS; SeaTwirl AB; Floating Power Plant).

*Impact:*

1) To develop a transnational scale-up offer for marine energy technologies, in which the services of large European service providers in offshore and marine energy are combined.
2) To accelerate the development of four technologies, leading to the deployment of 20 MW in large scale pilots.
3) To bring together stakeholders from the offshore industry, investment business and policy makers in a stakeholder platform and show the collaborative potential of marine energy in order to secure their support for future deployments in the ocean energy sector.

## Example 16: PortXL Accelerator

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*About PortXL:* Established in 2015 in Rotterdam, Netherlands, has actively engaged in nurturing the spirit of innovation within the global maritime industry. As the world's first port and maritime accelerator, PortXL's primary focus is on creating tangible business value for maritime start-ups and scale-ups. They have developed an ecosystem comprising start-ups, scale-ups, corporate partners, and mentors dedicated to disrupting the status quo in the maritime industry. Their involvement in the blue bio value chain likely includes fostering innovations that enhance the sustainability and efficiency of maritime operations.

*Project description:* PortXL, renowned for its commitment to fostering innovation in the maritime sector, has been instrumental in promoting the development and adoption of sustainable and digital solutions within the industry. Through its accelerator programs, PortXL has supported numerous startups and scale-ups focusing on green technologies, such as emission-reducing solutions and digital advancements in shipbuilding, effectively contributing to the blue bio value chain and enhancing maritime sustainability efforts. PortXL's main objectives include fostering innovation within the global maritime sector, establishing a collaborative ecosystem of startups, scale-ups, corporate partners, and mentors, and promoting disruptive technologies to change the traditional maritime industry landscape. This initiative aims to create tangible business value for maritime businesses serious about growth and innovation, supporting the development of sustainable and digital solutions in the maritime field. PortXL implements its project through a structured accelerator program that selects up to 15 startups and scale-ups annually. The process involves scouting for innovative companies worldwide, followed by an intensive selection day. Selected participants undergo a 100-day mentorship-driven program focusing on scaling their businesses and exploring pilot projects with leading maritime companies. Key milestones include the selection day, the start of the accelerator program, and the final "Shakedown" event where participants pitch their innovations to stakeholders.

*Challenges*: Main challenges were to get the corporate partners that are able to offer pilots in their organization ready to actually implement it. This means a larger commitment and internal processes that took longer than expected. Top level commitment was their but midlevel where the actual collaboration should happen was often not arranged.

*Impact:* PortXL has run since 2015, with every year a programme with on average 15 startups participating. Over 50 pilots were executed. The programme expanded to Singapore and Antwerp
PortXL's initiatives have positively impacted the blue bio value chain and its stakeholders by driving innovations and fostering collaborations that enhance sustainability and efficiency within the maritime industry. Through its accelerator program, PortXL has supported the development and implementation of green technologies and digital solutions, contributing significantly to the industry's transition towards more sustainable practices. This collaboration between startups, scale-ups, and established maritime companies accelerates the adoption of innovative solutions, ultimately benefiting the broader maritime ecosystem and promoting environmental sustainability.

*Lessons:*

1) Difficult to create value for all partners that bring in a challenge, year in year out as they also change their strategy.
2) The limited number of startups in the programme (only 15) makes it difficult to connect to that specific challenge of a corporate partner as the selection is not done of the match with the corporate but with the fit of the programme.
3) Acceleration programmes are very important tools to connect the ecosystem but need to be well aligned with the individual needs of the stakeholders.

## Example 17: RDM Campus- Innovation Dock

*Company/Institution:* RDM Campus
*Location:* Netherlands, South Holland, The Hague
*E-mail:* JRJ.Goslinga@portofrotterdam.com
*Web page*: https://www.rdmrotterdam.nl/
*Phone:* 31 6 13 022 813



*About RDM:* RDM Campus in Rotterdam is a dynamic hub for innovation and sustainable development within the maritime and marine sectors. We play a pivotal role in the blue bio value chain by fostering the integration of academic research with industrial application, specifically in marine biotechnologies. Through our comprehensive network of startups, industry partners, and educational programs, we support the development and commercialization of sustainable marine solutions. Our focus spans from biofuels and bioplastics derived from marine resources to advanced research in marine ecosystems, aiming to enhance the sustainability and efficiency of the maritime industry. By leveraging Rotterdam's strategic maritime position, RDM Campus is steering the transition towards a resilient and sustainable blue economy.

*Project description:* RDM Campus, including the Innovation Dock, is a vibrant hub for education, research, and innovation located in the heart of Rotterdam's port area. This unique ecosystem brings

together students, researchers, and entrepreneurs to collaborate on pioneering projects focusing on the maritime industry, clean technology, and sustainable innovation. Housed in a revitalized shipbuilding warehouse, the Innovation Dock provides cutting-edge facilities and workspaces designed to foster creativity and the development of new technologies. The campus plays a critical role in driving forward the green and digital transitions within the maritime sector, supporting Rotterdam's vision of becoming a smarter, more sustainable port city. Through its focus on practical learning and industry collaboration, RDM Campus serves as a beacon of innovation and education, preparing the next generation of engineers, designers, and entrepreneurs to tackle the challenges of tomorrow.

*Challenges*: The size of this project from both real estate perspective and all partners made it difficult in the setup phase. The role of the Port of Rotterdam, in collaboration with knowledge institutes, small and big companies made it a complex project. The learning here is that it takes time to settle and get to the desired outcome

*Impact:* RDM Campus is now a very important key stone in the maritime ecosystem, bridging education with innovation in this sector. Over 40 innovative companies – including Ampelmann, Franklin Offshore, Energy Floors and Urban Green – have found a home at RDM.
The initiative likely had a significant impact on promoting innovation and sustainability within the blue bio value chain by creating an environment that encourages collaboration between academia and industry. This would enhance research, development, and commercialization of sustainable marine solutions, contributing to the growth of the blue economy. By focusing on sustainable maritime technologies and practices, RDM Campus and its stakeholders are positioned to influence sustainable development in the maritime sector, though specific impacts on the blue bio value chain would require further investigation into project outcomes and stakeholder feedback.

*Lessons:* Location is very much a factor to take into account when setting the goals for the initiative. You need to build something that will incorporate multiple stakeholders that find their home in that location so it will work. It takes time to build something like this at scale. Next to that when connecting education institutions to it, you need to take time to let the education programme rhythm connect to other stakeholders in the physical location.

# Part III: Other blue economy sectors and technologies

As has been emphasized several times so far, the blue economy is a concept that aims for the sustainable use of ocean resources while achieving the triple bottom line of economic, social, and ecological sustainability. The blue economy implies an opportunity for innovation, for sustainable development and for contribution to the region's economy in a wide number of sectors. The two selected sectors have previously been presented in detail, while this part comprises the examples of best innovative practices and projects that do not exclusively belong to the described value chains/sectors. The blue

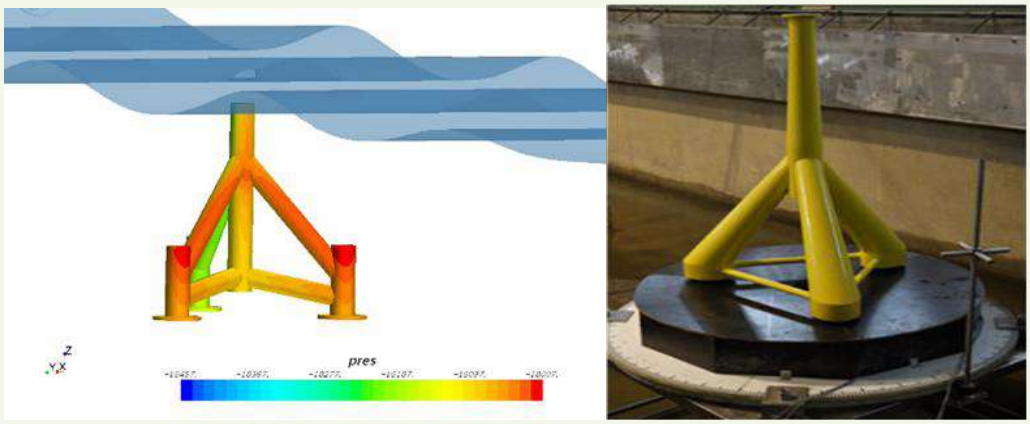
economy encompasses a wide range of economic activities linked to oceans, seas, and coastal areas. These activities include marine fisheries, aquaculture, maritime transport, tourism, offshore energy, marine biotechnology, and undersea mining which are critical for global food security, trade, and energy production.

This chapter contains the examples of blue practices that are referring to new innovations aiming to facilitate the use of machinery and traditional technologies for more efficient and sustainable valorisation of marine resources.

## Best practice examples

### Example 1: Project Aquilo

***Company/Institution:*** CTO S.A. (Maritime Advanced Research Centre)
***Location:*** Gdansk, Poland
***E-mail:*** mateusz.weryk@cto.gda.pl
***Web page***: https://www.cto.gda.pl/en
***Phone:*** +48 601 684 421




***About CTO:*** CTO is a multidisciplinary research facility which is constantly looking into possibilities of cooperation in all blue bio value chains related to its area of expertise. CTO was involved in several projects related to Blue Bio value chains, for example: Project Aquilo, Project Aquo,Project Esthetics. Additionally, CTO is frequently involved in ship model tests of fishing vessels and live fish carriers and has wide experience in optimization of ship geometry, reduction of its resistance and power consumption.

***Project description:*** The aim of the project was to create a database on the basis of which the investor will be able to decide on the best type of supporting structure for an offshore wind farm for a specific location in Polish maritime areas. After conducting research on the seabed of Baltic Sea, currents, waves and biological resources, the data obtained in the project aid decision-making on which type of support structure use and which installation method should be implemented. Criteria for selecting the supporting structure were created based on geotechnical, depth and local ecosystem conditions.

Analyses were made on installation techniques for various types of structures and criteria for selection of type of structure were developed taking into account the coupled effects of waves and sea currents. The developed methods of selecting the supporting struc ture depending on the conditions prevailing in a given location within Polish maritime areas are available to investors interested in building offshore wind farms.

***Challenges***: Creating such a large database involved a lot challenges related to the determination of environmental loads and taking into account their random nature. The studies involved extensive measurements over a long period of time and implementation of statistics.
The study included numerous numerical simulations with the use of determined environmental loads which required development of proper methodology as well as detailed analysis of solutions used in marine structures.

***Impact:*** The outcomes of the project provide the basis for the projects related to offshore wind farms in the regions of Polish Baltic Sea. The research provides valuable data to all stakeholders interested in this blue bio value chain. The results of the project were published in an open access database (see link below): https://www.iopan.gda.pl/MORCEKO-AQUILO/

***Lessons:*** The project provided valuable data and experience to all interested in the blue bio value chain related to offshore wind farms.

## Example 2: VR training simulator

***Company/Institution:*** Flint Systems Sp. z o.o.
***Location:*** Poland / pomorskie / Gdynia
***E-mail:*** m.kniter@flint.systems
***Web page***: https://flint.systems
***Phone:*** +48 791 229 026

***Project description***: Our VR training simulator revolutionizes the way we train operators for various types of port machinery. With modules for STS cranes, RTGs, reach stackers, ship and rail-mounted cranes, it provides a comprehensive training experience without the need for actual equipment.
By simulating real-world scenarios, operators can hone their skills in a safe and controlled environment, eliminating the risks associated with on-site training. Moreover, the simulator significantly reduces operational costs by eliminating the need for fuel for these machines.
Powered efficiently like a household iron, it consumes minimal energy compared to traditional training methods. This not only cuts down on expenses but also aligns with our commitment to sustainability by reducing carbon emissions. The main objectives of VR training are:

- Enhancing training effectiveness- The project aimed to improve the effectiveness of training for port personnel by providing them with realistic simulation experiences using VR technology. This approach allowed for hands-on practice in a safe and controlled environment, leading to better skill acquisition and retention;
- Cost reduction- By utilizing VR simulators instead of actual port machinery for training, the initiative sought to reduce costs associated with fuel, maintenance, and downtime. This cost-effective training solution allowed for more frequent and extensive training sessions without the need for expensive resources;
- Safety improvement- Another key objective was to enhance safety standards within the ports by ensuring that operators were well-trained and proficient in handling various types of machinery. The immersive VR simulations provided a risk-free environment for practicing complex manoeuvres and emergency procedures, thereby minimizing the likelihood of accidents or injuries on the job;
- Sustainability promotion- By reducing the reliance on fuel-powered machinery for training purposes, the project aimed to promote sustainability within the maritime industry. The use of energy-efficient VR simulators aligned with environmental goals by minimizing carbon emissions and resource consumption.

***Challenges***: Replicating the exact machine in virtual reality presents a significant challenge, as it requires creating a faithful VR twin of the real machine. Our team must meticulously reflect the physics and behaviour of the actual machinery to ensure an authentic training experience.
This process involves painstakingly capturing and integrating various elements, such as the machine's dimensions, structural integrity, mechanical components, and dynamic functionalities. Detailed modelling of these aspects is crucial to accurately simulate how the machine moves, responds to user inputs, and interacts with its environment. Moreover, achieving realism extends beyond visual representation; it also encompasses replicating the machine's tactile feedback and sound effects. Users must feel as if they are operating the actual equipment, experiencing the same sensations and auditory cues encountered in real-world scenarios.

***Lessons:*** VR training brings many environmental advantages:

- minimized equipment usage (VR training eliminates the need for physical equipment typically required for hands-on training sessions. This reduces the manufacturing, transportation, and disposal-related carbon emissions associated with producing training equipment);
- energy efficiency (platforms are designed to be energy-efficient compared to traditional training facilities);
- sustainable scalability (VR training offers scalability without significant increases in carbon emissions);
- lifecycle assessment (allows for the implementation of lifecycle assessments to evaluate environmental impacts comprehensively. Organizations can analyse the carbon footprint of VR training systems throughout their lifecycle, including production, operation, and disposal phases).

## Example 3: BONAZZA waveless sea experience

***Company/Institution:*** *BLUE GREEN PROJECT d.o.o.*
***Location:*** *Croatia, Dalmatia, Split*
***E-mail:*** marcella.zanki@gmail.com
***Phone:*** *+385 91 576 8705*

*Project description*: Bonazza is an environmentally and energetically self-sustaining concept that is a kind of perpetuum mobile of the first kind with the help of electricity generated from renewable and inexhaustible natural sources- sun, wind, waves, sea currents. Immune to sea waves and the unpredictable nature of the sea, the Bonazza concept has the potential to be applied in various fields, from offshore tourism, restaurants, mariculture, scientific research, electricity generation and many other activities that are carried out at sea. The main goal of the project is focused on creating additional market value in the blue economy sector through the use of renewable energy sources and as a completely new form of tourist hospitality offer in the off shore edition, energy production with the possibility of accumulation and mariculture. The project is in the concept development phase (blueprints, 1:25 model, legal protection of the idea, computer simulation on waves, 3D rendering of some of the applications). Preparation of project documentation and feasibility study is underway. The object as a floating island can be used in a wide variety of applications, from mariculture, floating lighthouse, agriculture, scientific laboratory, research stations, apartments, housing, catering facilities, anchorage for ships such as marinas, sports facilities, lifeguards, fishermen, shellfish and fish farming, electricity production, etc

*Challenges*: Currently, the biggest challenge is finding a source of funding, specifically for project documentation, model testing in a laboratory environment and then making the prototype and testing the prototype in a real environment, as well as obtaining the appropriate concessions in offshore execution.

*Impact:* At the moment, we do not have an estimate of the expected results, considering that the project documentation and feasibility study are being prepared.

*Plans:* Further commercialization of the project and expansion of infrastructure throughout the Adriatic with the goal of energy transition from fossil fuels to sustainable energy sources (such as charging stations for electric ships), sustainable tourism (hotels, apartments) and potential housing at sea in the future.

## Example 4: Water neutralization for human consumption

***Company/Institution:*** Associação NET4CO2 – Network for a Sustainable CO2 Economy
***Location:*** Portugal / Porto / Porto
***E-mail:*** marcelo.costa@net4co2.pt
***Web page:*** https://www.net4co2.pt/
***Phone:*** +48 220 731 349

***About NET4CO2:*** Network is a Portuguese Collaborative Laboratory, a nonprofit R&D organization focused on creating sustainable industrial solutions to respond to the European Green Deal ambition for climate neutrality in 2050. Our mission is to develop innovative decarbonization solutions, from science to market, and accelerate the deployment of competitive and disruptive solutions for CO2 capture, utilization, and storage towards a more sustainable world. We envisage to be an active player in decarbonization technological solutions, contributing to the industrial and social reforms needed to reduce CO2 emissions.

***Project description:*** This specific project consists in the application of an innovative mixing technology for the continuous dissolution of CO2 for water treatment solutions. Nowadays this process is done using a venturi-type injector, which is inefficient, and results in high CO2 (food-grade) consumption. With the implementation of the technology of this specific project, using a side-stream approach, the CO2 will mix with water in a more efficient way resulting in higher dissolution rates and lower CO2 consumption. A pilot-scale test unit was implemented in the wastewater treatment plant from Águas do Douro e Paiva for attest the unit efficiency coupled with a real-time monitoring digital interface.

***Challenges***: The main challenges are related with the pressure drop intrinsic to the design of the mixing technology. These challenges have no significant impact at the current pilot; however, it needs to be addressed during scale up of the technology. A second challenge is related to the testing

availability, since due to natural fluctuations of the water's pH, it is not always possible to test the technology.

*Impact:* Improving the water neutralization process using CO2; The neutralization process was enhanced by using our technology: the mass transfer rate (water/CO2) increased and consequently, the required amount of CO2 was reduced. Additionally, our optimized technology allows the reduction of required equipment working volume, in comparation with the conventional technologies.

*Lessons:* It is expected to learn what is the best configuration for an efficient mixing of CO2 in water for water neutralization in water treatment plants. Preliminary results seem to indicate that a 10-fold CO2 consumption reduction is expected. This is a significant impact since CO2 for the treatment of water for human consumption is extremely expensive and has significant impacts related to the CO2 production.

## Example 5: The blue bio value chain effectiveness increasing by innovative resource planning and managing.

*Company/Institution:* WAELLER sp. z o.o. sp. k.
*Location:* Poland / Pomerania / Trabki Wielkie
*E-mail:* a.rapicki@waeller.pl
*Web page:* https://waeller.pl
*Phone:* +48 784 046 763

*About WAELLER:* We are an ICT company that develops systems for resources planning, processes management and automation as well as energy management that improve blue bio value chain effectiveness. We are a representative of the German company Hoerster's Buero Organization GmbH, which has been operating since 1919 and offers comprehensive solutions for the organization and storage of documents globally under the WAELLER brand. We have been operating in Poland since 1992, and since 2015 as WAELLER sp. z o. o. sp. k. WAELLER means over a century of experience, hundreds of specialists, thousands of completed projects and tens of thousands of users. Our clients include listed companies, international corporations, capital groups, banks and financial institutions, public sector and administration companies and institutions, as well as many companies and enterprises that are world leaders in their industries.

*Project description:* Our project regards innovative fisheries and aquaculture resources planning and managing to achieve best effectiveness measured by KPIs increasing. We develop modern ICT system supported by AI and ML that deal with Big Data processing to generate accurate and up-to-dated information about blue bio value chain that helps waste and energy effective management.
Main project objectives are to reduce waste of resources and energy in fishery aquaculture and maritime economy. The project is significantly advanced but not implemented yet.
The project milestones are:

- Beta version for tests;
- Test implementation in a small port (or ports) of the Baltic Sea Region;
- Production version to launch on the market.

*Impact:* Significant increase of effectiveness, lower costs, decreasing of waste and loses. The blue bio value chain or related stakeholders will benefit of increase of effectiveness, lower costs, decreasing of waste and loses in their everyday activity. Thanks to the implementation they should be able to

reduce energy consumption and that will help them to switch to the renewable blue energy sources. All in all, it means easier and faster maritime economy decarbonization.

***Lessons:*** The most important lesson is the need to discuss with potential project beneficiaries in order to adapt the solution to their individual requirements and market conditions. This approach should ensure the success of the project.

## Example 6: Korcula Port Authority, oil spill monitoring on the sea

***Company/Institution:*** SeaCras Ltd.
***Location:*** Croatia
***E-mail:*** Mario.spadina@seacras.com
***Web page:*** https://seacras.com/
***Phone:*** 00385 91 193 0875

***About:*** SeaCras is technology provider for marine monitoring to the stakeholders in the blue economy. SeaCras leverages satellites for providing the efficient and affordable monitoring service with lowest greenhouse gas emissions. Our mission is to provide partners and clients with services and products that incorporate the full scope of coastal intelligence, encompassing both surveillance and environmental monitoring. This represents a new, data-driven path for the resilience of the blue economy, security, and the preservation and restoration of the marine environment.

***Project description:*** SeaCras implemented the oil spill monitoring system over Korcula Port Authority area during the touristic season. Partially funded by: Eurostars, Sar2dem project, SeaCras lead. The main project objective was to establish the efficient oil-spill monitoring system by combining different satellite technologies. The key milestones of the project were testing with the real clients, such as Port Authorities.

***Challenges***: As a startup, challenges are mostly financial in nature. SeaCras solved it by sales and strategic partnerships.

***Impact:*** More efficient oil-spill monitoring system, compared to the competition. It serves to strengthen the resilience in local community of the city of Korcula and the island as whole, thus fostering sustainable coastal tourism and maritime transport.

***Lessons:*** Product to market fit is the key to success. Carefully protect your previous, background IP and all IP that emerges form project activities. That is your main priority and your asset.

## Example 7: Transitioning to Emission-Free Inland Shipping with ZESPacks

*Company/Institution:* Zero Emission Services (ZES)
*Location:* Netherlands, South Holland, The Hague
*E-mail:* info@zeroemissionservices.nl
*Web page:* https://zeroemissionservices.nl/

*About ZES:* Zero Emission Services was founded as a joint venture by ING bank, ENGIE, Wärtsilä, and the Port of Rotterdam Authority, supported by the Dutch Ministry of Infrastructure and Water Management and the Netherlands Enterprise Agency. ZES aims to transition inland shipping from diesel-powered to emission-free vessels through the use of innovative, interchangeable battery containers (ZESPacks) powered by renewable energy. These batteries support zero-emission inland waterway transport, promoting sustainable shipping practices within the Netherlands and setting a benchmark for global maritime sustainability.

*Project description:* Zero Emission Services (ZES) facilitates emission-free inland shipping through the use of ZESPacks – eco-friendly battery containers charged with renewable power. These batteries are designed for easy exchange at a network of open-access charging points, minimizing downtime and promoting efficient operations. As a scalable and adaptable solution, ZESPacks also have the potential to stabilize local electricity grids onshore. 1. The primary objectives of ZES include reducing CO2 emissions in inland and short-sea shipping, promoting the adoption of climate-neutral technologies, and establishing a sustainable maritime infrastructure that aligns with the Paris Agreement's climate goals. ZES also aims to set a global standard for sustainable shipping practices. ZES launched its first operational battery exchange station in 2020, with the barge 'The Alphenaar' becoming the first to use a ZESpack for transporting beer from a Heineken brewery. The initiative is ongoing, with plans to expand the network of charging stations to other major Dutch cities and eventually across borders.

*Challenges*: A significant challenge is the hesitation among ship owners to invest in new technologies without an industry-wide level playing field. ZES addresses this through its innovative "pay-per-use" scheme, allowing users to rent the batteries and pay only for the energy they consume, reducing the upfront financial burden.

*Impact:* In its first year, ZES enabled the first zero-emission beer transportation by Heineken, with plans to add five more vessels to the fleet in 2021. The project aims to significantly reduce CO2 emissions from the maritime sector and serve as a model for sustainable shipping worldwide. ZES has positively impacted the maritime sector by providing a viable model for reducing emissions and demonstrating the feasibility and benefits of sustainable shipping practices. This initiative supports broader climate goals and fosters a shift towards more environmentally friendly maritime operations.

*Lessons:* The project highlights the importance of collaboration across sectors and the effectiveness of innovative financing models like "pay-per-use" in facilitating the transition to sustainable technologies. It also underscores the need for supportive infrastructure and government backing to scale such initiatives.

## Example 8: Synthesis of bioactive compounds from microalgae culture

*Company/Institution:* Fitoplancton Marino, S.L.
*Location:* España/Andalucia/El Pto. Sta. Maria
*E-mail:* cue@easyalgae.com

*Web page:* www.fitoplanctonmarino.com

*Project description:* The project is focused to development of new food supplements based on marine microalgae to combat oxidative stress. The aim is to develop the technology for the optimisation of bioactive compounds and clinical trials. The compounds will also be implemented in human clinical intervention studies to demonstrate the efficacy of these compounds for various health indications. The main objective was to optimise the culture systems to stimulate the production of primary antioxidants with SOD, CAT, GpX and other compounds of interest. In addition to demonstrating their efficacy. The culture part was developed in our laboratories, using olecular technologies focusing on specific markers in the species Tetraselmis chuii. In addition to inducing the stimulation of compounds in the microalgae, we aimed to identify markers in humans to demonstrate their efficacy.

*Challenges*: One of the main challenges was to demonstrate efficacy in humans. This was approached by conducting clinical studies, including muscle biopsies from patients. With the samples, an "Open Array" was set up in which more than 120 targeted genes were studied.

*Impact:* The results demonstrated that critical conditions existed to stimulate certain metabolic pathways in T. Chuii for the production of the enzymes mentioned above. However, we were finally able to develop a control method that guarantees the control of the production of these enzymes. This involved implementing a gene expression platform that allows us to know and control the expression levels of certain genes involved in enzyme synthesis.
The main impact was the development of a technical dossier and several scientific publications that endorse our technology, as well as the application of our compounds in food supplementation. This has allowed the sales of compounds to double in the first year after the publication of the results and the obtaining of several recognitions in the form of international awards.

*Lessons:* We apply molecular tools to monitor bioactive compound production systems. We have learned that the physiological state of microalgae is highly variable and therefore their ability to produce compounds is highly variable. Molecular tools allow us to produce with precision and to know when to harvest the microalgae. There are compounds that can have a variability of 95% within a day, which may or may not produce the target compound.

## List of I3 4 BLUE GROWTH project partners

| No. | ORGANISATION | LOCATION |
|---|---|---|
| 1. | ANI - AGENCIA NACIONAL DE INOVACAO, SA (ANI) | RUA DE SAGRES 11, PORTO 4150649, Portugal |
| 2. | OY MERINOVA AB (MERINOVA) | YRITTAJANKATU 12, VAASA 65101, Finland |
| 3. | HRVATSKA AGENCIJA ZA MALO GOSPODARSTVO, INOVACIJE I INVESTICIJE (HAMAG-BICRO) | KSAVER 208, ZAGREB 10000, Croatia |
| 4. | FUNDACION CENTRO TECNOLOGICO ACUICULTURA DE ANDALUCIA (CTAQUA) | MUELLE COMERCIAL S/N EDIF CTAQUA, EL PUERTO DE SANTA MARIA CADIZ 11500, Spain |
| 5. | CLUST-ER AGROALIMENTARE (C-ER) | VIA PEDRO GOBETTI 101, BOLOGNA 40129, Italy |
| 6. | POLE MER BRETAGNE ATLANTIQUE (PMBA) | 525 AVENUE ALEXIS DE ROCHON, PLOUZANE 29280, France |
| 7. | VICE-PRESIDENCIA DO GOVERNO REGIONAL DOS ACORES (VPGRA) | LARGO PRIOR DO CRATO, PONTA DELGADA 9700-157, Portugal |
| 8. | UNKNOWN INNOVATION BV (Unknown Group) | SATURNUSSTRAAT 95 UNIT 0.07, THE HAGUE 2516 AG, Netherlands |
| 9. | BALTYCKI KLASTER MORSKI I KOSMICZNY (BSSC) | UL. POLSKA NR 13A LOK 1, GDYNIA 81-339, Poland |
| 10. | BBA - ASSOCIACAO NACIONAL PARA OS BIORECURSOS MARINHOS E BIOTECNOLOGIA AZUL (BBA) | BIOCANT PARK SA PARQUE TECNOLOGICO DE CANTANHEDE NUCLEO 04 LOTE 2, CANTANHEDE 3060-197, Portugal |

# Annex 1: Questionnaire

## TEMPLATE ON WP2 USE CASE INPUT

## Task 2.1 - S3 Strategies roadmap analysis, ecosystem and initiatives mapping, and trend analysis in interregional cooperation – policies, technologies and best practices

Dear Respondents,

In front of you is a questionnaire which objective is to furnish the I3-4-BLUE-GROWTH Partnership with instructions on completing a specific portion of Activity A.T2.1 – "S3 strategies roadmap analysis, ecosystem and initiatives mapping, and trend analysis in interregional cooperation – policies, technologies, and best practices," focusing particularly **on gathering innovative best practices.**

The best practices that will be presented to the different project stakeholders, serving as a basis and input to be used to identify priorities and build a training and capacity building program to stimulate interregional investment among regional actors and blue economy SMEs/startups.

The questionnaire will serve as the foundation for the handbook's creation titled “Handbook on innovative best practices”, and will be publicly available.

The Project centres on **two** distinct blue economy **value chains**:

Value Chain 1: Sustainable Fisheries, aquaculture and valorisation of blue resources;

Value Chain 2: Renewable Marine Energy and maritime decarbonization,

aiming to enhance comprehension of the associated interregional value chains, disseminate knowledge and exemplary practices, and pinpoint a series of innovative investments to foster sustainable growth within these value chains.

Taking into account your relevant experience and commitment in the field of mentioned value chain we kindly ask you to compile the questionnaire below.

To complete the questionnaire will take some time and we are very grateful for your time.

Some **fundamental definition** may be helpful:

**Blue bioeconomy** incorporates any economic activity associated with the use of renewable aquatic biological resources to make products. Examples of these wide-ranging products include novel foods and food additives, animal feeds, nutraceuticals, pharmaceuticals, cosmetics, materials (e.g. clothes and construction materials) and energy. On other words Blue bioeconomy means economic activities and value creation based on sustainable and smart use of renewable aquatic resources and the related expertise.

**Best practices for innovation** may refer to standards, regulations, methods and procedures that are applied and can be followed in order to build a resource - efficient society, and promote SDGs. In addition, as best practice can be considered an implemented, ready to market project or/and a pilot action/research project with actual results.

**Innovation** is defined as the carrying out of new combinations – launch of a new product or service, an application of new methods, technology or practice; an opening of a new market; an acquiring of new sources of raw material supply or creation or destruction of a monopoly organization (Schumpeter, 1934).

**Technology transfer** has been characterized as adoption of innovation, application of technology, technique or knowledge that has been developed in another organisation, but is also seen as an application of technology to a new use or user or production of a new product and more efficient production of existing products moved to the marketplace (Cunningham, Menter, & Young, 2017; Dubickis & Gaile-Sarkane, 2015). The forms of technology embrace physical items such as tooling, equipment and blue prints as well as the information – methods and procedures (Teece, 1977).

**Innovation transfer in Blue economy** is therefore focused on adoption of innovation, technology, technique or knowledge developed by organisation A, to a marketplace organisation B.

In the meantime, we really appreciate your contribution and please do not hesitate to contact us for any clarification.

We are fully available to assist you in the completion of the questionnaire or to arrange an interview with you.

Thank you in advance for your collaboration,

***I3 4 Blue Growth Team***

**Disclaimer on the data treatment**

“By filling this questionnaire, you give us your explicit consent for collecting and use personal data. Your data is important for us to gather information only for the purposes of this Project. The European Union General Data Protection Regulation (EU-GDPR) requires your explicit consent to collect any personal details. In this view, the collection of your details in this questionnaire and related uses e.g. Handbook of innovative best practices will strictly respect the terms of the EU-GDPR.”

## Innovative Best Practice/Project Examples in Blue Bio value chains

| Company/Institution Information | |
|---|---|
| Name of Company/Institution: | Enter name |
| Location (Country/Region/City): | Enter location |
| Proposed by Project Partner: | Enter name |
| **Introduction** | |
| Which value chain does your innovative best practice example belong to? | ☐ Sustainable Fisheries, Aquaculture, and Valorization of Blue Resources<br><br>☐ Renewable Marine Energy and Maritime Decarbonization<br><br>☐ In a different value chain within the blue economy that has not been mentioned previously. Which one?<br>Please specify |
| Briefly describe your involvement in the blue bio value chain. | Enter max. 150 characters |
| **Innovative Best Practice/Project Example** | |
| Title: | Enter title |
| Please describe a specific initiative or project within your Country/Region related to one of the above mentioned value chains that is considered to be an innovative best practice/project example. | Enter max. 800 characters |
| **Objectives** | |
| What were the main objectives of this initiative/project? | Enter max. 300 characters |
| **Implementation** | |
| Is the initiative/project implementation finalised or still ongoing? | ☐ Finished<br>☐ Ongoing |

| | |
|---|---|
| How was the initiative/project implemented/is implementing? Please provide details on the process and any key milestones. | Enter max. 300 characters |
| **Challenges** | |
| Were there any challenges faced during the implementation phase? If so, how were they addressed? | Enter max. 500 characters |
| **Results and Impact** | |
| What were/will be the outcomes of the initiative/project? Please provide any relevant data or statistics. | Enter max. 500 characters |
| What impact did the initiative/project have on the blue bio value chain or related stakeholders? | Enter max. 500 characters |
| **Lessons Learned** | |
| What lessons were learned from this initiative/project? Are there any insights you would like to share with others? | Enter max. 800 characters |
| **Future Plans** | |
| Do you have any future plans to further develop or expand upon this initiative/project? | Enter max. 500 characters |
| Are there any other areas within the blue bio value chain where you are seeking to implement best practices? | Enter max. 500 characters |
| **Contact Information** | |

| | |
|---|---|
| Name: | Enter name |
| Position: | Enter position |
| Email: | Enter e-mail |
| Phone Number: | Enter phone number |
| Web page: | Enter web page |
| Pictures | |
| | |
| | |