OCEAN MULTI-USE BLUEPRINT

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IMPRINT

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TABLE OF CONTENTS

ACRONYMS

CIA	Cumulative Impact Assessment
EC	Ecosystem Component
EIA	Environmental Impact Assessment
GES	Good Environmental Status
IPR	Intellectual Property Right
LTA	Low-Trophic Aquaculture
MSFD	Marine Strategy Framework Directive
MSP	Maritime Spatial Planning
MU	Multi-Use
OWF	Offshore Wind Farm
SU	Single-Use
UAF	UNITED Assessment Framework

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1. EXECUTIVE SUMMARY

The Ocean Multi-Use Blueprints Collection report presents a comprehensive compendium of multi-use solutions. It draws upon the findings from the UNITED ocean multi-use pilots and an extensive literature review covering additional cases across the EU. The report encompasses 4 blueprints covering all explored ocean multi-use combinations within the five UNITED demonstration pilots:

1. Offshore renewable energy and aquaculture (seaweed, mussels, oysters)
2. Offshore wind and nature restoration
3. Offshore wind and tourism
4. Aquaculture (finfish) and tourism

Each blueprint provides a practical model to guide the development of optimised multi-use scenarios. It stands as the **ultimate 'How To' guide** to ocean multi-use development, taking into account crucial dimensions such as **legal, insurance, regulatory, policy, technology, socio-economic, and environmental considerations**, all covered by the UNITED Ocean Multi-Use Assessment Framework.

The blueprints are designed to assist planners and industry stakeholders in making informed decisions about the most effective administrative, functional and spatial arrangement of offshore multi-use activities. Grounded in real-world applicability, the Ocean Multi-Use Blueprints Collection, together with the **Ocean Multi-Use Commercialisation Roadmap**, serves as an essential resource aimed at enhancing sustainable development of multi-use.

1.1. KEY GOOD PRACTICES EXAMPLES: OFFSHORE WIND AND AQUACULTURE

Various ownership and cooperation models can be applied, such as **sharing infrastructure, logistics, operational expenses, workforce, and monitoring activities.**

Co-location offers multiple benefits, including sheltering effects from rough water conditions, energy provision for aquaculture operations, enhanced environmental conditions, and mutual support among different uses, such as joint monitoring activities offshore.

While various types of aquacultures can potentially be considered in this multi-use combination, the UNITED project has mainly focused on the **low trophic aquaculture species such as oysters, mussels and seaweed,** trying to maximize the potential positive environmental effects of these combinations.

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OFFSHORE WIND AND AQUACULTURE

GOOD PRACTICE / TOOL	COUNTRY WHERE IT HAS BEEN APPLIED

SPATIAL PLANNING

Country: N/A

- **Siting Tool that evaluates the suitability of cultivation** of mussels (*Mytilus edulis*) and seaweed (*Saccharina latissima*) based on the interplay of key ecological variables in the planning and optimiza- tion of offshore aquaculture configurations. Can be easily applied to other species or variables or even other locations and thus be used for decision-making on spatial planning of offshore aquacul- ture, incl. within offshore wind farms. Integration of aquaculture in zones for industrial and commercial activities, as designated in the MSP 2020-2026

REGULATION

Country: NL, BE

- **Multi-Use Procedure** - It sets out a clear guidance directed towards multi-users and covers the entire permit application process, as well as strategies for stakeholder engagement. It provides an overview of the steps that need to be taken, the conditions that have to be met for a multi-use in offshore wind farms.
- '**Area Passports'** – uses features specific to the area to indicate where shared use is possible, which forms of this have the greatest chance of success and can best be accommodated and, as such, are preferable.

Country: NL

- **A non-financial tendering and auction criteria** which supports innovative combinations between offshore wind farms and ecology. Introduction of this criteria has led to the consideration of innovative approaches for combination of OWF with other ORE development such as solar energy and ecology within the design of OWF.

REDUCING RISK AND INSURANCE COST

Country: NL, DE

- **SOMOS risk assessment model and its application** in the German, Dutch, Belgian and Greek pilot to support profound decisions in changing situations (e.g. pandemic, energy crises)
- **Practical guidance for mitigating risks and reducing insurance costs** for multi-use within wind farms based on UNITED experience
- **Contractual waiver of recourse** among the involved parties

TECHNOLOGY

Country: DE, BE

- **Weather stations on-site** for early storm warnings, surveillance through radar, AIS, or cameras

OPERATION & MAINTAINANCE

Country: DE, BE

- Size and design of operation vessel

Country: N/A

- Health & Safety Trainings for the staff offshore
- Synergy operations of offshore wind farm and aquaculture
- Remote monitoring solutions

OCEAN MULTI-USE COMMERCIALISATION ROADMAP

SCAN ME!

OFFSHORE WIND AND NATURE RESTORATION

ABOUT

Several innovative nature restoration approaches within offshore wind farms have been designed and employed in recent years to promote and enhance marine biodiversity and ecosystems. Moreover, wind turbine foundations and associated infrastructure can be designed in a nature inclusive manner 'nature inclusive-design' to serve as habitat enhancement structures, or the installations in the surrounding areas can be added or adapted to mimic natural reefs, providing shelter and substrate for marine organisms to attach.

In the UNITED pilot in Belgium, the restoration of native (European) flat oyster reefs, utilising the hard substrate was used for wind turbine foundation scour protection. The coexistence of aquaculture and reef restoration was a symbiotic relationship, where aquaculture provided initial stock for reef development, and established reefs offered oys- ter larvae for aquaculture. Applied in Belwind OWF, located 46 kilometers offshore in the Belgian part of the North Sea.

Several other examples of this multi-use have been noted during the project, which have fed into the blueprint:

- **BE, NL, UK: Oyster Reefs**
- **NL: Kelp Forests and or other types of seaweed**
- **NL: Shellfish Beds**
- **NL, UK: Artificial reefs supporting fish populations**
- **Nature inclusive design of the Princes Elisabeth Island**

GOOD PRACTICE / TOOL	COUNTRY WHERE IT HAS BEEN APPLIED
SPATIAL PLANNING • **A model to identify suitable locations** for flat oyster habitat restoration, restorative aquaculture, or nature-inclusive oyster designs of offshore wind farms.	**BE**
REGULATION • **Non-financial tendering criteria** – see previous blueprint under 'REGULATION'	**NL, BE**
TECHNOLOGY • **Nature restoration physical technology** examples, including oys- ter cages on scour protection, artificial reefs, concrete founda- tions/blocks of various sizes to provide shelter for lobster, Atlantic cod and other large fish species. • **Remote monitoring** solutions	**NL, BE**

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OFFSHORE WIND AND TOURISM

ABOUT

Combining tourist activities (such as boat tours, diving, and fishing) with offshore wind generation. Examples of existing projects include:

- DK: visiting and climbing turbines at Middlegrunden Wind Farm outside of Copenhagen (UNITED)
- DE/BE/UK/SE: boat tours to wind farms (not entering the safety zone)
- DE/UK: viewing platforms and visitor centres to educate tourists about offshore wind energy

GOOD PRACTICE / TOOL	COUNTRY WHERE IT HAS BEEN APPLIED
SPATIAL PLANNING • **Special layout** of the Middelgrunden OWF (following the curved shape of the Copenhagen city outline)	DK
PERMITTING/REGULATION • **Establishment of a one-stop-shop** authority to streamline permit- ting processes and lowering regulatory barriers • **Permitting recreational vessels** to access wind farms (within a carefully regulated legal framework)	DK, UK, NL
SOCIAL IMPACTS AND ENSURING ACCEPTANCE • **Cooperative Ownership** • **Early engagement of the local community through** co-design of • the windfarm layout • **Set up of a tourism fund** during the wind park construction phase • to advance coastal tourism in the area (Gwynt y Môr Fund)	DK, UK
TECHNOLOGY • **Utilizing a suitably sized boat equipped with its own ladder** for boarding the wind farm platform	DK
OPERATION AND MAINTENANCE • **Knowledgeable guides** employed in the offshore wind sector and familiar with the technical aspects of the turbines • **Manual for tour guides**, providing information about the educa- tional content of the tour and the relevant technological aspects for guiding the visitors up the nacelle	DK
COMMERCIALIZATION • **Innovative marketing strategy** involving the placement of QR codes with virtual tours of the wind farm at prominent city land- marks.	DK

AQUACULTURE AND TOURISM

ABOUT

This multi-use can take several forms allowing different types of tourism within or in a close proximity to an aquaculture site, for example:

1. Hosting customers on vessels for visits to aquaculture sites to educate them about aquaculture techniques and traditions
2. Diving, snorkelling, and other active recreational activities conducted near or within aquaculture installations
3. Sport fishing tourism in or around aquaculture sites

Examples of existing projects:

- GR: scuba diving in close proximity to the aquaculture site (UNITED pilot)
- ESP/MLTA: snorkelling/diving in tuna farms
- IT/PT/SI: visits to offshore aquaculture farms
- DK: Blue community gardens (maritime allotment gardens at the coast)

GOOD PRACTICE / TOOL	COUNTRY WHERE IT HAS BEEN APPLIED
PLANNING AND SPATIAL REGULATION • **Enabling and regulating small-scale aquaculture farms** in tourism and marine protection areas	SI
RISK MANAGEMENT • **Employment of well-trained and certified scuba diving instructors** (i.e. PADI or SSI), experienced to dive in enclosed spaces, if relevant	GR, MALTA
INSURANCE • **Establishing a safety track record** for the scuba diving company independently, aimed at reducing insurance premiums when obtaining supplementary coverage for MU projects	GR
TECHNOLOGY • **Advanced remote monitoring** to increase efficiency of the farm and ensure surveillance of the scuba diving activities (sensors, cameras, ROV)	GR
SOCIAL IMPACTS AND ENSURING ACCEPTANCE • **Involvement of the local population** in aquaculture through blue community gardens	DK
ENVIRONMENTAL RISK ASSESSMENT • **Monitoring of environmental parameters** through employment of sensors and cameras to ensure good water quality and a low impact of the project on the environment.	GR
COMMERCIALISATION • **Utilising innovative marketing approaches,** like an underwater QR code scavenger hunt.	GR

2. INTRODUCTION

The concept of ocean multi-use has generated considerable interest and sparked discussions within the industry and among public authorities. **It presents a solution for harmonizing diverse maritime priorities through a more integrated planning approach.** Sea space utilization in the EU is on the rise, driven mainly by the **growing demand for renewable energy generation and local sustainable food**. This trend is evident in the ambitious renewable energy targets and various initiatives aimed at promoting sustainable aquaculture development offshore. Moreover, nature conservation objectives require the allocation of **30% of marine areas for conservation by 2030**, which is potentially increasing the spatial **conflicts in already congested sea.**

Ocean multi-use involves the deliberate shared use of marine resources in close geographic proximity by two or more maritime activities, such as offshore wind and low trophic aquaculture, potentially leading to additional socio-economic and environmental benefits.

While extensive theoretical exploration of multi-use possibilities has been conducted, the practical experience of implementing and demonstrating offshore multi-use has been limited. Building upon the Ocean Multi-Use Action Plan of 2018, which initially defined the concept of multi-use and outlined its preliminary steps for realization, **UNITED has piloted 5 multi-use solutions in the real environment.**

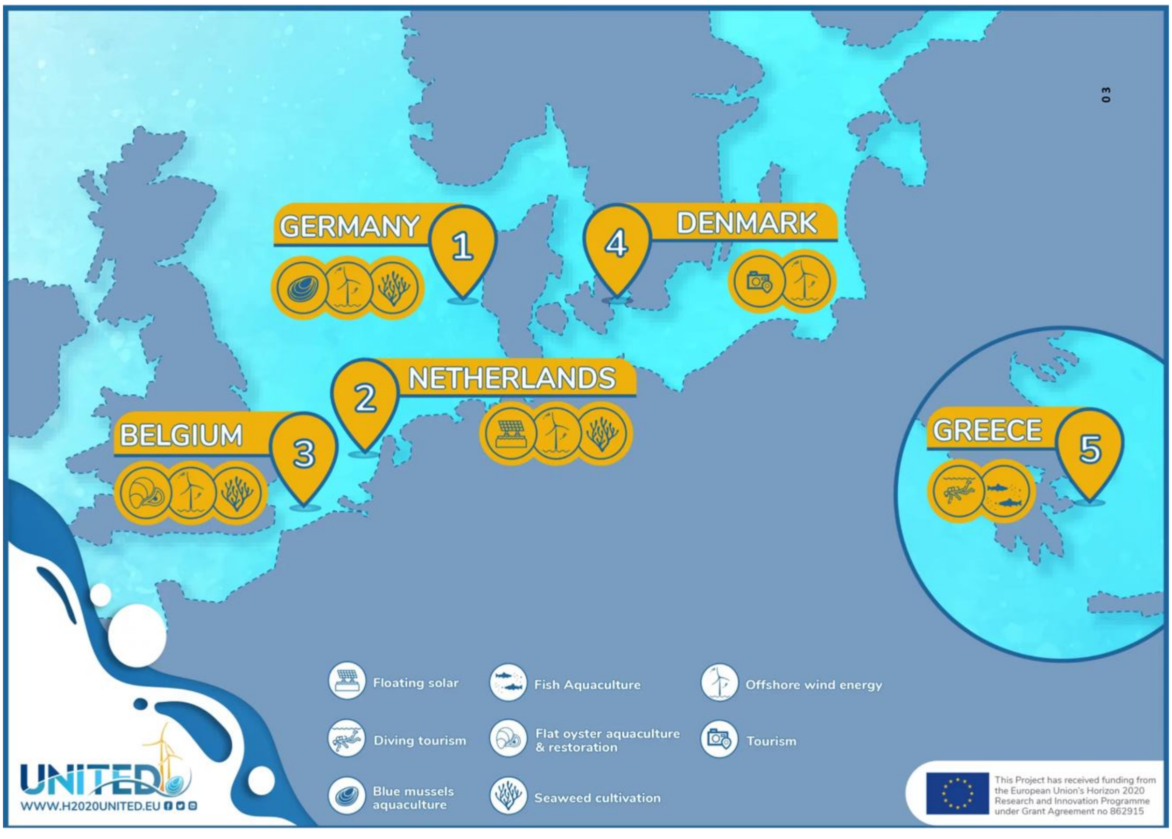

Figure 1 United's pilots map.

The UNITED Collection of Multi-use Blueprints presented herein compiles practical demonstration experiences derived from the UNITED project's pilots and other projects across the EU, to offer valuable insights, evidence, and guidance that can serve as an inspiration for industry stakeholders and public authorities to actively embrace the concept of ocean multi-use.

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Public authorities and policymakers play a pivotal role in facilitating multi-use initiatives.

These blueprints can serve spatial planners and policymakers as a resource for the development of the next round of maritime spatial plans, maritime strategies, and associated regulations. By showcasing successful examples, they can inspire authorities to integrate multi-use into their planning and regulatory frameworks.

By drawing on real-world experiences from the UNITED pilots and other relevant projects, these **blueprints serve to build confidence within the industry in investing in and developing multi-use projects.**

They provide tangible evidence that multi-use concepts are not just theoretical but can be successfully implemented and generate positive outcomes.

3. APPROACH

3.1. Evidence base for the Blueprints Collection

The Collection of Blueprints draws upon the findings from the UNITED ocean multi-use pilots and an extensive literature review covering additional cases across the EU. The report encompasses 4 blueprints covering all explored ocean **multi-use combinations within the five UNITED demonstration pilots.**

About UNITED project

The Horizon 2020 UNITED project ran for 4 years, between January 2020 and December 2023. Beyond technological strides, UNITED has explored the legal, regulatory, and insurance dimensions of ocean multi-use while also examining the environmental and socio-economic impacts.

The project has piloted **5 multi-use solutions in the real environment** in 5 European Member States, increasing the **TRL from 4 to 7** for most of the solutions.

Belgium: Offshore wind, flat oyster aquaculture & restoration, and seaweed cultivation.

Germany: Blue mussels, seaweed farming and offshore wind energy.

Netherlands: Offshore seaweed and floating solar/ or offshore wind energy.

Denmark: Offshore wind and tourism.

Greece: Tourism and fish aquaculture.

3.2. How to use the Blueprints

This Ocean Multi-Use Blueprints Collection report contains four blueprints, as well as a special case of offshore wind and solar energy. Each Blueprint chapter represents one multi-use combination and can be read as stand-alone guidance.

1. **Offshore wind and low tropic aquaculture (DE; BE; NL)**
2. **Offshore wind and nature restoration (BE)**
3. **Offshore wind and tourism (DK)**
4. **Fish aquaculture and tourism (GR)**

For each of the Blueprints following topics have been covered providing a resourceful how to guide based on the UNITED experience, among others:

- **Spatial Planning**
- **Regulation and Permitting**
- **Risk assessment and insurance**
- **Technology**
- **Operations and maintenance**
- **Environmental Impacts Assessment**
- **Social impacts and local involvement**
- **Commercialisation**
- **Decommissioning**

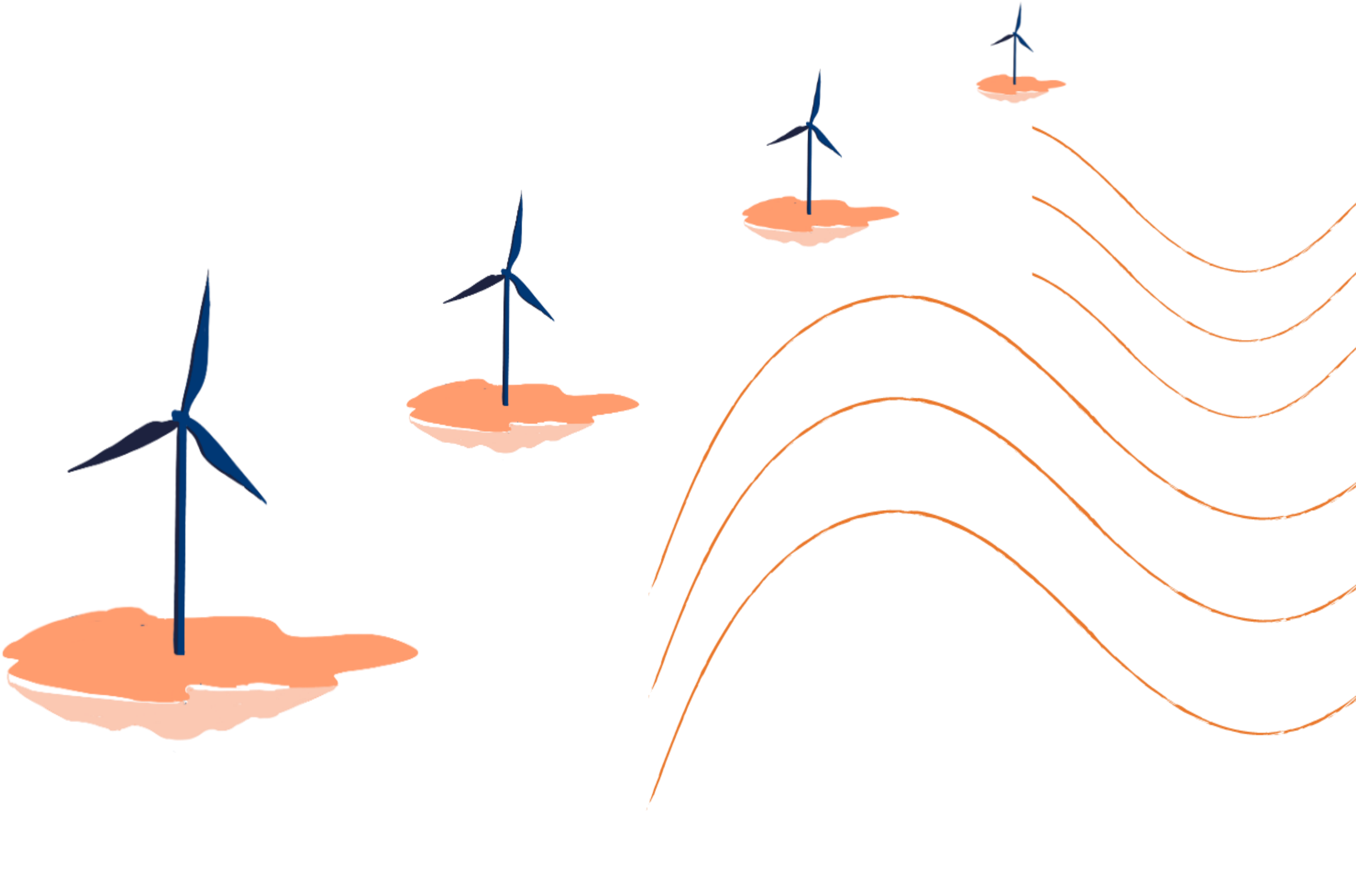
3.3. Replicability and operability

This report emphasizes the versatility of the blueprints for application in various environments and contexts. The multi-use blueprints outlined in this report primarily draw from the insights gained in the 5 UNITED pilot projects. It compiles practical demonstration experiences from these pilots and beyond to offer general guidance. The report provides specific recommendations on 'how to' implement each of the multi-use combinations covered by the four Blueprints. **The key lessons learned have broader applicability and can be valuable in other European sea basins.**

The document also underscores the importance of considering the operability of the proposed technology, as it may be contingent on specific spatial, environmental, or other conditions. Similarly, legal and social conditions can vary between jurisdictions. While the generic 'how-to' advice can be applied across different regions and environments, the specific examples presented in this report serve as valuable guidance for future multi-use endeavours that may have unique requirements.

It is also important to note that the **concept of multi-use while promising a variety of potential benefits, can yield different outcomes depending on the location and its specific circumstances.** Therefore, it is crucial to conduct a comprehensive assessment of all cumulative and in-combination impacts, encompassing economic, social, and environmental aspects. This assessment is necessary to determine the optimal configuration of uses and to consider potential indirect conflicts that may arise between multi-use projects and other current or future activities.

Hence, while this report offers general guidance and advice, **it is imperative to conduct a location-specific assessment of multi-use suitability.** In cases where data on potential impacts is lacking, the application of the precautionary principle is recommended.



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4. BLUEPRINTS

4.1. Offshore Wind and Aquaculture

4.1.1. Scenario

Combining offshore wind generation with low trophic aquaculture facilitates the expansion of sustainable farming offshore, while providing renewable energy and local, sustainable food sources. This approach benefits from diverse **joint ownership and operational models, encompassing shared infrastructure, logistics, cost-sharing, pooled workforce, and collective monitoring efforts.**

The combination of offshore wind and aquaculture offers opportunities for **efficiency, cost-sharing, and mutually beneficial relationships** within offshore areas, provided that safety, environmental, and regulatory considerations are carefully addressed.

While various types of aquacultures can potentially be considered in this multi-use combination, the UNITED project has mainly focused on the **low trophic aquaculture species.** The UNITED project has successfully piloted this integrated model in three sites, in **Belgium, Netherlands and Germany,** focusing on cultivating low trophic species like oysters, mussels, and seaweed, with some operations situated in challenging locations as far as 80 kilometres offshore.

However, more recently, **finfish aquaculture** technologies have also been considered in wind farms in other projects. For example, the SubFarm's distributed submersible cage system focusing on the farming of salmon and trout has been considered a viable option from the commercial and environmental perspective. Due to its submersible nature, the concept allows for integrated aquaculture farms inside the perimeter of offshore wind farms, in harsh offshore environments.

4.1.2. Planning and spatial configuration

Effective planning and spatial configuration are crucial to ensure sustainable co-existence and optimal resource utilisation. This section provides an overview of the tools and methods employed in the spatial planning of aquaculture and offshore wind projects. It is, however, important to note that the aquaculture spatial planning field is less explored compared to offshore wind, which enjoys more established spatial planning frameworks. Also, while many countries have well-defined maritime spatial plans that allocate specific areas for offshore wind energy projects, these plans often fall short when it comes to identifying suitable areas for offshore aquaculture and multi-use areas where combined use between offshore wind and, for example, aquaculture could take place.

UNITED has explored various tools and methodologies specifically designed to address the spatial challenges of offshore aquaculture, including those within wind farms, as shown in Table 1.

Table 1 Tools and methodologies for offshore aquaculture siting including within offshore wind farms

Reference	Main Purpose	Description
Gimpel et al. (2015)[1]	A tool for multi-use decision making for MSP is introduced which evaluates spatial co-location scenarios.	A decision-making tool has been developed for MSP, enabling the assessment of spatial co-location scenarios. This tool evaluates multi-use options, encompassing environmental considerations, economic factors, inter-sectoral interactions, and social-cultural risks and opportunities. Notably, this tool encompasses the evaluation of 13 native species in the German North Sea.
Tullio et al. 2017[2]	This study makes use of a sustainability index for co-location of offshore wind and open-water mussel cultivation.	In this study, a sustainability index is employed. The assessment leverages remote-sensing data, encompassing both physical and biological factors.
Benassai et al. (2014)[3]	This study also takes the approach of sustainability index. However, case study is conducted, focusing on co-location of offshore wind and open-water aquaculture in the Danish waters.	This study also adopts a sustainability index approach, with a specific focus on a case study. Various critical variables, including water temperature and chlorophyll-a concentration, are analysed to assess the feasibility and potential benefits of this co-location strategy.
GRASS project	A web platform enabling the consideration of several criteria in planning on offshore seaweed or mussels farm in the Baltic Sea, including the ecosystem services accounting and consideration of nutrient removal properties.	The ODSS web platform enables spatial planners and other users of maritime space to make effective decisions about macroalgae cultivation in the Baltic Sea based on existing monitoring and modelling data. It guides public authorities and private actors interested in licensing, setting up, investing in, or funding a farm, either as an environmental tool (e.g. ecosystem services, nutrient removal) or as a macroalgae business.

Building on the previously described methods and tools, **a novel approach has been introduced in the UNITED project for offshore aquaculture spatial planning that can be applied for siting aquaculture within offshore wind farms[4].**

This approach was applied in the German Pilot to evaluate the suitability of cultivation of mussels (*Mytilus edulis*) and seaweed (*Saccharina latissima*) based on key ecological variables.

1 Gimpel, A., V. Stelzenmüller, B. Grote, B. H. Buck, J. Floeter, I. Nunez-Riboni, B. Pogoda, and A. Temming (2015, 5). A GIS modelling framework to evaluate marine spatial planning scenarios: Co-location of offshore wind farms and aquaculture in the german EEZ. Marine Policy 55, 102–115.

2 Di Tullio, G. R. D., P. Mariani, G. Benassai, D. D. Luccio, and L. Grieco (2017, 1). Sustainable use of marine resources through offshore wind and mussel farm co-location. Ecological Modelling 367, 34–41

3 Benassai, G., P. Mariani, C. Stenberg, and M. Christoffersen (2014). A sustainability index of potential co-location of offshore wind farms and open water aquaculture. Ocean and Coastal Management 95, 213–218

4 Santjer, R., P. Mares-Nasarre, G. El Serafy, and O. Morales-Napoles (2023). A case study of ecological suitability of mussel and seaweed cultivation using bi-variate copula functions. Proceeding of the 33rd European Safety and Reliability Conference, 1877–1884

For mussel cultivation, the suitability was assessed based on water temperature, dissolved oxygen concentration, and chlorophyll-a concentration. In the case of seaweed cultivation, water temperature, dissolved nitrogen concentration, and dissolved phosphorus concentration were selected to determine the suitability.

To conduct this evaluation, data was extracted from a comprehensive three-dimensional hydrodynamic and ecological model[5], the software D-FLOW FM[6] and the extension of D-Water Quality[7]. Growth limits for each of the variables were also defined.

The suitability was defined by the probability that these limits are met. To respect dependencies between the selected variables, a copula approach was used. Copulas provide a robust method for describing the joint probabilities between these variables, acknowledging their interconnected nature.

It is important to note that this approach, initially executed in a single location, is currently undergoing further development in the wider south-eastern part of the North Sea. The study replicates the same species and variable selection, utilising an extended copula approach. However, the defined limits are split into two approaches: 1) optimal limits describing the optimal or ideal growth conditions and 2) critical limits ensuring the survival of the species.

Preliminary results indicate that a notable difference of approximately 10 % in probability can be observed between the two distinct approaches of respecting probabilities via copulas or disregarding them. This distinction underscores the significance of accounting for the interplay of ecological variables in the planning and optimising offshore aquaculture configurations.

This tool can be easily applied to other species or variables or even other locations and thus be used for decision-making on spatial planning of offshore aquaculture. For more information about the spatial tool developed in UNTED see Santjer et al. (2023) (4).

4.1.3. Regulations and Permitting

The approach to the permitting process and requirements of offshore wind-related multi-use differs across countries. Several countries have, to a certain extent, integrated the concept of offshore wind multi-use in their planning and associated permitting and tendering procedures (e.g. Poland, Belgium, and the Netherlands). Many however, still do not have a specific regulation or guidance addressing multi-use.

In the **Netherlands and Belgium a multi-use procedure**[8] has been established to facilitate the collaboration between potential multi-users and offshore wind park operators. In this context, multi-users refer to activities that aim to utilise the unoccupied areas within wind farms for their operations, such as aquaculture and or nature restoration activities (see next blueprint). The procedure serves as a valuable resource for identifying the necessary permits for multi-use endeavours and guides the application process for acquiring these permits. Additionally, it offers insights on effectively engaging with multi-use stakeholders and wind farm operators, with a particular focus on the Dutch and Belgian parts of the North Sea.

Entrepreneurs interested in conducting multi-use activities in these regions will find a clear and practical plan within this Multi-Use Procedure. It is designed from the perspective of potential multi-users and covers the entire permit application process, as well as strategies for stakeholder engagement. It is important to note that this procedure has been validated for the Dutch and Flanders sections of the North Sea, and its applicability to other areas is subject to future consideration.

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[5] Zijl, F., T. Zijlker, S. Laan, and J. Groenenboom (2023). 3D DCSM FM: A Sixth-Generation Model for the NW European Shelf. Technical Report, Deltares.

[6] Deltares (2023a). D-FLOW Flexible Mesh. User Manual, Deltares.

[7] Deltares (2023b). D-Water Quality Processes Library Description. Technical Reference Manual, Deltares.

[8] More information available at: https://www.northseafarmers.org/projects/multi-use-procedure-be-text.pdf

Example of a three-step assessment framework for co-use in offshore wind farms in the Netherlands

In the Netherlands, a three-step assessment framework is applied for co-use in OWF:

1. Preliminary consultation with Rijkswaterstaat and description of activity and spatial need (description of the natural values in the area, a description of the effects of the activity
2. Pre-assessment of intended activity and spatial need based on policy and Area Passport Guide specifications. If the proposed activity is not designated as a preferred activity, the competent authority will announce there is an intention to issue a permit for the specific location for other initiators to show interest.
3. Assessment of effects of activity and choice of location including spatial and operational effects, safety and liability, term of the permit, removal obligation and financial security, archaeological and cultural-historical values, good environmental status, and precautionary principle.

'Area Passport' example in the Netherlands

An 'Area Passport' guide has been produced for the Borssele OWF zone by the Dutch Government. This Area Passport guide uses features specific to the area to indicate where shared use is possible, which forms of this have the greatest chance of success and can best be accommodated and, as such, are preferable. The Area Passport guide is primarily a guideline that covers areas outside the OWF turbines as shown in the Figure 1.

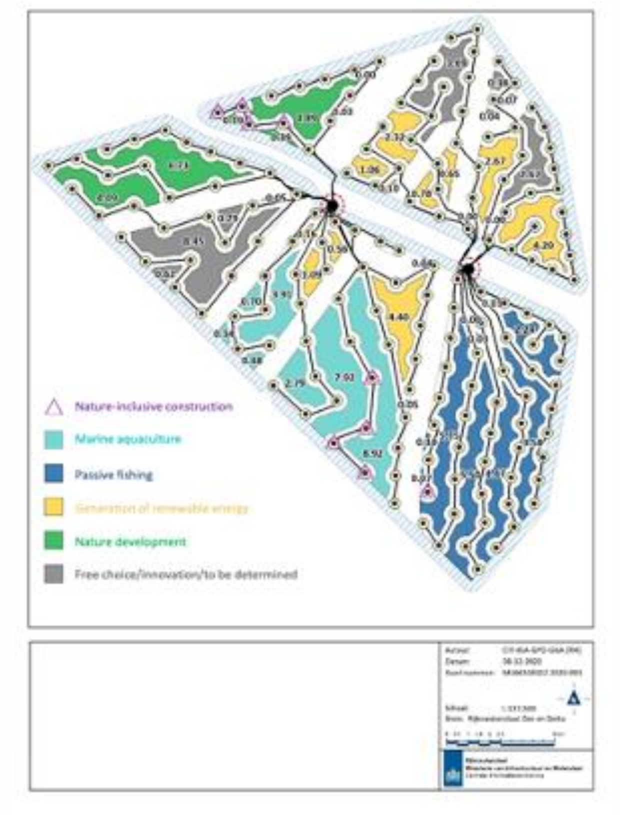

Figure 2 The Borssele offshore wind farm area passport and proposed multi-use combinations

Example of Belgian offshore wind installations: environmental permits and environmental impact assessments: Act on the Protection of the Marine Environment (1999 MEPA, replaced in 2022)

The Belgian Maritime Spatial plan allows for a joint application for an environmental permit and conducting a combined environmental assessment for different activities of the same nature. The plan's provision for a single environmental permit and the ability to conduct a combined environmental assessment for different activities of the same nature means that it simplifies the process for obtaining permission for such activities. This integrated approach allows project developers to navigate the regulatory environment more efficiently by submitting one application that covers all aspects of their project, as opposed to multiple applications for different permits. This is particularly relevant for activities that have interrelated impacts on the marine environment.

4.1.4. Risk assessment

Using the framework for safety assessment from the perceptive of food and feed, safety to man and equipment and environmental and cumulative aspects, as developed in the SOMOS project, an analysis of the multi-use safety was done for each UNITED pilot.

According to the analysis, inadequate insurance coverage and severe weather conditions are deemed to be the highest risks for this multi-use combination, based on the magnitude of their impact and the probability of the risk occurring. The table below shows the highest risks for the two UNITED pilots in Germany and the Netherlands. Most of the identified risks did not occur during the course of the pilot, but the risk analysis was carried out to analyse all possible scenarios and the appropriate risk mitigation. In the future, each new multi-use site will have to undertake its own risk analysis to evaluate and analyse its activity.

The SOMOS framework for safety assessment in marine multi-use projects

The SOMOS framework developed through collaboration between scientists at WUR, TNO, and the Lloyds Foundation, has been designed to address safety concerns related to marine food and feed production, human safety at sea, and the interactions and cumulative effects within the ocean environment. This framework offers a generic approach to safety assessment, encompassing various domains, including location-fixed offshore food/feed production and maritime operations of offshore wind farms. By combining dedicated safety considerations from these domains, this method allows for the simultaneous evaluation of the importance and vulnerability of each domain while considering relevant parameters from other domains. The aim was to establish a shared risk assessment denominator across different domains. While the framework aspires to be generic, it retains a degree of domain restriction, particularly in the context of location-specific maritime activities. In collaboration with the SOMOS project, UNITED has developed a series of nine concise videos[1] explaining this framework, promoting its use in UNITED pilots and beyond, with a special focus on offshore wind and seaweed multi-use scenarios.

- Minimise vessel traffic by consolidating activities (e.g., different MU users sharing a single trip)
- Use well-trained and certified personnel on-site.
- Where possible reduce personnel on-site through deploying remotely operated vehicles (ROVs) and autonomous vessels.
- Ensure clear visibility to mitigate collision risks by marking the MU project with visible buoys.
- Demand flexible insurance policy start dates. Delays can result from permit procedures or technical difficulties, as observed in the German and Belgian pilots. These delays may necessitate insurance policy extensions, impacting the budget.
- To address this, it's advisable to demand flexible insurance policy start dates. If flexibility is not an option, over estimating the project's duration is a prudent approach. In most cases, overestimating the policy duration initially proves more cost-effective than requesting extensions.

Table 2 Example of a risk assessment based on Dutch and German Pilot (UNITED Deliverable 6.3)

Risk Item	Description of Risk	Risk Mitigation Recommendations
Inadequate Insurance Coverage	Inadequate insurance coverage for multi-use offshore projects, leading to increased consequences in the event of risk events. Full insurance coverage is challenging and expensive.	**Create Comprehensive Safety Guidelines:** Develop in-depth safety protocols for both aquaculture and energy production activities. **Engage in Collaborative Efforts with Insurers:** Partner with insurance companies to enhance the understanding of risks and build trust. **Explore Self-Insurance Options:** Evaluate the possibility of self-insuring for less severe risks using cash reserves or adaptable credit lines.
Severe Weather	Severe weather conditions at sea can cause serious damage to pilot structures, staff, windfarms, and aquaculture production. Due to climate change severe weather events are likely to increase.	**Implement Decision Support Systems:** Utilise decision support systems, like those developed in the UNITED project, for monitoring weather forecasts. **Create Operational Flexibility:** Establish a system to adapt operations based on real-time information and current conditions. **Evaluate Feasibility and Simulate:** Assess the feasibility of technical projects for marine aquaculture, following international standards, through simulations. **Formulate Safety Protocols:** Develop internal safety protocols to safeguard staff and infrastructure during severe weather events. **Install Offshore Sensors:** Place sensors at the site location to enhance forecasting and gain better insights into site conditions beyond available forecasts. **Regular Equipment Monitoring:** Implement routine equipment checks to prevent damage or detachment. **Prepare Disaster Recovery Plans:** Develop and maintain disaster recovery plans to guide the response to severe damage and stabilize the site effectively.
Activity on the Site by Other Multi-Use Partners	Risk of damage to assets and the environment due to activities by other multi-use partners on the site.	**Ensure all workers receive training** and briefing on site layout and safety protocols. **Collaborate with multi-use site managers** to identify and mitigate risks. **Implement a near miss reporting mechanism**.
Decommissioning of Assets	Risk associated with the decommissioning of assets, potentially leading to environmental contamination and damage.	**Develop a decommissioning plan** at project inception. **Consider minimizing complexity** and impact during project design. **Include a sinking fund** in the business model to ensure adequate finances for decommissioning.
Engineering Design Solutions Interacting	Risk of structural failures in complex facilities leading to accidents, environmental damage, and cost implications.	**Develop a robust maintenance plan** to keep infrastructure in good condition. **Train staff** to handle facility incidents. **Implement** remote monitoring for informed decision-making. **Ensure insurance coverage accounts for facility failures**.

Lack of Qualified Staff	Potential difficulty in finding workers that match skill requirements for multi-use projects, leading to injuries, equipment damage, and reduced production efficiency.	**Develop Clear and Open Safety Protocols:** Create transparent safety protocols to ensure clarity and openness. **Commit to Employee Training and Ongoing Growth:** Dedicate resources to staff training and continuous professional development.
Water Quality at Production Site	Poor water quality caused by external factors (i.e. boats) may lead to contamination and reduced yield.	**Preventative Site Analysis:** Use pre-emptive site assessments to minimise contamination risk. **Regular Water Testing:** Conduct routine water testing to prevent damage, such as yield contamination. **Consider Offshore Cultivation:** Explore offshore cultivation for better water quality, despite more challenging weather conditions.
Lack of Regulations for multi-use at Sea	Lack of regulations can cause delays, additional costs, market inefficiencies, legal problems, and environmental risks.	**Set Site Protocols:** Implement internal protocols at the project's start to mitigate risks, ensuring high standards for environmental and human protection. **Establish Multi-Use Standards:** Encourage licensing authorities to create environmental and safety standards specifically tailored to multi-use activities at sea.

For more information about multi-use risk assessment:

- Deliverable 6.3 Case specific report on risk management aspects within the confines of legal and insurance aspects.
- Van Hoof, L., et al. "Can Multi-Use of the Sea Be Safe? A Framework for Risk Assessment of Multi-Use at Sea." Ocean & Coastal Management, 2020

4.1.5. Insurance

Based on UNITED pilot experiences, concerns have emerged regarding the insurability of aquaculture product losses, loss of revenue from temporary business interruptions, the absence of government-backed funds for force majeure situations, and potential imbalances in the allocation of insurance costs. As UNITED pilots transition from research into commercial ventures and scale up, risks can expand, potentially leading to higher insurance fees. These concerns have been documented in UNITED Deliverable 6.1.

Apart from the generally high fees for insurance policies, concerns were expressed as to the insurability of loss of aquaculture products, loss of revenue due to temporary business interruptions, the absence of a government-backed fund which can assist in times of force majeure and a potential imbalance between MU users and allocation of insurance cost.

For example, in the **German pilot**, most insurance policies were already established, with the addition of a novel asset insurance policy specifically covering infrastructure related to mussel and seaweed cultivation. This policy includes coverage for unforeseen damage, destruction, or loss of insured items due to various external events, such as fire, lightning, explosion, storms, frost, ice, landslides, earthquakes, floods, high water, as well as misappropriation or unauthorized use by non-employees. There is a general deductible in place, along with caps for coverage per occurrence and per object or type of event, with an overall annual cap. A waiver of subrogation is applied for all parties present at the insured location, including the entire FINO 3 structure, with the policyholder's consent. Notably, loss of stock, such as mussels or seaweed, is not covered under this policy.

In the **Belgian pilot**, partners secured a novel insurance policy covering both asset insurance and liability. The principal insured party is Ghent University, obtained through a tendering procedure due to its status as a public institution. The liability policy has a financial cap of 10 million euros, as per the wind farm concession holder's minimum requirement. In a separate contract with the wind farm operator, both parties agreed to waive recourse beyond the 10-million-euro cap. Any project alterations must be communicated to the insurer, accompanied by a method statement and impact simulation. The imbalance between the wind farm concession holder and additional multi-use users is notable, especially when using maritime areas within existing wind farm concessions. Addressing this issue will be crucial when granting concessions to both wind farm operators and other multi-use users in new maritime areas.

The imbalance between MU parties: When a MU project is deployed in an area already occupied by another actor, such as a wind farm held by a concession holder, the MU actor coming to the area later will likely have to shoulder the entire cost of insuring the added MU risks, as was demonstrated by the Belgian pilot. This could be corrected by allowing the projects to start jointly. Costs for insuring MU risks can then be shared ab initio. Alternatively, the projects can be coordinated to minimise MU risks and thereby lower the MU insurance cost. For example, wind turbines could be placed further apart so that safety zones around the turbines would not need to be entered by the MU partner.

Contractual waiver of recourse among the involved parties is crucial to manage potential liability risks in multi-use (MU) projects. This contract should explicitly state that they will not seek damages from one another beyond the insured limit. It's also advisable to avoid high-risk zones in the sense of risks leading to potentially significant monetary damages. For instance, in a wind farm, damages to cables or turbines can result in millions of euros in losses. Even when insurance coverage is adapted for high-risk zones, it's common for third-party liability insurance to have a cap (e.g., 10 million euros for the Belgian pilot and 5 million euros for the Dutch pilot) and may not cover full damages. Without a contractual waiver of recourse, the MU user remains exposed to the possibility of bearing the full extent of severe damages.

Risk estimate: Insurance fees for projects are largely influenced by the inherent risks they carry. Static installations pose fewer risks than dynamic ones. For instance, in the Dutch wind farm Luchterduinen, oyster cultivation structures on the seafloor had minimal impact on wind farm operations and vessel passages. Similarly, in the Belgian pilot, the insurance broker expected no significant damage from the gabions in the restoration tables due to their significant depth (25 meters below MSL) and a thorough understanding of sea currents.

Historical data on risks significantly impacts insurance fees: Due to the novelty of multi-use, insurers lack such historical data, resulting in higher fees. To mitigate this, detailed project descriptions are crucial, including risk assessment, consequences, mitigation measures, probability, and impact. It's essential to demonstrate that all project partners have well-trained staff and secure equipment, and subcontractors should have a strong safety track record. Vessels used in projects should undergo thorough inspections and certification. Lastly, projects should outline how they plan to minimise damage in case of risk realization, such as nearshore equipment testing or computerized risk scenario simulations, as seen in the Belgian pilot.

To minimise risks and reduce insurance costs in multi-use (MU) aquaculture projects within wind farms, several strategies can be implemented:

- Confine aquaculture activities to specific areas, such as the maintenance zone of wind turbines and infield cables.
- Restrict transit through the wind farm to designated corridors and work within the wind farm might be limited to daytime hours.
- Minimise vessel traffic by consolidating activities (e.g., different MU users sharing a single trip)
- Use well-trained and certified personnel on-site.
- Where possible reduce personnel on-site through deploying remotely operated vehicles (ROVs) and autonomous vessels.
- Ensure clear visibility to mitigate collision risks by marking the MU project with visible buoys.
- Demand flexible insurance policy start dates. Delays can result from permit procedures or technical difficulties, as observed in the German and Belgian pilots. These delays may necessitate insurance policy extensions, impacting the budget.
- To address this, it's advisable to demand flexible insurance policy start dates. If flexibility is not an option, overestimating the project's duration is a prudent approach. In most cases, overestimating the policy duration initially proves more cost-effective than requesting extensions.

For more specific insurance-related recommendations, see UNITED Deliverable 6.2. Case specific report on legal aspects and insurance issues

4.1.6. Technology

From a physical technology perspective, there are two key scenarios for combining the offshore wind farm with aquaculture activities:

1. Direct Attachment or Multi-Purpose Platforms: This concept involves directly attaching various installations (e.g., seaweed and mussel longlines or oyster tables) to offshore wind turbine foundations or developing fully integrated multi-purpose platforms. While this approach offers the potential for efficient use of offshore space, it requires engineering solutions to be integrated during the pre-planning phase of offshore wind farm (OWF) development. Commercial experience is currently lacking, and there are no established safety or construction standards, resulting in unknown risks and high insurance premiums. This concept is most feasible for OWFs in the pre-planning stage, before specific use and technology licenses have been granted.

2. Co-Location within Wind Farm Security Zones: This concept involves placing installations within the security zones of operational or planned wind farms. It is applicable to both existing and planned OWFs. Most of the UNITED pilots were estimated to be at the technology readiness level 5 at the beginning of the project in January 2020. Transition to the offshore environment represented the primary focus for **advancing the overall TRL from 5 to 7 by the end of 2023 for all three pilots.**

Cultivation of sugar kelp in the Belgian pilot of UNITED

The Belgian pilot of UNITED has co-located cultivation of sugar kelp and European flat oysters within the Belwind OWF, located 46 kilometres offshore in the Belgian part of the North Sea. In a preoperational phase, a variety of aquaculture systems were tested at a nearshore site, focusing on different equipment and substrates for flat oyster and sugar kelp cultivation, along with nature-inclusive scour protection. The technical components of the aquaculture system were procured off- the-shelf and customised to suit the environmental conditions of the target site. Implementation was carried out in collaboration with a specialised company that has previously installed similar anchors and longlines worldwide, including for commercial purposes. The installation of oyster restoration structures offshore occurred in the summer of 2021, followed by the installation of aquaculture longlines in the summer of 2022.

Cultivation of sugar kelp (*Saccharina latissima*) under offshore conditions demonstrated successful growth. The trials succeeded in demonstrating that even under the harsh offshore conditions, the juvenile sugar kelp can attach sufficiently and grow into macroscopic thalli. However, installation, monitoring and harvesting are strongly weather dependent, and delays experienced throughout the cultivation trials resulted in lower yield than anticipated. Fouling on cultivation structures was observed to be significantly lower compared to the nearshore site. Simultaneously, successful growth was observed until a higher depth (3m) at the offshore location in comparison to nearshore (1m). Yields averaged about 0.8 kg m-1 cultivation substrate with maximum yields of 1.8 kg m-1 cultivation substrate observed in the first meter of cultivation depth. Due to the usage of net cultivation structures (4x2m, 20 x 20 cm mesh size), a substrate length of 16 m per m backbone length is reached, resulting in on average 12.8 kg m-1 backbone length.

From the monitoring technology perspective, having weather stations on-site are crucial for early storm warnings, ensuring safety in multi-use (MU) projects. Surveillance through radar, AIS, or cameras can aid in early detection of drifting MU equipment, preventing potential damage, and enhancing security against unauthorized vessel entry. This data and footage can also serve as evidence for insurance purposes, demonstrating a lack of incidents, but cost control is essential when implementing these additional requirements.

Table 3 TRL of Offshore wind farm and low trophic aquaculture multi-use

Economic activity	Baseline TRL	Accomplished TRL
Offshore wind farm and low trophic aquaculture – UNITED pilots in the BE (Belwind), NL (Offshore Test Site) and DE (FINO3)	TRL 5	TRL 7

Example of the UNITED Technology Readiness Level (TRL) assessment procedure:

The UNITED project has developed a Technology Readiness Level (TRL) assessment procedure and applied it the five pilots of the project. Moreover, a guide for environmental and socio-economic audit of future ocean multi-use projects was also designed as an internal audit for an organisation to reflect on its activities and its progress towards meeting its objectives towards environmental and socio-economic benefits. Overall, the proposed audit guide is conceived as a handbook, based on the experience gathered by the UNITED project, to help each project in the design of its own audit procedure. The identified themes should be pertinent for many ocean-multi use projects, but each project should further adapt this guide to fit its own specificities.

For more information about the UNITED Assessment Framework see UNITED Deliverable 8.4

4.1.7. Operations and maintenance

The findings from the UNITED pilot outlined herein shed light on crucial aspects of vessel operations, health and safety protocols, monitoring practices, and the potential for synergy between offshore wind farms (OWF) and aquaculture ventures. Nevertheless, most of the insights outlined herein also hold true for the offshore wind and nature restoration multi-use. These insights are essential for optimising operations and ensuring the sustainable success of such ventures in the future.

Vessel operations: Crew vessels are used for monitoring the position of the offshore installations. Installation happens with hired specialised vessels that have to go through a vessel vetting while sampling is organised together with research vessels that have a license to enter the OWF for monitoring purposes. Based on the experience of the BE and DE pilots it is very difficult to find a proper vessel. Suitable vessels are extremely expensive, weather forecast is poor, which makes it very difficult to plan activities, hire boats etc.

Recommendation: Explore the use of larger vessels capable of working in higher waves. Consider designing modular ships that can serve multiple purposes, benefiting both offshore wind farms (OWF) and aquaculture enterprises. However, it's essential to acknowledge that this is just one solution among many to be considered. Larger ships tend to be significantly more expensive and may have limited availability. Alternatively, one could adapt aquaculture systems by utilizing lighter materials, smaller components, and modular systems to make them compatible with the vessels already operating in the area.

Health and safety: Sea survival training for everybody joining the vessel, an on-line test Parkwind (for accessing the OWF), medical approval, protective clothing. Based on the BE pilot example, sea survival training is organised only a few times per year and is costly.

Recommendation: Raising awareness regarding the hazards associated with open-sea work, preparing mentally for potential challenges, and gaining a comprehensive understanding of the stringent conditions necessary for a successful trip. Adopting a modular approach to health and safety training for offshore multi-use activities, enabling individuals to focus on and undertake only the specific components relevant to their future roles.

Monitoring: Offshore wind farm structures can function as installation points for a range of components, such as sensors, webcams, receivers, and data storage servers. This facilitates data transfer from offshore locations to onshore facilities, enabling stakeholders to access monitoring reports and utilise the results for their activities. In general, offshore monitoring data sources can be divided into three different categories:

1. Real-time data from in-situ sensors and from public available data and from access to data platforms of other offshore users e.g. shipping companies, wind farms
2. Real-time via web cam observation; and
3. Sampling/collecting data from sensors with internal saving unit/visual inspection on site.

Based on the experience of the UNITED pilot in Germany, the remote data sampling and system observation is in general planned to take place 24/7 and is checked at least once per day. Ideally the maintenance and sampling of the aquaculture system takes place every 2-3 months but can be expanded to 6 months. On a trip, as many tasks as possible are combined and carried out. Data is uploaded as soon as it is available to the UNITED Data platform in HiSea.

Important monitored parameters vary, depending on the application. For any offshore sea mission wave height and wind are monitored to determine the optimal weather window for a safe operation. The decision when to schedule a sea mission is based on the consultation of all offshore users at this location and several weather data providers, such as Windfinder or Wetterwelt[9].

In general, **the most important monitoring parameters** based on the experience of the UNITED German pilot include:

- Mussel growth: water temperature, light and chlorophyll
- Seaweed growth: water temperature and light conditions
- Technical questions: wind, wave height, load forces on mooring system, behaviour of mussel net in the water
- Impact of aquaculture systems on environment and vice versa: Do aquaculture structures attract or scare fish? When is “food” for mussels available?
- Licensing authorities’ requirements: the CPODs data to monitor the presence of harbour porpoise

HiSea Data platform: The data platform used in UNITED supports standardized access to geospatial data and downstream services that can be used by (future) multi-use initiatives to:

- Easily manage and analyse data with relevance to local operations.
- Have access to short term forecasts that may optimize the operations and reduce risks.
- Support operational decisions through a decision support system that takes into consideration multiple operational restrictions.

To ensure the effectiveness, the services should be built or adapted in close corporation with the users.

[9] https://www.wetterwelt.de/

For more information about the data platform see UNITED Deliverable 2.1

Table 4 Example of the sampling frequency in the German pilot of UNITED. Note: No. 3: Marking buoys need to be checked every 6 months. But the BSH requirements to use the standardized C-pods which are not offshore suitable demanded visiting the site every few months. The CPODs are attached to the marking buoys. No. 4 and 5 every 6 months is also applicable, but every 2-3 months is optimal.

No.	Testing / task	Frequency
1.1	Checking/investigating aquaculture area and systems via webcam (re-mote)	Once per day
1.2	Checking/investigating aquaculture area and systems via binoculars (on site)	Once every flight to FINO3 (~50 per year)
2	Checking/investigating the lander system and data-buoy (remote)	Once per day
3	Checking/maintaining site marking buoys (on site)	Every 2-3 months
4	Checking/maintaining mussel system including sampling (on site)	Every 2-3 months
5	Checking/maintaining seaweed system including sampling (on site)	Every 2-3 months
6	Checking/maintaining CPODs (on site)	Every 2-3 months

Recommendation: Identify site-specific synergies and establish effective communication channels with regional stakeholders. When installing offshore wind farms (OWF), consider conducting sonar and unexploded ordnance (UXO) operations, which can also benefit other activities like aquaculture and restoration. Incorporate specific location requirements for these activities from the outset when planning combined projects, making it easier to leverage synergies.

4.1.8. Environmental Impacts Assessment

An Environmental Impact Risk Assessment (EIRA) has been applied to upscaled projections of the UNITED pilots to predict their potential impact and to compare the impact of a single-use scenario and a multi-use scenario. The results presented in UNITED Deliverable 4.4 (2023) show that substantial negative environmental impact reductions can be achieved through the implementation of a multi-use instead of a single-use situation. The highest reductions reported included: (I) approx. 40% negative environmental impact reduction for two ecosystem components, fish and mammals, during the installation phase of upscaled Dutch and Belgian pilots (II) approx. 15% for two ecosystem components, fish and mammals, during the operational phase of an upscaled Dutch pilot, and (III) approx. 20% for the ecosystem component seabed habitats during the decommissioning phase of an upscaled Belgian pilot.

Several approaches have been suggested to maximise environmental gain and minimise negative environmental impacts based on the UNITED experience with offshore wind and aquaculture multi-use:

- **Seaweed nets made of relatively small mesh** size to minimise the risks of sea animals getting stuck in the nets.
- **Selection of materials:** The restoration tables constructed from galvanized stainless steel, with sacrificial zinc anodes attached can mitigate corrosion risks. The careful selection of non-toxic anti-fouling agents not only safeguarded against the leakage of toxins into the ecosystem but also ensured the safety and purity of the harvested mussels and algae, aligning with the project's commitment to producing clean and sustainable resources.

- **Choice of anchors:** for example, utilization of screw anchors for the backbone offshore can help minimise bottom disturbance compared to other anchor types. Rather than resorting to ramming or drilling techniques, only weight and drag anchors were utilised in the German Pilot of UNITED, ensuring minimal disturbance to marine mammals (sound). Moreover, eco-anchors were applied in the Dutch pilot to mount the floating seaweed installation to the seabed instead of the application of a traditional anchor. Traditional anchors are an unfavourable option in a wind farm because they give substantial reworking of the seabed, which risks the present infrastructure and can harm benthic biodiversity. The concept of the eco-anchor is to install a semi-permanent pile with a certain elevation above the seabed which can be used as a mounting point for floating structures. First, this means that there will only be regular activity on the water surface level and much less potentially harmful activity on the seabed level. Second, this pile will be drilled instead of piled, which reduces the marine environmental impact. Third, due to the long-term presence of the pile, it will not only serve as an anchor, but also as an artificial reef.

  More background information on the eco-anchor can be found on the North Sea Farmers' website

- **Shared vessels** during offshore installation, inspection, and maintenance operations, to reduce costs and minimise environmental impact. By strategically placing the aquaculture installations, backbones, and restoration tables on the outskirts of the wind farm, the need for frequent vessel charters is minimised. Regular monitoring of the surface buoys by passing wind farm vessels and research vessels ensures updates on system functioning without unnecessary boat trips, resulting in reduced fuel consumption, and minimised carbon emissions.
- **Electrically propelled vessels:** Transitioning to an electrically-powered fleet makes use of infrastructure already in place such as the turbine platform and electrical cables, to provide renewable electricity to vessels used for installations, operations, or monitoring of multi-use installations.

4.1.9. Social impacts and ensuring acceptance

The OWF and aquaculture multi-use requires extensive engagement between relevant parties to properly understand each other's needs and align on the operation requirements, business plans, and project schedules. A forum that brings different actors together, not only OWF and aquaculture farmers but also fishers, has been so far of paramount importance in facilitating the development of this multi-use. Namely, the development of any type of fixed structure may cause conflict with other existing uses, such as fisheries. Thus, proper engagement going beyond MSP consultations and proper user representation is crucial to defining proper mitigation and compensation mechanisms.

Dutch Community of Practice In n the Netherlands, the Ministry of Agriculture, Nature, and Food Quality (MinANFQ), led the establishment of the Dutch Community of Practice North Sea (COPNS) after realising that that practice was overtaking policy discussions on ORE use combinations. It was also identified that coordination and exchange of experience were needed to advance ORE use combinations. This resulted in a decision to start the Dutch Community of Practice North Sea (COPNS). The Netherlands Enterprise Agency (RVO) was tasked with the organisation and setting up a platform on which all North Sea stakeholders meet and debate, where initiatives are forged and where people work together on solutions.

The COPNS was set up to ensure that initiators are responsible for developing their business cases, risks, and investment decisions. The Dutch Government is responsible for facilitating licensing at appropriate moments by creating frameworks and commissioning a strategic investigation into (cumulation of) environmental impact. The COPN meetings have a steady attendance of between 50 and 70 participants, including the Government, offshore energy companies, research institutes, the fishing industry, water sports and the financial sector. The first meeting focused on how to support entrepreneurs involved in or interested in ORE use combination pilots so that needs could be addressed in subsequent COPNS meetings. Subsequent meetings have covered different topics, including OWF and multi-use, nature conservation and development, food production, policy and regulations, funding for research and innovation, and restoration of shellfish beds, amongst others.

4.1.10. Commercialisation

Multi-use projects with offshore renewables offer the potential for scaling up offshore aquaculture operations and achieving cost savings through combined logistics and operations. Sourcing renewable energy for the aquaculture farm locally, such as from wave or solar energy, can reduce costs and enhance the environmental credentials of the aquaculture products, potentially creating a premium product (e.g. certified carbon-negative seafood). Existing initiatives to bring offshore aquaculture products to the market can be capitalised for this, such as Brevisco's "Mosselen van de Vlaamse Banken" ("Mussels from the Flemish Banks") and Colruyt Group's "Seafarm Westdiep". The latter became feasible through the integration of aquaculture in zones for industrial and commercial activities, as designated in the Belgian MSP 2020-2026.

The Ocean Multi-Use Commercialisation Roadmap developed as part of the UNITED project provides several relevant recommendations for maximising the commercialisation potential of this multi-use combination. Moreover, for each of the UNITED pilots a business model as well as an economic assessment was conducted.

There is a need to address the limited financial capacity of aquaculture farmers to take on the associated risks and liabilities of multi-use projects, especially in the case of combination with offshore renewables; limited 'soft skills' such as marketing, branding and customer service to build a premium product; limited involvement of aquaculture farmers in marine and coastal planning processes. More pilot investigation is also needed to improve the technology readiness level for a safe scaleup in harsh offshore conditions.

Recommendation:

Key enablers for the offshore aquaculture multi-use market entry include:

- Aquaculture farmers active involvement in the planning process to raise awareness about the benefits of multi-use and discuss possible business scenarios.
- Provision of financial support to aquaculture farmers to test the technologies offshore and test different business models supporting value-added applications of sustainable aquaculture products.
- Integration of sustainable aquaculture as a government requirement in new projects, such as including multi-use as a non-financial tendering criterion or a permit condition.

4.1.11. Decommissioning

In the case of fixed installations offshore engaged in multi-use it is especially important to synchronise the anticipated operational lifetimes. Coordinated Exit Strategies developed at the project's inception can be useful to outline how one business can exit or decommission while minimizing disruption to the other. This may include a phased decommissioning approach or transitioning responsibilities. Moreover, insurance policies should be tailored to the specific risks such as business interruption or high costs of decommissioning.

In the case of UNITED German pilot decommissioning of aquaculture installation was carried out using several boats over two sea missions. The strain of harsh weather conditions on the algae and mussel systems was evident. Nonetheless, these systems performed very well, demonstrating the feasibility of long-term installation of aquaculture equipment in an offshore, high-energy environment. Unfortunately, the monitoring system (including the lander and winch system) suffered critical damage, resulting in data loss. However, implementing backup systems proved valuable, ensuring basic data collection throughout the project's duration.

4.2. Offshore wind and nature restoration

4.2.1. Scenario

Northern European seas are a key area for offshore wind power development, with potential negative environmental effects during construction but positive effects on marine life during the operational phase. With the recent implementation of marine spatial planning, there is a need to explore the relationship between marine conservation and wind power. Research suggests that offshore wind farms can be as effective as marine protected areas in creating refuges for benthic habitats, benthos, fish, and marine mammals[10]. However, their success depends on the wind farm's location and fishing restrictions. Several innovative nature restoration approaches within offshore wind farms have been designed and employed in recent years to promote and enhance marine biodiversity and ecosystems. Wind turbine foundations and associated infrastructure can be designed in a nature-inclusive manner, 'nature inclusive-design' to serve as habitat enhancement structures or the installations in the surrounding areas can be added or adapted to mimic natural reefs, providing shelter and substrate for marine organisms to attach.

Offshore wind farms may predominantly benefit specific sessile species and mobile fauna with limited home ranges, offering them resources and shelter. For species that roam larger areas, the advantages could be temporary. Nonetheless, introducing hard substrates can contribute to habitat conservation in regions where extensive hard bottom substrates have been lost due to activities like bottom trawling, particularly in areas like the eastern Kattegat and the southeastern North Sea[11].

It's important to note that the suitability and success of restoration efforts depend on factors such as local environmental conditions, water quality, substrate availability, and the presence of target species.

The North Sea has seen the biggest progress in this type of multi-use, as presented in Table 5 below. In the UNITED project, the pilot in Belgium has worked for 4 years to demonstrate the restoration of native flat oyster reefs within offshore wind farms.

[10] Available at: https://www.researchgate.net/publication/291555891_Offshore_Wind_Power_for_Marine_Conservation

[11] Available at: https://www.researchgate.net/publication/291555891_Offshore_Wind_Power_for_Marine_Conservation

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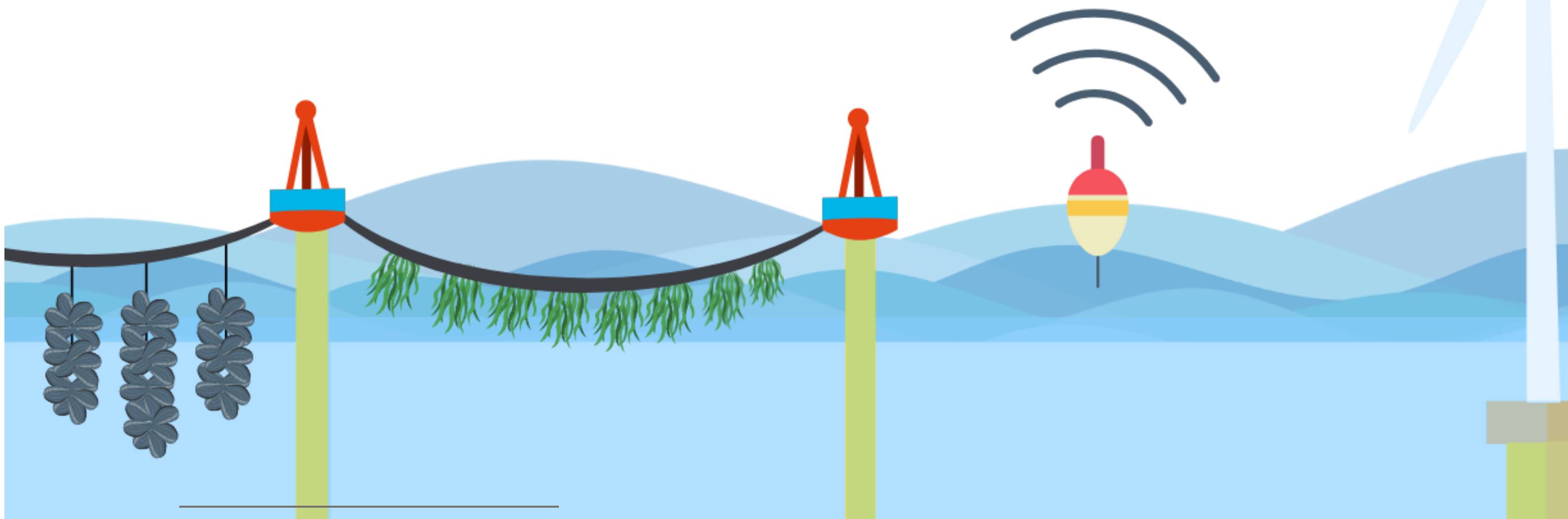
Table 5 Evidence base for the offshore wind and nature restoration Blueprint

Species[12]	Effect	Projects / evidence
Oyster Reefs	European flat oysters (*Ostrea edulis*) are native to the North Sea and have historically been present in the region. Restoring oyster reefs in the North Sea can help enhance local biodiversity and water quality.	UNITED BE pilot evaluated the potential of wind farms as locations for restoring native flat oyster reefs as well as culturing flat oysters for human consumption. This included the development of suitable scour protection fulfilling all the technical requirements as well as offering a substrate that attracts oyster larvae to settle on. A longline with tailored seed collectors and grow-out systems was developed to enable commercial flat oyster cultivation in offshore conditions.
Kelp Forests and or other types of seaweed	Kelp forests can be found in parts of the North Sea, especially in areas with rocky substrates. These habitats provide shelter and food for a range of species. Kelp restoration efforts can enhance biodiversity and carbon sequestration.	North Sea Farm 1 project, off the Netherlands coast, consists of a 10-hectare (25-acre) seaweed farm that is expected to produce at least 6,000kg of fresh seaweed in its first year.
Shellfish Beds	Mussels are common in the North Sea, and mussel beds play an important ecological role in filtering water and supporting other species. Restoring mussel beds can contribute to improved water quality.	Local effects of blue mussels around turbine foundations in an ecosystem model of Nysted off-shore wind farm, Denmark
Fish Populations	Various fish species are commercially important in the North Sea, including cod, haddock, plaice, and herring. Habitat restoration activities within offshore wind farms using artificial reefs and nature inclusive design of the turbine can help maintain and rebuild fish populations.	Concrete foundations of various sizes have been placed in four places in Borssele 1 & 2 OWF in the NL to provide shelter for Atlantic cod and other large fish species. The behaviour of the cod the North Sea lobster around the reefs is studied to inform co use options.



[12] The suitability of each species or habitat depends on local conditions and ecological factors.

Restoration of native flat oyster reefs within offshore wind farm

The Belgian UNITED pilot was conducted within the Belwind wind farm operated by Parkwind, situated approximately 46 km offshore with an average water depth of 25-30 meters. Building on the prior experience gained from the Edulis offshore mussel aquaculture pilot (September 2016 to 2019) hosted at the same location, this pilot explored the potential for wind farms to serve as sites for both the restoration of native flat oyster reefs and the sustainable cultivation of North Sea native flat oysters for human consumption. The pilot aimed to develop tailored infrastructure that would benefit both the environment and industry stakeholders, necessitating effective coordination and communication throughout the project. To realise these objectives, the Belgian pilot successfully:

- Identified suitable areas within offshore wind farms where trawling activities were restricted, providing ideal conditions for oyster reef restoration.
- Demonstrated the development of scour protection systems that satisfied technical requirements while fostering the formation of small oyster reefs. This innovative approach had the potential to create a network of oyster "islands" covering several square kilometres, with careful consideration given to the choice of filling material.
- Designed a longline system capable of supporting flat oyster production within the challenging offshore environment, drawing from previous experience in this domain.
- Selected appropriate seed collectors and grow-out systems tailored to the unique conditions of the offshore environment, offering specialised solutions.
- Implemented remote monitoring techniques to track oyster growth relative to various environmental parameters, enhancing data collection.
- Efficiently coordinated activities and streamlined communication between project components, improving installation efficiency.
- Investigated potential synergies between oyster reef restoration, aquaculture, and wind energy production, highlighting opportunities for combined benefits.

Pilot project for Native oyster (*Ostrea edulis*) restoration at the Gunfleet Sands OWF

This pilot project aimed at determining the suitability of the Gunfleet Sands OWF to act as a broodstock site to aid native oyster restoration within a nearby MCZ. The Gunfleet Sands Offshore Wind Farm is a 172 MW wind farm about seven kilometres off the Clacton- on-Sea coast in the Northern Thames Estuary.

The project concluded that the perfect window of opportunity for larval transport is relatively small and unlikely to coincide with larval release (Robertson et al., 2021). In addition, to make a meaningful contribution to populations within the MCZ a significant number of broodstock oysters would need to be housed within the wind farm. Depth, bed sediment and infrastructure constraints reduced the area available for broodstock installations to are small number of monopiles and surrounding scour stones. This raised concern over the potential to scale up broodstock numbers and the overall impact of the project, as well as financial investment. It was, therefore, decided that a pilot phase to determine survivability and reproduction of oysters would not be developed.

4.2.2. Planning and spatial configuration

EU and Member State regulations promote sustainable development in offshore areas, making flat oyster habitat restoration an attractive option to enhance biodiversity and ecosystem services. Identifying suitable sites for these projects is currently a significant challenge.

In the UNITED project, Northern Europe's potential for restoring offshore European flat oyster (Ostrea edulis) habitats has been evaluated based on population dynamics. A model combining seabed substrate data, population dynamics (Dynamic Energy Budget - Individual-Based Models), and particle tracking (larvae dispersal) has been employed. This model provides valuable insights into spatial suitability indicators like population growth, fitness, reproduction, and self-recruitment. By applying this model to the English Channel and the North Sea, potential locations for flat oyster habitat restoration, restorative aquaculture, or nature-inclusive oyster designs have been identified.

Comparing historical oyster bed sites with model outputs offers validation of the approach and insights into why certain locations were suitable for oyster bed development. The results indicate that coastal and nearshore environments are generally more suitable for flat oyster habitat restoration, with populations growing more rapidly in these areas. Offshore restoration in the North Sea presents challenges when relying solely on self-recruitment. In addition to site selection, the model allows for evaluating the impact of management strategies and environmental factors on restoration success, such as initial population size, climate change, and pollution (Brecht et al 2023).

Apart from the tool developed in UNITED there are also several other tools and methods that can be used to assess the site suitability of restoration actions as well as to conduct the offshore wind park siting.

Table 6 Selection of tools relevant for siting the restoration and offshore wind farms

Tool	Source
Marxan for the identification of suitable areas for the Macroalgal forests	https://pubmed.ncbi.nlm.nih.gov/36436438/
Marxan was applied as a support tool to identify suitable sites for offshore wind power in the pilot area Pomeranian Bight / Arkona Basin in the western Baltic Sea.	https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0194362
Site selection for biogenic reef restoration in offshore environments: The Natura 2000 area Borkum Reef Ground as a case study for native oyster restoration	https://onlinelibrary.wiley.com/doi/full/10.1002/aqc.3405

4.2.3. Permitting and Regulations

In recent years, governments have taken significant steps to incentivize nature restoration within offshore wind farms, especially considering the substantial number of wind farms planned for rollout in the coming years to meet climate targets while also addressing marine protection goals.

Example of a non-financial tendering criteria in the Netherlands

In the Netherlands, a non-financial tendering and auction criteria was introduced which supports innovative combinations between offshore wind farms and ecology. The introduction of these criteria has led to the consideration of innovative approaches for a combination of OWF with other ORE developments, such as solar energy and ecology within the design of OWF.

For example, in the new renewable energy concession zone, the Princess Elisabeth zone, MU is stimulated and foreseen in the planning legislation and this co-location does not depend on the consent of the offshore wind operator anymore. The new tendering mechanism will work with several selection criteria and MU will probably be included in a bulk criterion on sustainability (combining circular economy, fuel consumption and MU in the same criterion). The eventual weighing of criteria and the position of MU in the tendering procedure will be of great importance for further MU developments in wind farms in Belgium. Aquaculture projects need to reduce the eutrophication level in that zone, while passive fisheries are possible in contrast to the older renewable energy concession zone in which the Belgian pilot takes place.

For the Hollandse Kust (west) Site VI the expert committee that decided on the tender added 'contribution to the ecology of the North Sea' as a criterion as part of the comparative assessment. Applications were assessed on the basis of the following criteria:

- Amount of the financial offer;
- Certainty of the wind farm being completed – (knowledge and experience of the parties involved and financial guarantees issued by the parent company(s));
- Contribution of the wind farm to energy supply;
- Contribution to the ecology of the North Sea.

This advice meant that half of the total points available could be obtained, which was decisive for the final ranking. This 'ecology' criterion was split into two parts:

1 - Stimulation of investments to benefit naturally occurring biodiversity (species, populations, and habitats) in the Dutch North Sea.

2 - Stimulation of innovation and the development of solutions to benefit naturally occurring biodiversity in the Dutch North Sea from the wind farm at Site VI and future Dutch offshore wind farms.

While nature restoration and nature-inclusive design within offshore wind farms present exciting prospects for large-scale habitat restoration, there are still legal constraints and challenges to address when implementing such MU projects. A key concern is ensuring alignment with conservation and protection duties, particularly within the context of Natura 2000 sites.

The EU Habitats Directive has led to the establishment of Natura 2000, an extensive European ecological network covering terrestrial and marine environments. While the designation of marine Natura 2000 sites continues, the focus shifts toward protecting these sites and managing potential harmful activities within them. Although MU is not explicitly mentioned in the EU Habitats Directive, it does not impose a comprehensive ban on MU strategies, including those combining aquaculture, nature restoration, and renewable energy projects. Nevertheless, the concept, even in its nature-inclusive design approach, can affect multiple aspects of the EU Habitats Directive, such as the overarching objective of achieving a favourable conservation status, MPA designation, conservation objectives, and protection and assessment regimes. While MU, with restoration actions, contributes to the EU Habitats Directive's objectives, it does not exempt projects from detailed conservation duties.

Aligning MU, especially those with nature-inclusive design, with the EU Habitats Directive requires addressing potential interference with designation duties. The development of proactive conservation objectives specific to each site ensures MU compliance with conservation objectives, simplifying subsequent authorisation procedures. However, the existence of restoration actions mandated by Article 6(1) of the EU Habitats Directive should not be used as a justification for future permitting strategies.

For more information see Deliverable 6.2 Case specific report on legal aspects and insurance issues

4.2.4. Risk assessment

In line with findings for the offshore wind and aquaculture multi-use, the analysis of the offshore wind and nature restoration multi-use has also shown that inadequate insurance coverage and severe weather conditions are deemed to be the highest risks. Table 7 below shows the full assessment, based in the findings of the UNITED pilot in Belgium.

Table 7 Risk assessment based on the Belgian Pilot

Risk Item	Description of Risk	Risk Mitigation
Inadequate Insurance	Inadequate insurance coverage for multi-use offshore projects, leading to increased consequences in the event of risk events.	• Draft detailed safety protocols for aquaculture and energy production activities. • Collaboratively work with insurance companies to improve risk understanding and trust. • Consider self-insurance for less severe risks through cash reserves or flexible credit lines. • Improve understanding of multi-use at sea with public sector and insurance companies. • Seek collaboration with third parties and insurers.
Environmental Catastrophic Events	Risk of damage due to extreme adverse environmental catastrophic events such as storms or underwater earthquakes.	• Develop extensive safety protocols at the port, on vessels, and at the site. • Review equipment design to minimise environmental hazard and detachment. • Consider long-term impacts of ocean salinity on materials used. • Regularly check equipment to prevent detachment. • Provide mandatory health and safety training. • Continuously monitor weather forecasts and collaborate with the coast guard. • Obtain insurance coverage for potential damage. • Develop disaster recovery plans.
Decommissioning of Assets	Decommissioning assets is an intensive and expensive activity, creating uncertainty about legal status and decommissioning costs.	• Develop a decommissioning plan at project inception. • Minimise complexity and impact during decommissioning at the design stage. • Include a sinking fund in the business model for decommissioning finances.
Connectivity Issues	Connectivity failure due to poor internet connection can lead to equipment malfunction, misunderstanding of site conditions,	• Implement alternative connectivity protocols and transmission systems for data retrieval.

	injuries, fatalities, and slow response times.	
Damage Risks of Mechanical Loads and Collisions	Increased marine traffic and equipment interactions may lead to vessel collisions, damage to individuals, the marine environment, and physical assets.	• Plan and closely coordinate between multi-use businesses to minimise risks and disturbances to the ecosystem. • Design the site to minimise collision risks. • Share site visit schedules and equipment reviews. • Explore remote control operation opportunities with durable automated monitoring devices to reduce site visits.

4.2.5. Insurance

Experience of obtaining insurance for this offshore multi-use combination is limited. Partners of the UNITED Belgian pilot took out a novel insurance policy for both insurance of assets and liability. University of Gent is the principal insured party. As the university is a public institution the policy was obtained via a tendering procedure. There is a financial cap for the liability policy, set at 10 million euros, as was the minimum demand of the concession holder of the wind farm. In a distinct contract with the wind farm operator, each party ensured it would waive recourse to one another beyond the cap of 10 million euros. Every alteration to the project must be communicated to the insurer accompanied by a method statement and simulation of the impact of the change. Given that the pilot is taking place in a wind farm which is already in concession, there was little leeway for the additional MU user to negotiate with the concession holder on the necessary terms and guarantees required by the concession holder. When novel maritime areas are taken into use for wind farms, this imbalance between parties will likely repeat itself when concessions are granted for wind farms and other MU users once again need to deal directly with the already present wind farm concession holder.

For more details about insurance, see the previous Blueprint on offshore wind and aquaculture.

For a full list of the insured items and insurance holders of the Belgian pilot, see Table 4.2.4 in the UNITED Deliverable 6.2.

4.2.6. Technology

Several initiatives have trailed restoration within offshore wind farms in the last several years. Several techniques and technological solutions have been proposed including the oyster and lobster cages enforcing the scour protection, artificial reefs and concrete structures. The nature inclusive design of offshore wind farms has also been tested, such as the holes in the foundation piles of turbines to provide shelter to marine life.

The Belgian UNITED pilot aimed to restore native flat oyster reefs, utilising the hard substrate used for wind turbine foundation scour protection. This environment, free from bottom fishing activities, provided an ideal setting for oyster larvae to settle, initiating natural reef development. The coexistence of aquaculture and reef restoration was a symbiotic relationship, where aquaculture provided initial seed stock for reef development, and established reefs offered oyster larvae for aquaculture. **Cultivation of native oysters** (*Ostrea edulis*) was successful in terms of promising survival and growth in a harsh offshore environment. Of the four different cultivation techniques tested, the metal frames containing SEAPA baskets performed the best when considering structural integrity, biofouling accumulation, and capacity. The SEAPA baskets have a cylindrical design and are oriented horizontally. This encourages a tumbling motion which seems to control internal biofouling accumulation, but may also cause oysters to grow thicker, more rounded shells. It is unclear whether this shell morphology would have an effect on marketability.

The designed tables, constructed with galvanised steel and standing at a height of 1.50 meters, equipped with gabion cages for offshore applications or a single cage divided into compartments for nearshore conditions, have proven effective in testing scour material as a settlement substrate. However, it was noted that this approach lacked representativeness for assessing scour protection around the turbine, as the tables were deemed too small for this purpose. The design incorporated features for easy decommissioning at the project's conclusion, in compliance with wind farm requirements. An additional limitation was the restriction on sample collection, permitting only scientific divers aboard research vessels to conduct sampling within the wind farm for scientific monitoring purposes. Despite these constraints, the tables' elevated height of 1.5 meters above the scour protection facilitated the survival and likely reproduction and settlement of flat oysters. The pilot suggests the potential for synergy with aquaculture, contingent on necessary design adjustments. Overall, the stability of the tables was confirmed, and the pilot concluded that, in general, tables placed atop scour protection can effectively assess flat oyster settlement and fouling development.

- Some of the key technology-related learnings for the offshore wind and oyster restoration:
- Stones stuck together due to fouling and oysters grown between them, this way complicating their removal. The latter however was interesting from a restoration reef building perspective.
- Deployment of the tables at the sea bottom was very easy due to practical design of the tables. The four corners had loops through which shackles and ropes could be easily connected to the on-board winch system hence facilitating easy deployment and removal of the tables.
- Tables proved to possess the stability required to withstand the hydraulic load of wave action and currents. Tables stayed upright and did not sink into the sand, which was crucial in order to evaluate their potential for restoration. This as sand would smother the oysters and would not allow oyster growth.
- Exact location determination for retrieval seemed tricky, partly due to poor visibility during the dive. Hence tables need good location marking (e.g., via buoy). Once the exact location was determined, the divers could easily reconnect the shackles and ropes and the tables were very easily lifted from the water
- Various substrates were tested showing variable attractiveness among them, making it difficult to decide on a singular preferred substrate. However, the scour protection stones currently in use (granite) provided a substrate comparable in quality to reference substrates such as limestone. Especially the small size category 0-200mm showed good settlement.

Table 8 TRL of Belgian Pilot

Economic activity	Baseline TRL	Accomplished TRL
Offshore wind park and oyster restoration (UNITED Belgian pilot)	TRL 5	TRL 7

4.2.7. Operations and maintenance

Operation and maintenance of offshore wind and nature restoration activities described under the previous blueprint share a lot of commonalities with the multi-use of offshore wind and low trophic aquaculture. Therefore, this section explains only the findings specific to the UNITED BE pilot to shed light on crucial aspects of synergy between offshore wind farms (OWF) and nature restoration.

Based on the experience of the BE pilot, operational synergies of OWF and nature restoration were limited to monitoring longline positions by crew vessels. For future developments, it would be important to identify the site-specific synergies and open up good communication channels with regional stakeholders. If OWF is being installed, sonar and UXO operations have to be carried out, which can also benefit restoration activities. **Future multi-use projects should be designed upfront in such a way that makes these synergies easier to adapt.**

Monitoring in the Belgium offshore pilot involved no remote real-data collection. However, existing services such as Copernicus Marine Satellite, EMODNET and Windguru were extensively used. In addition, **experimental variables** were monitored through sampling missions limited to 2-3 times per year:

- Oyster growth (shell length, shell weight, total weight, and tissue wet, dry and ash weight),
- Fouling (species composition, estimate of species cover, presence of non-indigenous species),
- Seaweed (seaweed length, seaweed weight, seaweed growth),
- Oyster settlement (number of settled spat, survival, size)

Numerical modes were also set up and field measurements were used to validate them. Two types of numerical models were constructed and were linked to satellite products, ERSEM data and DCSM data:

1. DEB models for the European flat oyster which enables the prediction of growth, fitness, survival, reproduction and nutrient budgets of individuals

2. DEB population models for the European flat oyster which enables the prediction of population dynamics

Models were applied to 10-year geospatial data for the North-Atlantic, Channel and North Sea. Oyster samples resulted in information about growth, fitness, reproductive status, disease status and fouling of the organisms.

Recommendation:

Future multi-use developments should consider more remote monitoring solutions, with minimal ship time, sensor retrieval system to grant access for repairs.

4.2.8. Environmental impacts assessment

The potential **introduction of exotic species** posed a significant concern for the development of a multi-use pilot in Belgium. Introducing European flat oysters for restoration purposes proved challenging, given the requirement that the introduced material must be free from specific diseases, including the *Bonamia* parasite, necessitating a '*Bonamia*-free' status. This implied import from Norway, which at the same time increased the risk of introducing other exotic species. However, there is no risk assessment to balance the risk of introducing *Bonamia ostreae* versus the introduction of other exotic species. There seems to be a discussion on definitions as well: it appears that EU legislation allows the introduction of the Japanese oyster *Crassostrea* (a genus of true oysters, family Ostreidae), while environmental parties in Belgium are reluctant and advise against it.

4.2.9. Social impacts and ensuring acceptance

Please refer to the preceding chapter on the offshore wind and aquaculture blueprint for more details on this topic.

4.2.10. Commercialisation

Non-financial benefits become especially evident in cases where nature inclusive design has been applied or nature restoration activities take place within offshore wind farms, such as the case in the UNITED Belgian pilot. These benefits include **enhanced environmental stewardship, better acceptance of OWF and the overall corporate social responsibility** image of the OWF project. Moreover, 'regenerative aquaculture' offshore can potentially bring in several environmental benefits - seaweed has carbon-fixing properties while shellfish purify the water. Moreover, both algae and mussels do not need to be fed, so no input of nutrients is needed to grow mussels and algae.

Since this multi-use mainly relies on the non-financial added benefits, the Ocean Multi-Use Commercialisation Roadmap highlights that there is a need for **innovative funding streams**. Financing such multi-use initiatives that have no direct economic benefits such as those integrating the ecosystem restoration and blue corridors in wind farms, may rely on government financial incentives, or initiatives in collaboration with environmental NGOs e.g. 'adopt an oyster farm' or consider the financial benefits that can result from CO_2 sequestration properties of seaweed farming.

Funded by the European Union (H2020 Grant Agreement no 862915). Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union. Neither the European Union nor the granting authority can be held responsible for them

4.2.11. Decommissioning

Decommissioning is a crucial aspect that should be considered during the initial planning phase of a multi-use project. Specifically, when it comes to offshore wind farms, which typically have a lifespan of around 25 years, it's essential to consider the fate of the effects of nature restoration activities once the turbines are decommissioned and removed. The same principle applies to the nature-inclusive design of offshore wind farms, which are intended to contribute to nature restoration efforts.

In the case of the **UNITED Belgian pilot**, this phase of the project coincides with the beginning of the follow-up project, ULTFARMS which will continue the Belgian pilot's investigation into multi-use scenarios involving offshore energy production, low-trophic aquaculture, and restoration. Therefore, only limited decommissioning has taken place for the time being. This includes the removal of oyster cultivation longline and seaweed nets from the long lines. The end of the ULTFARMS project will include the full decommissioning of the Belgian pilot infrastructure, including the seaweed cultivation, screw anchors, and restoration tables. In preparation for this inevitability, the Belgian pilot developed a **detailed method statement** in collaboration with Parkwind and Jan de Nul Group which will carry out the full decommissioning in 2026 at the end of the ULTFARMS project.

More information on the decommissioning procedures can be found in UNITED Deliverable 7.6 Development and implementation of a decommissioning procedure.

4.3. Offshore wind and tourism

4.3.1. Scenario

The multi-use activity combining offshore wind and tourism focuses on the shared use of marine space, promoting cooperation between **offshore wind energy and tourism**. This combination does not necessarily include only off-shore infrastructure but can also involve onshore facilities. In this context various engaging activities can be offered. These activities include boat tours that take visitors up close to the offshore wind farm and in some cases even allow climbing of the wind turbines. On land, shared facilities like OWF-themed information centres and museums that educate tourists about renewable energy initiatives are possible. A unique aspect of this MU scenario involves the opportunity to create specialised offshore platforms positioned around the wind turbines. These platforms can serve multiple purposes, such as providing a space for seals, offering facilities for divers to explore the marine environment, and hosting restaurants where guests can enjoy delicious meals with a stunning ocean view.

In its multi-use action plan MUSES identified the following **benefits and barriers** to this combination. By offering economic benefits to local communities and turning OWFs into positive tourism attractions this approach aims to address OWF project acceptance issues. It can reduce negative OWF operational costs, promote green energy awareness, and boost regional development, especially in remote areas. However, developing the MU within OWF zones faces hurdles like complex licensing, cost-sharing uncertainties, and natural obstacles. Furthermore, integrating the MU concept early in OWF planning isn't common practice.[13]

The MU combination of offshore wind and tourism can be found in Sweden, Denmark, Belgium, Germany, the United States and the United Kingdom.[14]

[13] Schultz-Zehden, A. et al. (2018). *Ocean Multi-Use Action Plan.* MUSES project. Edinburgh. https://maritime-spatial-planning.ec.europa.eu/sites/default/files/muses_multi-use_action_plan.pdf.

[14] Przedrzymirska, J. et al. (2021). "Multi-Use of the Sea as a Sustainable Development Instrument in Five EU Sea Basins" Sustainability 13, no. 15: 8159. https://doi.org/10.3390/su13158159.

Table 9 Evidence Base for offshore wind farm and tourism Blueprint

Country	Pilot description	Project
Denmark	At the Middelgrunden Offshore Wind Farm in Denmark, visitors have the unique opportunity to ascend the 60-meter tower of one of the turbines and, weather permitting, access the nacelle. This offshore wind farm also serves as an excellent illustration of an appealing layout and the advantages of involving the local community in a collaborative design process from the outset. The wind farm's design follows a single, gracefully curved line, mirroring the structure of Copenhagen city, which is shaped like a super-ellipse, inspired by the historical defence system located to the west of Copenhagen.[15]	UNITED Pilot
Belgium	Belgium offers boat tours to the initial national offshore wind farm, Thorntonbank, which is under the ownership of C-Power. This wind farm is located 30 kilometres off the coast. For corporate groups, the tour operator collaborates with the C-Power visitor centre in Ostend. Here, a representative from the wind farm operator delivers a presentation about the offshore wind farm. Although the tour boat remains within a safe distance of 500 meters, visitors can still enjoy impressive views of the wind farm despite the considerable distance.[16]	Commercial
Germany	In Germany, specifically in the North Sea, besides boat tours that stay beyond the 500-meter safety zone of offshore wind farms, there is also a land-based observation platform located in Bremerhaven. This platform features an information board and a multimedia terminal for visitors[17]	Commercial
UK	In the United Kingdom, the typical safety distance is just 50 meters, enabling vessels to get quite close to the turbines. Some instances of this can be observed in Brighton, East Sussex, located in Southern England (offering visits to the Rampion Offshore Wind Farm); Ramsgate, Kent (offering visits to the Thanet Offshore Wind Farm); and Great Yarmouth, Norfolk (offering visits to the Scroby Sands Offshore Wind Farm) in Eastern England. Additionally, in Llandudno, Wales, situated in the Irish Sea, you can experience visits to the Gwynt Y Mor Offshore Wind Farm. [18]	Commercial
Sweden	Boat excursions have been organised at both the Utgrundet and Lillgrunden offshore wind parks to offer tourists and local residents an opportunity to explore and learn about the wind parks up close. In one instance, this was specifically done during the early stages of development to inform interested parties and the public about the wind park. In the other case, it has become	MUSES, Case Study Analysis[19]

[15] Ibid.

[16] Ibid.

[17] Ibid.

[18] Ibid.

[19] Franzen, F. et al. (2017). *Case study 4: Multi-Use for local development focused on energy production, tourism and environment in Swedish waters (Island of Gotland – Baltic Sea).* MUSES project. https://maritime-spatial-planning.ec.europa.eu/media/12378.

	an annual event that consistently draws a large number of participants. The trips are coordinated by the energy company that owns the wind park. It's worth noting that in Sweden, there are no specific restrictions on visiting the wind park areas, which could potentially support the growth of tourism in these regions.	
US	Visitors of Block Island, off the coast of Rhode Island, can take a boat tour to Block Island Wind Farm and learn about renewable energies and the construction of offshore wind parks from their captain.	Multi-Frame, Blueprints Collection[20]

4.3.2. Planning and spatial configuration

For this MU planning and spatial configuration are heavily dependent on the (national) context in which the MU is to be set up. Furthermore, planning differs depending on whether the OWF was already in place when tourism was set up in relation to the wind farm or whether offshore wind and tourism were developed simultaneously under the multi-use concept. Where offshore wind developments are still in the pre-planning phase it is advised to integrate the local tourism sector from an early stage on to foster effective cooperation and integrate the multi-use from the start. This would reduce barriers and costs as i.e. insurance, suitable vessels and required infrastructure around the OWF could be jointly acquired or developed. Table 8 below provides an overview of key spatial factors that should be addressed in the planning and development of this MU combination.

[20] McCann, J. (2022). *Ocean Multi-Use Blueprints Collection. Aquaculture, Recreational Fishing and Boating in Rhode Island, United States.* Multi-Frame. https://www.2020.submariner-network.eu/images/3_Projects/Multi-frame/mf-multi-use-blueprints-WEB-230331.pdf

Table 10 Spatial considerations offshore wind and tourism MU

Spatial Consideration	Elaboration
Spatial Requirement of Tourism: Access to the Coastline	Coastal and maritime tourism depend on easy access to the shoreline. The integration of offshore wind and tourism offers the potential to e**nhance access to the shoreline** through strategic investments in new or improved infrastructure, as well as by adopting more flexible operational models that allow public assets such as ports, harbours, piers, and marinas to be shared with private enterprises.
Distance to Shore	An essential consideration in this integration is the **distance from shore**. As offshore wind installations move further from the coastline to harness stronger and more consistent winds, it becomes a critical spatial factor when combining offshore wind farms and tourism. Excessive distance from the land can render tourist activities financially unviable and less attractive. Risks are increasing when moving offshore. Rescue operations in far offshore locations can take several hours or are nearly impossible due to poor visibility because of bad weather or fog (no helicopter flights) Therefore, this MU combination can mainly be developed in marine spaces close to the shore.
Appeal of the Coastal Region	Wind farms may adversely affect the visual appeal of the coastal landscape. However, if planned strategically and integrated with the tourism sector, wind farms can also contribute to the reputation of the region as sustainable and add **cultural value**, making it an attractive destination for tourists. For instance, the unique design of OWFs, such as the Middlegrunden Wind Farm's curved shape mirroring the outline of Copenhagen, can serve as a cultural representation of the area. Transforming the wind park into an artistic space, such as allowing artists to paint on the turbines or organizing light shows using the safety lights, serves as another example of how combining OWF and tourism can add cultural value.
Economic Development	The areas identified should be determined in collaboration with relevant tourism authorities, aligning with broader zones of interest designated for ORE projects. Socio economic assessment can help determine in what area adding certain type of tourism activity to the offshore wind farm can have positive socio-economic effect. For example, rural coastal communities can benefit from additional tourism attractions related to offshore wind farms that diversify the tourism offering and stimulate economic growth. This approach may also serve to divert some of the intense tourism often concentrated in major cities toward more rural coastal regions, creating an economic boost.

4.3.3. Permitting / Regulations

Wind energy and tourism are two diverse sectors, each carrying its own set of regulations and permitting processes, which additionally differ across countries. Generally, there is no overarching legislation in place to address this MU but rather different sectors and levels of governance influence its regulatory framework:

1. Environmental law

Generally, EIAs are required to receive permits for offshore development projects such as OWF construction, however, tourism activities often do not legally require environmental assessments to operate. The increased pressure on the environment, for example in the Danish UNITED pilot, was not seen as substantial enough to undertake an EIA (Lukic et al. 2020). While conducting EIAs is advised to better understand the environmental impact of this type of MU, there is currently no specific legal framework for conducting multi-use EIAs in place. This presents a challenge as the unique environmental impacts and interactions associated with combining offshore wind energy and tourism require tailored assessment criteria (see 4.3.7).

2. **National regulations and permitting requirements in the tourism sector**

General permits that need to be obtained by the tourism operators include i.e. permits for commercial transport of passengers and permits for placing the boats when they are not in operation. While some tourist activities, such as visiting the turbines by boat, if a certain distance to the turbines is ensured, may fall under the umbrella of general permits, others, such as guided tours, diving expeditions, or exclusive dining experiences, might require more specific permits. In cases where tourists engage in activities that **involve direct interaction with wind turbines or subsea infrastructure, close cooperation with wind farm operators** is essential and permission of the OWF operators might have to be obtained. This collaboration ensures that safety protocols are upheld, and any potential disruptions to wind farm operations are minimised.

3. **National regulations and permitting requirements in the energy sector**

National regulations within the energy sector provide a framework for obtaining the necessary permits to construct and operate OWFs. Typically, this involves a thorough assessment of the project's environmental impact, technical feasibility, and compliance with safety standards. Additionally, tendering processes are employed to allocate rights to develop OWFs. These competitive processes aim to ensure that developers meet specific criteria and commitments, contributing to the overall sustainability and efficiency of offshore wind energy projects. To streamline permitting processes, the establishment of a **one stop shop agency** is advised. This can simplify and speed up the permitting process, reducing the complexity and duration of obtaining approvals for offshore wind development, as it can significantly reduce the administrative burden.

Many European countries (i.e. Germany) consider OWFs as maritime exclusion zones and require **a safety zone of 500m** around wind turbines, where no other maritime activity (such as shipping, recreational boating or aquaculture) is allowed to take place. Safety zones are set up to prevent accidents that could lead to injury or damage of the turbines.

Danish Energy Agency as one-stop shop and safety zones in Denmark

The Danish Energy Agency, a division within the Ministry for Climate, Energy, and Utilities, serves as the regulatory body responsible for offshore renewable energy initiatives. Developers are required to enter into a concession agreement and acquire three essential permits, covering pre-investigation (including feasibility assessment), construction (comprising EIA), and electricity production. These permits align with the Danish legislation governing Renewable Energy promotion, electricity supply, and environmental impact assessments for various plans, programs, and projects. The Danish Energy Agency operates as a consolidated service point, or one-stop shop, for applicants engaged in offshore wind farm development (Maes et al. 2023).

In Denmark, unlike many other European countries, specific safety zones around OWF are not mandated by law. Consequently, boat tours for viewing the wind farms from the water can be conducted without the need for additional permissions from the wind farm operators. However, any interactions with the wind farms themselves, such as climbing the wind turbines, requires approval from the owners of the wind farms. The pilot emphasizes the significance of establishing strong collaboration between tourism providers and wind farm operators.

Safety zone regulations in the United Kingdom

In the UK, safety zones around wind farms vary depending on the phase of the wind farm's life cycle. During construction, a 500-meter safety zone is enforced around structures where work is active. For partially completed or fully completed structures not undergoing work, the zone is reduced to 50 meters. During operation, free navigation is allowed unless a permanent 50-meter safety zone is requested by the project owner. For maintenance activities, a 500-meter zone is mandated around any structure requiring major maintenance.

Regulatory framework for recreational vessels in offshore wind farms in the Netherlands

Since 2018, the Netherlands has permitted recreational vessels that are 24 meters in length overall (and up to 45 meters for some new wind farm projects) to pass through certain offshore wind farms under strict conditions. Basic rules require that vessels maintain a distance of 50 meters from wind turbine towers and 500 meters from transformer stations, with passage through safety corridors only permitted if established. Vessels exceeding 24 meters in length overall are prohibited from entering wind farm areas. The following regulations apply for behaviour within the wind farm areas:

- Recreational vessels are required to be equipped with an AIS (satellite) transponder.
- Access is restricted to daytime hours only.
- Anchoring within the wind farm area is prohibited.

Activities such as diving, kite surfing, and the disposal of any waste or garbage are strictly forbidden.

Another important issue which emerges in this MU combination is **the temporal aspect of the operation** of the different ocean uses. The operation of OWF needs to be discontinued after 25 years whilst tourism could technically operate further. As tourism in this case relies on the offshore wind infrastructure, the question arises which regulatory and permitting consequences derive from this.

Recommendation: Future multi-use developments should consider more remote monitoring solutions, with minimal ship time, sensor retrieval system to grant access for repairs.

- Consider the varying lifespans of OWF and tourism permits and establish a legal framework that regulates this issue at the outset. This proactive approach mitigates potential future conflicts and reduces uncertainties.
- Create a centralised one-stop shop dedicated to streamlining the permitting procedures, offering a unified point of contact to facilitate the process.

4.3.4. Risk assessment and insurance

A comprehensive risk assessment is important to ensure the sustainable growth of this MU combination. Insurance solutions tailored to the unique challenges of this multi-use concept are crucial for mitigating potential financial losses and safeguarding investments in this evolving sector. In this context, SOMOS, as described in the first blueprint, can be a valuable tool for assessing and managing risks in multi-use projects.

Table 11 outlines the key risks identified in the UNITED project based on data gathered from the Danish pilot, focusing on their potential impact and the probability of occurrence. These risks have been evaluated based on comprehensive risk analysis, considering the pilot activities, and anticipating challenges in scaling up multi-use operations of this nature. Furthermore, risk mitigation solutions are presented in the table based on each identified risk item.

Table 11 The highest risks for OWF and tourism multi-use based on UNITED analysis of Danish pilot (Barlow et al. 2022)

Five highest risks based on impact and probability

SOMOS Risk Category	Risk Item	Description of Risk	Risk Mitigation
OTHER	Inadequate Insurance	The complexity and high premiums of insurance stems from the involvement of multiple stakeholders and the need for wind power insurance to cover diverse elements, including staff and infrastructure. Inadequate coverage, especially for high-risk components like sea cables can lead to the occurrence of high costs and the inability for operators to recover from risk events.	Drafting detailed safety protocols for different activities. Collaborating with insurance companies to lower premiums. Considering the creation of a self-insurance fund within the company to manage minor risks.
Safety to Man and Equipment	Severe Weather	The risk of severe weather, including storms, poses threats to both individuals and the wind farm infrastructure, leading to potential damage and detachment. Weather-related issues can disrupt tourist activities, resulting in cancellations and associated costs.	Development of extensive safety protocols for various aspects of the operation. Equipment reviews and design to withhold severe weather events. Mandatory health and safety training Continuous weather monitoring. Disaster recovery plans Implementation of marketing strategies to handle visit cancellations due to severe weather conditions.
	Presence of Tourists and Workers	The presence of tourists and workers on the wind farm interacting with the infrastructure raises technical, administrative, practical, and legal issues. This includes the risk of personal injury due to tourists' lack of training, hazards associated with access and transportation on-site, and potential incidents that could harm the reputation and legal standing of the business.	Establishment of precise safety protocols for both staff and tourists. Staff training for risk management and incident handling. Securing comprehensive injury insurance coverage. Procedures for managing injuries.
Safety to man and equipment	Lack of Specific Technology Knowledge	The risk of inadequate technological knowledge poses a challenge in hiring qualified and experienced staff for multi-use facilities. This risk can lead to severe damage to people and infrastructure, particularly when	Development of detailed protocols for behaviour during the journey and on site.

		untrained tourists interact with the site.	Provide basic training to tourists regarding appropriate behaviour within the facility. Investments in staff training regarding windfarm operations and infrastructure.
Safety to man and equipment	Structure Failure	Complex facilities like wind power installations face the risk of structure failures due to various causes, including bird strikes, lightning strikes, detachment of blade furniture, delamination, leading-edge corrosion, or blade cracks. Such failures can disrupt energy production, potentially causing accidents and environmental damage.	Development of an infrastructure asset management plan for timely equipment replacement. Establishment of incident management protocols. Staff training for facility incident management. Insurance coverage including protection against facility failures.
Environmental and Cumulative Impact	Pollution	Risks associated with the environmental impact, particularly pollution of the site and its effects on living organisms. Risk of contamination can hinder the expansion or upscaling of MU activities in order to preserve the environment.	Analyse the possibility of cleaning up the polluted area. Establish practices to prevent human contamination from the polluted water. Comply with institutional guidelines for equipment renewal and disposal.

4.3.5. Technology

Table 12 TRL of the Danish Pilot

Economic activity	Baseline TRL	Accomplished TRL
Offshore wind park and tourism (visiting, diving, fishing in UNITED Danish pilot)	TRL 6	TRL 9

TRL improvement in the Danish UNITED Pilot

At the outset of the project, the Danish pilot operated at a TRL of 6. Initially, visits were incorporated in addition to the biennial shareholder visits, where a board member from the Wind Turbine Cooperative joined a group of visitors. One specific boat operator was employed due to its ability to navigate in shallow waters. As the UNITED project progressed, two additional boat owners were successfully encouraged to include these tours as part of their regular sea trip offerings. This expansion led to the establishment of insurance regulations, along with an improved focus on overall security and risk assessments. Furthermore, three additional guides were trained, and a manual for guides was created. In response to the challenges posed by the COVID-19 pandemic, two videos were produced to facilitate virtual visits. Overall, the Danish pilot, which had initially operated at an baseline TRL level of 6, has now evolved into a fully commercial project, reaching TRL 9.[1]

Information technology includes software required for scheduling visits to the wind turbines and any technology that facilitates virtual tours. Having a proper **scheduling system** is relevant to ensure good communication between all parties involved. High flexibility of the tour operators and guides is required due to the unpredictability of the weather conditions.

Relevant considerations for **physical technology** include the infrastructure for tourism activities on turbine foundations such as divers platform and restaurant facilities, the logistics and structural characteristics of tourist boats, the technology required to cross from the boat over to the platform and, in case of offering turbine climbing activities, the structure of the turbine.

Another technological consideration, when combining OWF and tourism are the **type of boat** used to transport the visitors to the wind turbines. The boats need to be properly equipped to safely transport the relevant number of tourists. The size of the boat is determined by several factors. As the offshore location results in increased wind and wave strength bigger boats might be preferable. However, non-floating wind turbines are often located in shallow waters which means that the boat cannot be too big as this would increase the risk of collision or surge of the boat.

Climbing onto the turbine platform from the boat can become challenging, especially if the waves are stronger. To ensure the safety of the visitors and prevent falls into the water as well as squeezing of limps, a ladder construction needs to be provided that does not as quickly respond to water disturbance. The ladder could either be attached to the foundation of the turbine or alternatively attached to the boat or stored onboard.

When offering tours climbing the turbines, it is relevant to look at the age and **structure of the turbine** in question. Tourism activities that involve climbing wind turbines are only feasible in older turbine models predating 2007, characterized by having multiple floors within the turbine structure. In contrast, modern wind turbines, with a maximum gap of 8 meters between floors, require the use of safety equipment for any climbing activities.

Table 13 Shortcomings and Advantages of different vessel types used in Danish Pilot

Technology	Description	Shortcomings	Advantages
Zodiac – rubber boat without own ladder construction	Small rubber boat, used to transport visitor groups to the wind turbines and back.	• The boat does not have its own ladder but can only use the fixed ladder on the foundation of the turbine. • Limited ability to choose which direction to approach the turbine from. • The boat is more exposed to wind and waves. • Noise levels too high to have presentations during the boat ride.	• Lower fuel consumption. • Faster transport time (30min to foundation).
Big boat with own ladder construction	Bigger boat, used to transport visitor groups to the wind turbines and back.	• Higher fuel consumption. • Slower transport (45min to foundation).	• The turbine foundation can be approached from four different directions. • The boat can be fixed to the foundation with its front, which makes the transfer between boat and foundation more stable. • Less dependent on weather conditions. • Can listen to presentations during the trip to the turbine.

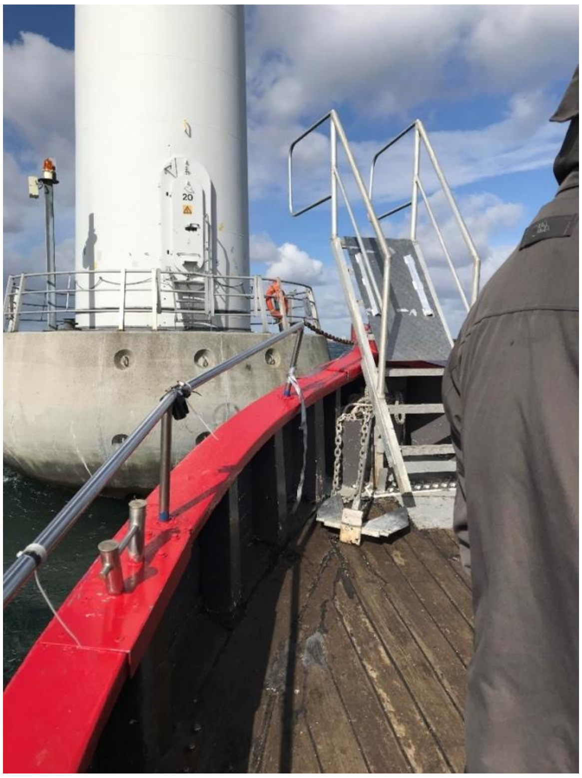
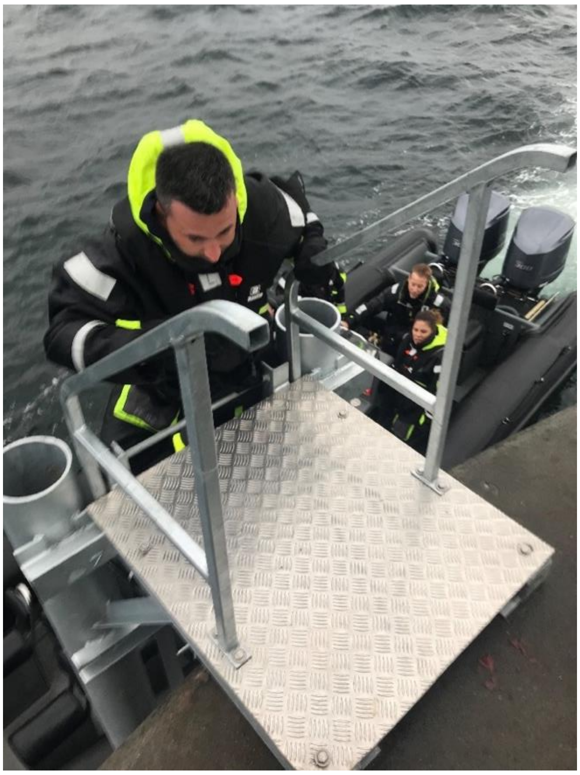



Figure 3 Access to the turbine with SPAR shipping (on the left) and CPH Shipping, Boat type: Zodiacs/RIB (on the right). Showcasing two different types of ladder systems.

Vessel Operation in the Danish UNITED Pilot

The Danish pilot employs boats from two different operators in the Copenhagen region. It was not possible so far to use the same boat operator as the service provider for the wind turbine because the service vessels are not able to meet the flexibility demands of the tourism sector and they are often not willing to get involved in another sector.

Recommendation:

1. Turbines need to be suitable for entering without safety equipment if the MU activity includes climbing the nacelle.

2. To transport the visitors to the OWF, a boat should be chosen that offers the possibility of giving presentations during the trip and ensures safety in different weather conditions.

3. A combined booking system should be implemented that has access to the boat operators' schedules as well as the maintenance schedule of the OWF operators. Future multi-use developments should consider more remote monitoring solutions, with minimal ship time, sensor retrieval system to grant access for repairs.

4.3.6. Operations and maintenance

Operation of this MU combination is suggested to only take place at a limited number of wind turbines within the wind farm so that these turbine's infrastructure can be adjusted to hosting visitors and protocols can be put in place.

Vessel Operation: Shared vessel operations (service for the OWF and tourism transport) have proven to be difficult as the operators require different licenses and skills for the two sectors.

Vessel Operation in the Danish UNITED Pilot

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Monitoring: Monitoring involves tracking the number of visitor and the turnover of the tourist activity, which can be done digitally via spreadsheet programs like excel. Furthermore, visitors could be asked to fill out surveys about their experiences to monitor the quality of the trips and track the satisfaction of the visitors.

Health and Safety: To safeguard the health and safety of tourists, it is essential to implement a comprehensive safety protocol specifically designed for the tourist activities involved. Additionally, staff members should undergo thorough training and briefings on both the tour processes and the wind turbine operations. As part of this training, a guidebook can be compiled and distributed to all staff members for reference.

A manual for guides in the Danish UNITED pilot

Within the UNITED project, the Danish pilot has crafted a guidebook for tour guides, providing essential knowledge needed to lead tours to the Middelgrunden Wind Farm. This manual encompasses various aspects such as the types of tours available, technical considerations, safety protocols (including weather restrictions), guidelines for handling accidents, and educational background information about the Middelgrunden wind farm. Not only is this guidebook valuable for existing guides, but it also serves as a training resource for new guides.[1] Moreover, this comprehensive guidebook can serve as a reference for other wind parks and tourist operators aiming to establish their own MU businesses.

Service and Scheduling: Further operational considerations include the educational content of the tour and visitor management. It is important to develop engaging, informative content for the participants to increase their understanding of renewable energy technologies as well as the contribution to the mitigation of climate change. Visitor management strategies should be implemented to prevent overcrowding, reduce the environmental impact and ensure a high-quality experience. In the Danish UNITED pilot, the tour-scheduling process has proven to be rather challenging as the weather conditions are not always stable and the location makes disruption through wind and waves more likely.[21] A high flexibility of the tour operators and guides is required.

Maintenance is crucial for the successful operation of guided tours to the wind turbines. Required maintenance related to this MU activity includes general maintenance for offshore wind facilities and boat operators. Additional maintenance might become relevant depending on the type of activities offered to the visitors. In case of activities that require the visitors to climb onto the platform, added infrastructure, such as the ladders attached to the boat or the turbine platform require regular maintenance to ensure the safety of the visitors. [22]

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[21] Lukic, I. et al. (2020). *Revision of the current environmental assessment and status of pilots – Deliverable 4.1.* UNITED project. https://www.h2020united.eu/images/PDF_Reports/D41_current_environmental_assessment_and_status_of_the_pilots_revised_dec2021_220207.pdf.

[22] Strothotte, E. et al. (2022). *Blueprint for the offshore site operation – Deliverable 7.2.* UNITED Project. https://www.h2020united.eu/publications.

Maintenance efforts at the Danish UNITED pilot

In terms of maintenance, a subcontractor handles turbine upkeep twice a year, while the electrical system undergoes inspection once annually and maintenance every other year. Routine daily maintenance falls under the administration's responsibility, covering tasks like checking ladders for damage caused by ice or vessel collisions, maintaining the moisture control system, repairing foundation rail cracks and tower-to-foundation joints, and inspecting rescue equipment and warning lights on turbines (Reimert et al. 2023). The boat operators are responsible for the maintenance of their boat and related infrastructure.

Recommendation:

1. To ensure the safety of tourists during wind farm tours, it is essential to develop comprehensive safety guidelines and protocols.

2. Regular maintenance checks on windmills should be conducted to guarantee their structural integrity remains intact.

3. Collaboration with local tourism authorities is crucial for promoting windmill tours and educating visitors about renewable energy.

4.3.7. Environmental impacts assessment

The UNITED project developed an evaluation framework that assesses the multi-use activity in relation to the single-use activity. To comprehend the environmental consequences of the primary activity, first the single-use scenario is evaluated in comparison to the baseline.

1) Single-use assessment

Evaluation frameworks for single-use OWF scenarios have been well established. Environmental Impact Assessments are legally mandated to safeguard the health of marine ecosystems within the designated area. Furthermore, these assessments may serve to identify any potential need for compensation in recognition of environmental impacts.[23]

In the UNITED assessment framework, the impact risk (IR), calculated by multiplying the effect potential by the exposure, indicates the damage that the activity is expected to cause.

1. OWF: Offshore wind farms have been identified as having the highest Impact Risk score on the environment compared to other assessed marine activities. This high IR is particularly evident in their effects on marine mammals, birds, fish, and cephalopods. Birds are most impacted during the operational phase, facing risks such as death or injury from rotor collisions and barriers to species movement. During construction, the noise from pile driving particularly affects mammals and fish. Additionally, electromagnetic changes from OWFs have been recognized as a significant impact on fish and cephalopods, including sharks and rays.

Despite these impacts, OWFs also contribute positively to marine habitats by adding hard substrate habitats, which shows a negative IR score in the UNITED assessment. Furthermore, the high IR score can partially be traced back to the size of OWFs, especially in comparison to the other activities assessed in the UNITED assessment framework.[24]

2. Tourism: A single use assessment for tourism in the Danish pilot was not conducted, as the limited additional pressure on the environment was not seen as significant in comparison to the already existing heavy pressure through boat traffic in the busy area.

[23] Rozemeijer, M.J.C. et al. (2022). *Application of assessment framework within pilots – Deliverable 4.3.* UNITED project. https://www.h2020united.eu/publications.

[24] Ibid.

Funded by the European Union (H2020 Grant Agreement no 862915). Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union. Neither the European Union nor the granting authority can be held responsible for them

Table 14 Selected impact chains (activity-pressure-ecosystem a component linkages) as focus for the next phase and as a suggestion for monitoring and research[25]

Activity	Phase	Pressure	Ecosystem Component
Wind	Installation	Impulsive noise	Mammals
		Disturbance of species	Birds
		Impulsive noise	Fish
	Operation	Death or injury by collision	Birds
		Barrier to species move-ment	Birds
		Electromagnetic changes	Fish & Cephalopods

[25] Ibid.

2) MU assessment

Table 15 Possible negative and positive environmental impacts from this MU combination[26]

Positive Impacts	Negative Impacts
CO2 Reduction: Due to tourism activities OWE can gain greater acceptance among the public, making it possible to develop more OWF and generate more renewable energy.	**Pollution from Boat Traffic:** Higher boat traffic levels may result in increased CO2 emissions and spillage from transportation vehicles, OW maintenance equipment, lubricants, paint, and other chemicals.
Awareness and Education: Tourism can serve as a platform for educating the public about the importance of renewable energy and ocean conservation, fostering a sense of environmental stewardship.	**Additional Litter:** Tourists might contribute to plastic pollution or eutrophication by disposing of trash overboard.
Easing pressure on touristic hotspots: Through the MU activity, the tourism sector is being diversified which strengthens the local economy and reduce overcrowding.	**Introduction of New Habitats:** The introduction of new habitats may inadvertently support the proliferation of invasive species.
Increased Surveillance of the Marine Environment: Joint use of human resources could improve e.g. surveillance and data collection and dissemination of information as part of a tour.	**Increased Bacteria Levels in Water:** The higher tourist population may contribute to elevated bacteria levels due to increased excreta.

4.3.8. Social impacts and ensuring acceptance

To assess the socio-economic impacts of the different pilots, the UNITED project developed an audit guide that can help MU operators assess the social impact of their MU project, which can be found in D8.4 and comprises of questions such as whether the expected social benefits were met, if local communities are empowered and whether relevant stakeholders are properly integrated in the process.[27]

Combining offshore wind farms with tourism, presents a variety of social benefits that can transform initial scepticism into widespread community support and economic opportunity.

Social Benefits of Offshore Wind Farm-Tourism Multi-Use (OWF-Tourism MU):

1. Mitigation of Conflicts: By integrating tourism with OWFs, potential conflicts can be mitigated as tourism operators can capitalize on the presence of the wind farms. This coexistence can lead to a harmonious balance between energy production and recreational activities, ensuring that both sectors thrive without impeding each other.
2. Enhanced Social Acceptance: MU initiatives can significantly contribute to the social acceptance of OWFs by countering the NIMBY phenomenon. Informative tours and educational programs about OWFs can

[26] Lukic, I. et al. (2020). *Revision of the current environmental assessment and status of pilots – Deliverable 4.1.* UNITED project. https://www.h2020united.eu/images/PDF_Reports/D41_current_environmental_assessment_and_status_of_the_pilots_revised_dec2021_220207.pdf.

[27] Van Gerven, A. et al. (2023b). *UNITED auditing procedures and TRL assessment manual – Deliverable 8.4.* UNITED project. https://www.h2020united.eu/publications.

enlighten local communities and tourists about the environmental benefits, thereby changing perceptions and reducing opposition.[28]

3. Economic Incentives for Tourism Operators: The presence of OWFs can provide financial benefits to tour operators by expanding their offerings to include wind farm visits. This can attract a niche market of eco-conscious tourists interested in sustainable practices and renewable energy.
4. Job Creation: The combination of OWFs and tourism can create additional employment opportunities within the local economy, from tour guides specializing in OWFs over maintenance and service roles to other tourist-related services such as gastronomy that cater to increased tourist activity.
5. Infrastructure Development: The demand for access to OWFs for tourism purposes can lead to improved local infrastructure. This includes better transport links to the shoreline and enhanced facilities for visitors, which can benefit both tourists and the local population.
6. Tourism Attraction: Studies suggest that OWFs may act as a new point of interest, potentially increasing tourism in the area. The infrastructure around OWFs, designed for both functional and touristic use, can become an educational and experiential attraction.
7. Community Integration: Opportunities for local involvement in OWF projects, such as cooperative ownership models (see 4.3.9) or including the local population in the project's planning process, can foster a sense of community investment in local energy production, leading to economic benefits and enhanced local support for renewable energy initiatives.
8. **Financial support and compensation:** In addition to the boost to the local economy that this MU combination can enable, wind farm operators can set up funds to improve local tourism and infrastructure and compensate for any income loss that might be caused by the construction of the wind farm.

Local Tourism Development Fund and the Gwynt y Mor Wind Farm

Operators of the GYM Offshore Wind Farm, located off the coast of North Wales, set up a fund aiming to reach £19 million, allocated to the coastal communities of Conwy, Denbighshire and Flintshire. Additionally, a one off tourism fund of £690,000 was established that enabled the further development of the coastal tourism sector.

Social acceptance of the Danish UNITED pilot and Layout Design Process of the Midelgrunden Windfarm

In Denmark, the Middelgrunden OWF has even transcended its role as an energy source, becoming a prominent regional landmark and being recognized as the second most significant landmark in the Copenhagen area. [1]

“Having a wind farm as a major city landmark sends visitors an important message: it’s our choice to decide how to produce energy, and ocean multi-use can be a viable option” (UNITED website).

The presentation of the Middelgrunden windfarm plans to the public in June 1998, initially sparked a big wave protest over the project and the design. However, incorporating feedback from the local community transformed opposition into collaboration, leading to the curve shaped design that the windfarm has today, following the outline of Copenhagen. [1]

The Middelgrunden OWF, furthermore, serves as an example of how social acceptance can be cultivated through inclusive ownership models, engendering community pride and making wind energy projects not just a source of sustainable energy but also a symbol of local identity and environmental stewardship. [1]

[28] Van Gerven, A. et al. (2023a). *Environmental impact assessment models for the commercial rollout of Multi-Use Platforms – Deliverable 4.5*. UNITED project. https://www.h2020united.eu/publications.

How can the acceptance of an MU project be assessed?

One way to better understand the visitor's opinion on this type of MU combination is to ask the visitors to fill out a survey and rate the experience upon their return to shore.

Example of the satisfaction survey executed in Danish UNITED Pilot

The survey utilised during the Middlegrunden wind farm visit is presented below. These questions were employed to gather feedback and gain insights into visitors' opinions on the tour.

1. How did you hear about the boat tour to the wind farm?
2. What is your role in relation to this tour?
3. On a scale of 1-10, how satisfied were you with the overall booking procedure? (1 being extremely frustrated and 10 being extremely satisfied)
4. On a scale of 1-10, how satisfied were you with the overall tour experience? (1 being extremely frustrated and 10 being extremely satisfied)
5. Were the tour guides knowledgeable and informative?
6. Was the duration of the tour appropriate?
7. Did you receive appropriate and relevant information before and during the tour?
8. Were there any specific highlights of the tour that you particularly enjoyed? (Please select all that apply)
9. Were there any areas of the tour that you feel could be improved upon?
10. Would you recommend this tour to others?

In general, visitors expressed a high level of satisfaction with the services provided, as evidenced by an impressive average satisfaction score of 9.7 when rating their overall experience. While generally positive, some participants did offer valuable feedback, suggesting that they would welcome additional background information and improvements

4.3.9. Commercialisation

Business structures, scaling up and financial benefit

To be economically viable, commercialisation is an important aspect of MU combinations in general. Interestingly, for wind turbine operators, the direct financial gains from this MU are often limited. Instead, its appeal lies in **non-financial benefits, such as fostering acceptance of offshore wind construction** in the area and improving the sentiment towards offshore wind in general. Boat operators engaged in this MU, on the other hand, typically seek profits, although their investments are generally modest, as they already possess the necessary boats for other purposes. To incentivise tour operators to offer tours to the wind turbines, the MU combination could be **integrated into local and national tourism strategies.**

Cooperative ownership can be a practical business structure for this type of MU, involving the local community from the outset. This not only enhances acceptance of OWFs in the region but also streamlines the organization of tourist activities within the OWF, with owning companies taking the lead in coordinating tours. The close ties local companies have with the region facilitate the recruitment of boat operators, training guides, and conducting effective marketing efforts.

Cooperative Ownership and Commercialisation of the Danish UNITED Pilot

The Danish Middelgrunden windfarm project, comprising 20 turbines with 2 MW capacity each, exemplifies the potential of fostering local community support. The wind farm's ownership structure, with 10 turbines held by "Københavns Energi" (now HOFOR utility) and the remaining 10 by the "Middelgrundens Vindmøllelaug" (Middelgrunden Cooperative), consisting of 8,000 private owners, showcases a unique collaborative effort. Cooperative ownership of the Middelgrunden wind farm enables earlier and more effective involvement of local communities in decision-making. This approach ensures that the design of the offshore wind farm, associated tourism and recreational activities, and profits from the project remain local. This MU activity itself primarily serves as a promotional tool for offshore wind energy, with no profit-seeking motive. However, it can be observed that the interest by visitors, locals and industry to take a tour to the Middelgrunden windfarm has grown in the recent years, leading to 90 tours being carried out in 2023. Scaling up has therefore happened gradually, in line with an increasing demand in the tours. To meet this growing demand, two additional guides

Table 16 Number of trips, guests, and income of the UNITED Danish pilot

Business	2017	2018	2019	2020	2021	2022	2023
Trips	31	35	48	4	13	75	90
Guests	676	930	1117	130	246	1687	1912
1.000EUR	38.9	44.3	55.6	4.4	19.5	102.1	136.1

Marketing

The following marketing strategies are recommended when aiming to scale up this MU combination:

- **Creative marketing strategies to attract visitors:** Creative marketing strategies such as placing QR codes at important landmarks from which one can see the windfarm, could be employed.
- **Involvement of the boat operators:** The tour operators could include the wind farm tours in their regular tour offers and display them on their website.

Virtual tours as innovative marketing in the Danish UNITED Pilot

The Danish pilot has mainly increased in popularity through the UNITED marketing campaign. Visitors were satisfied with the experience and have turned into ambassadors of the tours, returning years later with their own group. Furthermore, advertising through magazines and home pages of UNITED or the boat operators played an important role in reaching possible interested parties. A virtual tour was created, and QR codes, which lead to the virtual tour, are currently in the process of being placed at sustainability hubs and high-rise landmark buildings around Copenhagen from which the wind farm can be seen. The video shares the journey from the harbour to the wind turbine's nacelle, highlighting various elements encountered during the tour, such as the foundation, tower, electrical cables, and generator. This innovative idea, on the one hand, provides a marketing strategy to reach possible future tour participants and, on the other hand, delivers educational value for individuals who may not have the opportunity or inclination to participate in the boat tour or climbing experience.

Financial risk

In the commercialisation of the multi-use combination of tourism and offshore wind, a strategic financial measure to ensure long-term sustainability is the **incorporation of a sinking fund into the business model.** This sinking fund serves as a dedicated financial reserve, systematically set aside to secure ample funds for critical activities such as site renewal and decommissioning.[29]

4.3.10. Decommissioning

Decommissioning of this MU combination is strongly connected to the decommissioning of the wind farm, which occurs after approximately 20-25 years depending on national regulations and their lifespan. As tourist activities such as visiting and climbing the turbines require the existence of the turbines, they cannot continue after decommissioning. However, some activities only interact with the foundation of the wind turbine, such as diving activities

[29] Barlow, J. et al. (2022). *Case specific report on risk management aspects within the confines of legal and insurance aspects – Deliverable 6.3.* UNITED project. https://www.h2020united.eu/publications.

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or offshore-restaurants and could support a **repurposing of the turbine foundation** after they go out of operation. This could even lead to cost saving for the OWF operators as they might be able to leave i.e. the platforms of the turbines in the sea.

Repowering, as an alternative to traditional decommissioning, offers the prospect of extending the operational life of these projects while improving energy efficiency. By upgrading to more modern wind technology, repowering not only ensures a consistent energy source but can also lead to a revaluation of tourism integration, potentially affecting the visitor experience. While there may be temporary interruptions in tourism activities during repowering efforts, the economic benefits, reduced environmental impact, and the promise of a sustainable future make it an attractive choice for offshore projects.[30]

Repowering of the Middelgrunden Wind Farm

The Middelgrunden Offshore Wind Farm is approaching the end of its operational lifespan. In response to this, the cooperative managing the OWF is actively pursuing repowering rights, seeking to refurbish the aging turbines, retaining the existing infrastructure and spatial layout. If repowering rights, which are currently under review, are granted, the wind turbines would be able to generate power for another 25 years. This initiative demonstrates how repowering can be a strategic approach to renovate offshore wind farms, ensuring continued energy production while optimising the utilization of offshore space and resources (Declercq et al. 2023)

[30] Declercq, A. et al. (2023). *Development and implementation of a decommissioning procedure – Deliverable 7.6.* UNITED project. https://www.h2020united.eu/publications.

4.4. Aquaculture and tourism

4.4.1. Scenario

This multi-use activity includes the integration of **aquaculture and tourism**, expanding the scope of tourism offerings to incorporate aquaculture-related experiences. Activities can range from guided tours to aquaculture facilities, underwater diving and snorkelling adventures in close proximity to or within the aquaculture installations, to sport fishing and angling opportunities.

The MU combination of aquaculture and tourism can be divided into three different categories:

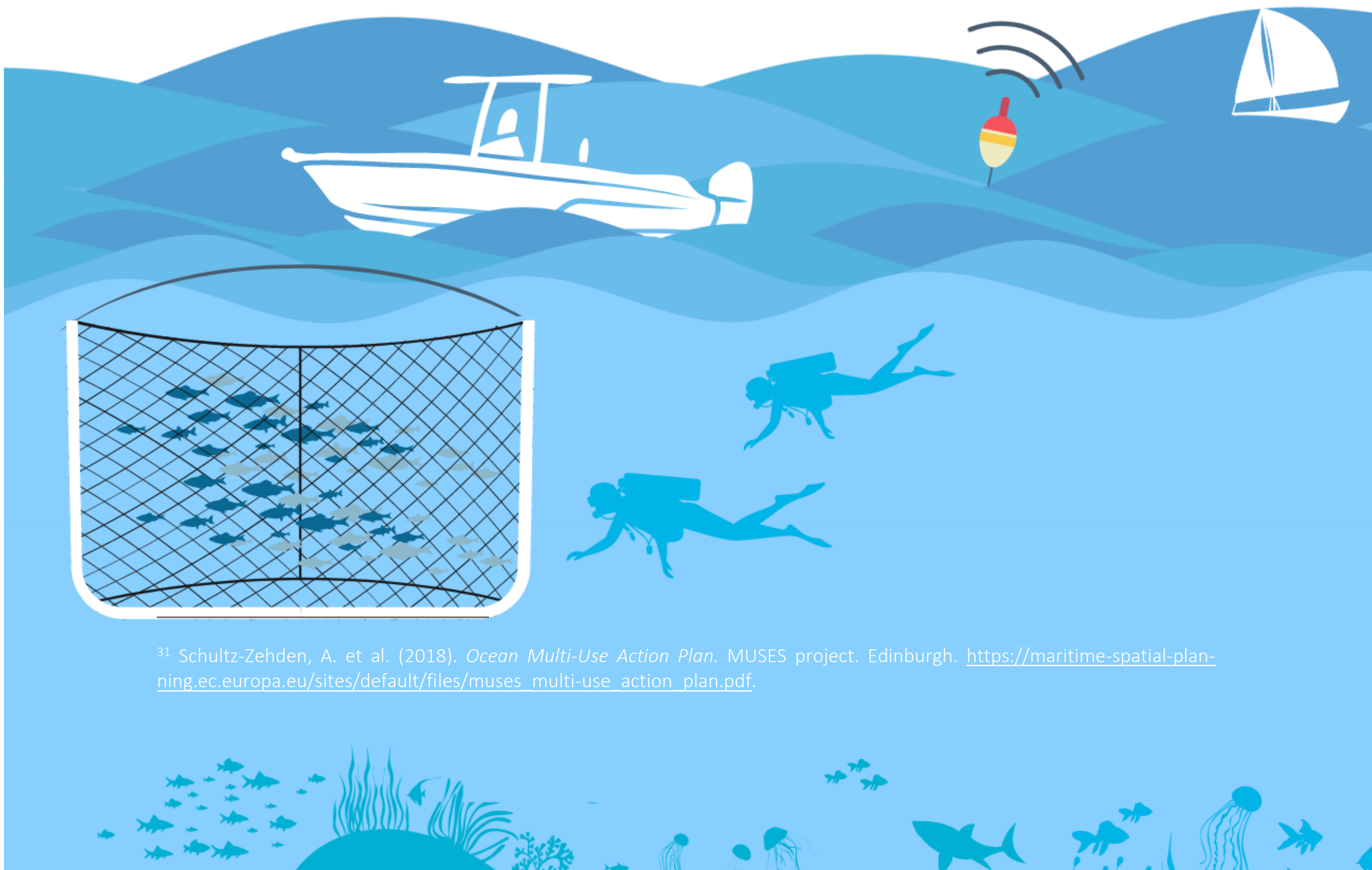
1. First form: This type shares similarities with pescatourism but distinguishes itself through its approach, as it entails **hosting customers on vessels for visits to aquaculture sites to educate them about aquaculture techniques and traditions**.

2. Second form: This type encompasses **diving, snorkelling, and other active recreational activities conducted near or within aquaculture installations,** allowing participants to observe the local marine life.

3. Third form: This type involves **sport fishing tourism**, primarily angling, conducted in the vicinity of aquaculture installations located in marine areas that are typically attractive to a variety of fish species.

Under the MUSES project, the most important **drivers** for this specific multi-use combination were identified to be the opportunity to resolve conflicts for space, provide an alternative income source for aquaculture operators, and increase the local community's acceptance of aquaculture. **Challenges** that currently hinder the expansion of this MU are considered the underdeveloped legislative and insurance frameworks, the absence of standards and guidelines and an insufficient skillset regarding service provision and entrepreneurship by the aquaculture operators.[31]

This MU can, at least on a small scale, already be found at multiple locations in the Mediterranean and Atlantic Seas, including in Greece, Spain and Malta.



[31] Schultz-Zehden, A. et al. (2018). *Ocean Multi-Use Action Plan.* MUSES project. Edinburgh. https://maritime-spatial-planning.ec.europa.eu/sites/default/files/muses_multi-use_action_plan.pdf.

Table 17 Evidence Base for the Blueprint

Country	Pilot Description	Project
Greece	Outside the privately owned and largely protected islet of Patroklos in the Saronic Gulf, the company Kastelorizo Aquaculture S.A. is operating an aquaculture business, farming sea bass and sea bream. In collaboration with Planet Blue, a local diving company, tours to the aquaculture farms in combination with educational talks are organised. Additionally, tourists can scuba dive in close proximity to the aquaculture site, where excess food from farm operations attracts a divers marine life. The Greek Pilot initiative aims to boost tourism while promoting acceptance of aquaculture. To enhance the efficiency for aquaculture and fish welfare management advanced technologies are utilised. By leveraging shared infrastructure and optimising activity scheduling, the initiative supports local businesses, high-quality food production, and job creation.[32]	UNITED
Spain	In the scenic Costa Daurada region of southern Catalonia an innovative ecotourism venture called the 'Tuna Diving Tour' was introduced, which offers participants the unique opportunity to engage in scuba diving amidst a group of 400 bluefin tuna.[33]	Commercial
Malta	In Malta, there is another variation of this multi-use concept that entails organised diving activities within open sea Bluefin tuna farming cages situated one mile offshore. [34]	Commercial
Italy	In Italy, the concept of multi-use was recognized in the Veneto and Emilia Romagna regions. Emilia Romagna's regional law (LR 22/2014) takes a step further by defining this multi-use as "acquiturismo," which combines aquaculture and tourism. An actual instance of this combination can be observed at the Cavallino-Jesolo mussel facility in the northern Veneto region, where recreational fishing and guided tours occur within the aquaculture site. [35]	Commercial
Portugal	In Portugal, at least two distinct manifestations of this MU combination have been put into practice: one aligns with the first form, involving tourists being guided to observe aquaculture activities, particularly mussel farming, onboard vessels, while the second form focuses on diving activities conducted in close proximity to offshore tuna farming installations.[36]	Commercial

4.4.2. Planning and Spatial Configuration

The partially corresponding spatial needs of offshore aquaculture and tourism can lead to conflicts: due to the visual impact of aquaculture sites, spatial restriction to recreational fishing and boating, decreased access to safe anchoring areas, accidental damage to boats and aquaculture installations, impact of aquaculture on water quality and

[32] Schultz-Zehden, A. et al. (2018). *Ocean Multi-Use Action Plan.* MUSES project. Edinburgh. https://maritime-spatial-planning.ec.europa.eu/sites/default/files/muses_multi-use_action_plan.pdf.

[33] Tuna Tour, L'Ametlla de Mar. https://tuna-tour.com/en/.

[34] Schultz-Zehden, A. et al. (2018). *Ocean Multi-Use Action Plan.* MUSES project. Edinburgh. https://maritime-spatial-planning.ec.europa.eu/sites/default/files/muses_multi-use_action_plan.pdf.

[35] Ibid.

[36] Ibid.

impact of waste on aquaculture. However, if the two competing activities are combined well, these conflicts can be mitigated and similarities in spatial requirements can even become an asset.[37]

Table 18 spatial considerations when combining offshore aquaculture and tourism

Spatial Consideration	Elaboration
Proximity to Shore	The site must be close enough to the shore to ensure accessibility for tourist activities. A location that is too distant may be financially unfeasible for tourist transport. Moreover, far offshore locations pose rising security risks, demanding additional training and potentially leading to extended rescue times, especially during emergencies, when fog or poor visibility can make rescue operations difficult. However, it's also important to position the site such that it doesn't compromise the natural beauty or integrity of the coastline. This balance is essential for maintaining the attractiveness of the site for both tourists and local communities.
Infrastructure Availability	The chosen site should be in an area where relevant infrastructure, either existing or feasible to develop, can support both aquaculture and tourism activities. This includes the availability of docks, piers, and other facilities that facilitate tourist access and engagement, as well as infrastructure necessary for sustainable aquaculture operations.
Safety and Water Quality	The location should be safe for tourist activities like swimming, diving, and boating. It is essential that the water quality is high enough to support both safe tourist recreation and the farming of fish for consumption. This requires careful assessment of oceanographic conditions and water quality parameters to ensure the health of both visitors and aquaculture products.
Economic Impact and Community Benefit	Ideally, the site should be located in a region where this multi-use approach can maximize economic benefits. Rural and coastal areas, often in need of economic diversification, can benefit significantly from this integration. Such locations could see an influx of tourists, creating new job opportunities and enhancing local economic growth. This approach can diversify the tourism sector and potentially increase the region’s appeal as a sustainable and innovative destination.

Recommendation for Operations and Maintenance:

1. Integrate Environmental and Spatial Analysis Tools Early in the Planning Process.
2. Prioritise Site Selection Based on Synergies with Local Communities and Infrastructure.
3. Optimise Location Selection for Aquaculture Based on Oceanographic Data, Depth and Seabed Data.

[37] MSP Platform (2021b). *Conflict fiche 6: Aquaculture and maritime tourism*. European MSP Platform. https://maritime-spatial-planning.ec.europa.eu/media/document/12452.

4.4.3. Permitting / Regulations

It is crucial to understand the regulatory framework in place before operating this multi-use combination. Even though regulations differ across countries, following levels of regulation might be relevant:

1. National regulations and permitting requirements in the tourism sector

In the context of diving tours, specific permits and licenses are often required. Diving operators typically need licenses for commercial diving, ensuring that they meet safety standards and are qualified to lead diving expeditions. When it comes to combining tourism and aquaculture, the legal landscape can become more complex. Operators might need to adhere to not only tourism regulations but also aquaculture permits and environmental conservation guidelines. Licensing requirements can vary depending on the type of aquaculture and the tourism activities involved. Furthermore, if the tourism activities take place within the aquaculture site, **permission from the site operators will be required.**

Permits required for tourism activity in the Greek pilot

In the Greek pilot program, where a diving tour operator provides diving tours near the aquaculture farm, only the standard licenses needed for conducting commercial diving experiences are necessary. However, additional permits are mandatory for diving excursions conducted near shipwrecks and within protected areas.

2. National regulations and permitting requirements in the aquaculture sector & food safety regulations

In the aquaculture sector, obtaining the necessary permits and adhering to national regulations is a complex process, often involving multiple agencies and strict requirements. Key processes to obtain permits include environmental impact assessments, which determine the suitability of the proposed location and its potential impact on the environment. Aquaculture site licenses generally need to be renewed every 3 to 10 years, depending on the national or regional regulations. Additionally, aquaculture establishments must be approved by sanitary authorities for animal health, and producers are required to conduct disease surveillance. Strict rules on food hygiene, animal health, and the use of veterinary medicines are enforced to ensure consumer safety. Compliance with these regulations and continuous environmental monitoring are essential for maintaining authorization. The complexity and fragmented nature of these processes underline the importance of coordinated and efficient planning, especially when integrating and additional marine activity, such as tourism.[38]

A potential question arises regarding the **impact of diving activities on the application of the regulations in place for commercial fish production**, i.e. regarding food safety. It is unclear whether diving activities may have implications for compliance with these regulatory frameworks. This highlights the need for a comprehensive understanding of how the coexistence of aquaculture and diving may intersect with existing regulations and guidelines, ensuring that both activities can be conducted safely and sustainably.

[38] Falconer, L. et al. (2023). Planning and licensing for marine aquaculture. *Reviews in Aquaculture,* 15(4), 1374–1404. https://doi.org/10.1111/raq.12783

Policy Framework in Greece

Greece has not yet adopted an MSP. Alongside the ongoing MSP process, MSP related issues are also addressed in “Special Frameworks for Spatial Planning” (terrestrial spatial plans - TS Plans) covering specific economic sectors. Sectoral plans have been elaborated so far for aquaculture and tourism which include spatial planning guidelines for the land-based, coastal and marine segments of each sector.

During the Summit organised by the International Union for Conservation of Nature held in Marseille on September 2021, entitled “Mediterranean: A Model Sea by 2030”, Greece’s Prime Minister announced that the MSP in Greece will be implemented under the National Recovery and Resilience Plan "Greece 2.0". To facilitate Greece in implementing the MSP Directive and also in the framework of the European Green Deal (EGD), emphasis should be given to the inclusion of Multi-use in the National Strategy for the marine space and as a principle of the draft MS Plan(s), which is also consistent with cooperative schemes financed by the Recovery and Resilience Plan “Greece 2.0”.

In Greece, aquaculture policy is overseen by the Ministry of Rural Development and Food. The country's administrative structure involves multiple levels of government, from the central government to municipalities. Establishing and operating a fish farm necessitates obtaining a lease for a specific marine site, a license for farm establishment and operation, and a water use permit. The application process, which includes an EIA, involves consultations with various agencies responsible for different aspects like environmental protection, health, antiquities, fisheries, tourism, and more, as well as local authorities.

Applications are submitted to the General Secretariat of the relevant region, with specific authorities handling applications in sensitive areas like NATURA 2000 sites or very sensitive areas where aquaculture is generally not permitted. Shellfish farming is restricted to designated "Shellfish Farming Zones." Additionally, the Veterinary and Public Health

Policy recommendations for setting up tourism-aquaculture multi-use (based on the Greek UNITED pilot):

Multi-Use integration into MSP: Integrate tourism multi-use considerations into the ongoing MSP efforts. Ensure that the development of tourism MU aligns with the broader spatial planning goals, taking into account ecological, economic, and social factors.

Collaboration and Consultation: Facilitate collaboration and consultation among relevant ministries and authorities, including the Ministry of Tourism, Ministry of Maritime Affairs and Insular Policy, Ministry of Environment and Energy, and others. Ensure a coordinated approach to address the complexities of tourism MU.

Stakeholder Engagement: Prioritise stakeholder engagement in the planning process. Involve local communities, tourism operators, aquaculture companies, environmental organisations, and other relevant stakeholders to gather insights, address concerns, and foster a sense of ownership in decision-making.

Cultural and Environmental Preservation: Develop policies that prioritise the preservation of underwater cultural heritage (UCH) and other environmental assets. Implement measures to protect sensitive areas and promote sustainable tourism practices that minimise impact on cultural and natural resources.

4.4.4. Risk assessment and insurance

Combining aquaculture and tourism introduces further risks, that might not emerge when the two activities appear as single use. As discussed in the first blueprint, SOMOS constitutes a useful tool to assess risks relevant for MU project. Based on information gathered from the Greek UNITED pilot, the following table illustrates associated risks and risk mitigation strategies for this MU.

Table 19 The highest risks for Aquaculture and Tourism based on UNITED analysis of the Greek pilot (Barlow et al. 2022)

Five highest risks based on impact and probability

SOMOS Risk Category	Risk Item	Description of Risk	Risk Mitigation
Other	Inadequate Insurance	Insurance complexities can lead to inadequate coverage. This increases the consequences a risk event has on the operator and can lead to an inability for the operators to recover from risk events.	Set up internal security protocols. Inform tourists of safety rules and have them sign responsibility forms. Collaborate with insurance companies to improve understanding and coverage. Establish separate insurances if comprehensive coverage is too costly.
Safety to man and equipment	Severe Weather	Storms and earthquakes can cause significant damage to aquaculture infrastructure which can have ecological and economic consequences. Weather conditions also influence the safety of tourists on board.	Develop extensive safety protocols for port, vessels, and aquaculture site. Design equipment to minimise hazards and detachment. Monitor weather forecasts and establish appropriate response protocols. Collaborate with insurance providers to cover weather-related damage. Develop disaster recovery plans.
Food and Feed / Environmental and Cumulative Impact	Site Water Quality	Poor water quality can harm fish health and product quality as well as diver's health and the ecosystem. Furthermore, there is a risk of water quality reduction due to the activities itself, such as increased nutrients and fish overmedication.	Conduct feasibility studies to choose a suitable farming area. Continuously analyze water and fish in the farm. Monitor water parameters and develop action plans to restore water quality. Comply with aquaculture regulations. Implement ecological practices and avoid harmful substances. Educate staff on environmental regulations.
Safety to man and equipment	Anchoring Boats near the Site	Improper boat anchoring can cause damage to vessels, infrastructure, the environment.	Establish robust anchoring procedures aligned with equipment used. Ensure staff is trained and qualified.

Safety to man and equipment	Camera and Sensors	Malfunctioning or poorly maintained cameras and sensors can lead to poor understanding of site conditions, injuries, and damage to assets and ecosystem.	Ensure proper installation and maintenance of cameras and sensors. Use high-quality equipment. Train staff on camera and sensor operation and maintenance.
Safety to man and equipment	Connectivity issues and power supply	Stable communication can be difficult to set up offshore but a lack thereof can lead to staff and tourists at risk as well an inadequate response to infrastructure issues, leading to more severe damage.	Research into new connectivity and data transmission alternatives such as LoRA, ZigBee, wifi to transmit data from site Ensure that the site power supply is adequate for the devices. Consider installing new sources of electricity (i.e. solar panels).

A comprehensive insurance coverage is essential for conducting this multi-use combination. As described in the risk assessment table, inadequate insurance coverage can lead to the operators in ability to recover from an accidents or damage to equipment, the site or its product. However, proper insurance coverage can be very costly and covering all risk aspects can be complicated. MU insurance premiums can be reduced if the involved parties (such as the scuba diving company) independently have established a safety track record and can show comprehensive safety and risk mitigation protocols.

4.4.5. Technology

Various technologies and their readiness for practical implementation should be considered when setting up a project combining aquaculture and tourism.

Table 20 Technology relevant for the MU of offshore aquaculture and tourism

Technology	Description	Shortcomings	Advantages
Scheduling Software	The scheduling system implemented allows planning multi-use activities between the aquaculture unit, touristic expeditions, and related activities.	Weather-dependent cancellations might affect scheduling.	Efficient coordination of aquaculture and tourism activities.
Monitoring Software	Real-time data management and decision support system monitors aquaculture production parameters (e.g., salinity, water quality) and co-location activities using algorithms for analysis and predictions.	Dependence on accurate sensor data.	Real-time monitoring enhances proactive decision-making. The Decision Support System generates early warnings, alerts, and recommendations for several critical aspects, including optimising feeding, planning optimal harvesting and seeding, disease prevention and control, as well as enhancing the coordination of combined activities.

Vessel	The right type of boat should be employed to transport tourists, facilitate diving activities and possibly conduct maintenance work. Important considerations when choosing a vessel are the size of tourist groups that need to be transported and the location of the aquaculture site.	Weather-dependent limitations.	Facilitates transportation, essential for tourism and aquaculture logistics.
Sensors	Various sensors (e.g., water quality, fish, meteorological) are employed to monitor parameters critical to aquaculture and tourism activities.	Dependency on sensor accuracy and reliability.	Real-time data collection for informed decision-making.
Cameras	Underwater cameras monitor fish behavior, performance, and diving activities.	Limited visibility in certain conditions.	Visual monitoring of fish and activities, aids in decision-making and can support in ensuring that the tourism activities do not negatively affect the fish.
ROVs	Remote Operating Vehicles (ROVs) are used for inspecting and maintaining aquaculture infrastructure, especially in great depths.	Dependence on accessibility and logistics for ROV deployment.	Allows inspection of deep-sea infrastructure, enhancing maintenance, monitor divers during their underwater maintenance work.
Wireless Power Supply (i.e. solar panels)	Power supply is essential for the functioning of cameras, sensors, and other equipment.	Vulnerability to power disruptions.	Continuous power ensures uninterrupted monitoring and data collection. The
Wireless Internet Supply (Wifi)	Internet supply is crucial for data transmission and real-time updates on the aquaculture platform.	Connectivity issues can disrupt data transmission.	Enables real-time data sharing and accessibility through the platform.

TRL assessment in the Greek UNITED Pilot

The Greek pilot project has significantly advanced, moving from its initial TRL of 5 to its current TRL of 7-8. At the outset (TRL 5), the project focused on developing an aquaculture unit using floating facilities near the Greek coast. To deepen the exploration of the underwater environment and aquaculture operations, scuba diving and boat tours were introduced, and professional divers were engaged to assist with various tasks, deploying ROVs for infrastructure maintenance. The project also invested in infrastructure improvements, including the establishment of internet connectivity and the utilization of renewable power through photovoltaic panels. A range of sensors was strategically deployed to monitor critical aquaculture parameters. This substantial progress has brought the pilot site much closer to a state of readiness for production, characterized by integrated systems and a comprehensive grasp of aquaculture practices. This positions the Greek pilot as a mature and promising solution within both the aquaculture and tourism industry.[1]

Table 21 TRL for aquaculture and tourism

Economic activity	Baseline TRL	Accomplished TRL
Aquaculture (finfish) and touristic scuba-diving activities (UNITED Greek pilot)	TRL 5	TRL 7-8

Technology in the Greek UNITED pilot

To facilitate multi-use activities at the Greek pilot site, a scheduling system has been introduced. This system is designed to coordinate activities between the aquaculture unit and tourist expeditions, along with all associated scenarios. All entities involved have access to this calendar, allowing them to check the availability of the aquaculture site and make reservations for co-use activities. This scheduling tool is a product of WINGS and is integrated into the software platform connected to sensors and cameras at the aquaculture site. Additionally, to enhance communication and coordination among various stakeholders, telephone calls are being employed as part of the scheduling process. For instance, the diving center arranges tourist diving expeditions by scheduling appointments with customers, either through social media or direct phone calls.

The Greek pilot aquaculture project employs continuous real-time monitoring of a wide range of production parameters, encompassing salinity, water quality, temperature, Dissolved Oxygen (DO), pH, electrical conductivity, total dissolved solids (TDS), turbidity, Chlorophyll-a, Nitrates (NO3), and ammonium (NH4). This monitoring extends to co-located activities, including connectivity, aquaculture infrastructure, and sea transportation infrastructure. It utilises underwater sensors, fish sensors, water quality sensors, meteorological sensors, and underwater cameras to observe fish behavior and performance. Diving activities are closely supervised through individual diver position sensors to ensure safety in unforeseen circumstances. For deep-sea aquaculture infrastructure inspections, Remote Operated Vehicles (ROVs) are deployed. Real-time data management and a decision support system are integrated, with water quality data consistently uploaded to the AQUAWINGS platform for user accessibility.[1]

Recommendation for Operations and Maintenance:

1. Install wireless infrastructure to provide internet and power, as wires can accidentally be cut by maintenance vessels, leading to a power or internet outage.

2. Enhance Weather Monitoring: Implement advanced weather monitoring systems to improve the accuracy and timeliness of forecasts. Access real-time weather data to enable better planning and reduce the number of cancelled dives.

4.4.6. Operations and maintenance

Vessel operation: Shared Vessels and combining activities can be helpful in reducing the cost of transport. However, problems arise due to the different times needed for each activity. Furthermore, extra permits might be necessary for commercial visitor transport and diving activities.

Cooperation on vessel deployment in the Greek UNITED pilot

The crew vessels at the aquaculture farm transport the farm's staff once daily to facilitate the feeding of the aquaculture stock. Additionally, 2 to 3 times weekly, these vessels are utilised by the farm's divers for monitoring activities. During peak tourist periods, the farm's vessels serve to transfer divers, ensuring a smooth and well-coordinated tourist experience.

Monitoring: If the pilot is well equipped with monitoring technologies, monitoring can mainly be done remotely through advanced technology, such as sensors and cameras. More information on the monitoring technology can be found under 4.4.5. Synergies between tourism and aquaculture operations should be explored. In the Greek pilot, for example, the diving company employs ROVs to conduct regular surveillance of the vicinity surrounding the aquaculture farm.

Health and safety: To mitigate the chance of any accident occurring during the operation of this MU combination, staff and visitors should be aware of the possible risks. Injuries can be avoided through obligatory safety procedures and well-trained personnel.

Health and Safety Standards of the Greek UNITED Pilot

In the Greek pilot safety is ensured through a strict safety protocol. Operation of the project follows following ISO standards:

1. Guidelines for personal protective equipment in the aquaculture farm (e.g helmet, gloves)
2. ISO 9001:2015 Management System (Scuba training, recreational diving, scuba gear rental, filling of tanks)
3. ISO 14001:2015 Environmental Management
4. ISO 45001:2018 Occupational Health and Safety Management (Scuba diving)

Regulations for scuba diving are being set by the various accredited International Organizations such as SSI, PADI, or NAUI. These should be strictly followed by the guide masters, dive guides and visitors.

Scheduling and support systems: Cooperation between the tourism operators and the aquaculture operators is essential to ensure that the tourist activities to not interfere with the aquaculture operations and to prevent overcrowding. Scheduling can be done through a shared software platform and decision support systems can assist in well-informed decision-making (see 4.4.5).

In terms of maintenance, routine checks of the technological equipment should be conducted to address any alerts or malfunctions quickly. Hereby, collaboration between tourism and aquaculture staff ensures the safe and efficient functioning of the multi-use site. Notably multi-use between diving activities and aquaculture staff have proven to provide attractive synergy opportunities regarding maintenance as underwater maintenance of the aquaculture infrastructure can be conducted by the diving operators. **Seasonality** also plays and important role in the maintenance of the MU combination. Especially during the summer months underwater monitoring technology needs to be kept clean as it will otherwise be affected by fouling which will negatively impact the data collection as well as the longevity of the gear.

Maintenance Procedures in the Greek UNITED pilot

Maintenance of the various systems involves the following procedures:

Diving expeditions are conducted to clean the aquaculture area and remove waste.

Aquaculture infrastructure is inspected with the assistance of Remote Operating Vehicles (ROVs) while necessary repairs are carried out.

ROVs are used to inspect the aquaculture infrastructure positioned at significant depths, such as anchors.

Through underwater inspections and photographic documentation of the anchoring system, it has been established that all the targets are in excellent condition. This demonstrates the safety and reliability of the expeditions for the divers.

Daily monitoring routine includes real-time checks of parameters through the online platform to ensure system integrity. Routine checks of the technological equipment are conducted to address any alerts or malfunctions quickly.

Recommendation for Operations and Maintenance:

1. The aquaculture dive site is not similar to regular dives. In order to provide an initial understanding, it is advisable to offer divers a detailed briefing that will include videos, photos clear guidelines in order to enrich their knowledge, enhance their attention and minimise the environmental impact on the marine ecosystem.

2. Establish clear guidelines for divers to minimise the environmental impact on the marine ecosystem and how to better use a monitoring system and interpretation of the results.

3. Collaborate with local diving tourism operators to promote the integration of fish aquaculture and diving tourism.

4.4.7. Environmental impacts assessment

Offshore aquaculture operations must carefully manage environmental impacts, including the risk of eutrophication resulting from fish feed. Eutrophication occurs when excess nutrients from uneaten feed and fish waste enter the marine ecosystem, leading to algal blooms, oxygen depletion, and potentially harmful changes in water quality. To mitigate this concern, sustainable feed sourcing, efficient feeding practices, and advanced waste management systems are critical. These efforts help minimise nutrient runoff and maintain water quality, ensuring that offshore aquaculture remains an environmentally responsible approach to seafood production while safeguarding the health of the surrounding marine ecosystem. Furthermore, monitoring environmental factors can help adjust or suspend aquaculture operations if a reduction of water quality in the region is detected. Additional pollution can occur through increased boat traffic from tourist activities, discharge from tourist boats, and needs to be carefully monitored.

1) Single use assessment

Aquaculture: The environmental impact of fish aquaculture is multifaceted, with significant implications for ecosystem components during both the construction and operational phases. The main environmental pressures identified in the UNITED project include **ghost nets and other litter,** which can cause entanglement of marine life, and the **introduction of synthetic and anti-parasitic compounds,** which can be toxic and affect both pelagic and benthic habitats. Furthermore, in the TROPOS project, issues such as smothering, the alteration of organic matter input, and nitrogen and phosphorus (N&P) enrichment have been identified, with the latter two rated as very high in impact.[39]

In terms of **mitigating these impacts,** several strategies have been proposed and evaluated. The MERMAID project, for instance, emphasizes the importance of site selection for fish farms. Locating fish farms in areas with strong currents can help disperse nutrients and prevent eutrophication. The use of medicine, pesticides, and biocides in fish farming should be carefully controlled, especially in protected areas and where dilution is limited. Technology and planning play crucial roles in preventing escapes of cultured fish, which can impact genetic variability in native stocks. Disease management procedures are critical to prevent pest transmission to wild stocks and between farms. Fish farms can also attract wild fish populations, which may help limit the concentration of nutrients and organic matter in surrounding waters. [40]

Some fish culturing sites, like the Greek pilot, are seen as potential areas of nature restoration with high biodiversity. Structures used in finfish culturing can become overgrown with marine life, attracting pelagic lifeforms and potentially enhancing local biodiversity. However, the frequent cleaning, replacement, or removal of these structures in aquaculture contrasts with the largely untouched structures used in other marine applications, like offshore wind farms, which can have different implications for biodiversity. It is important to note that not all hard substrates have the same environmental impact, and this distinction is crucial for future evaluations of their role in nature restoration.

[39] Rozemeijer, M.J.C. et al. (2022). *Application of assessment framework within pilots – Deliverable 4.3.* UNITED project. https://www.h2020united.eu/publications.

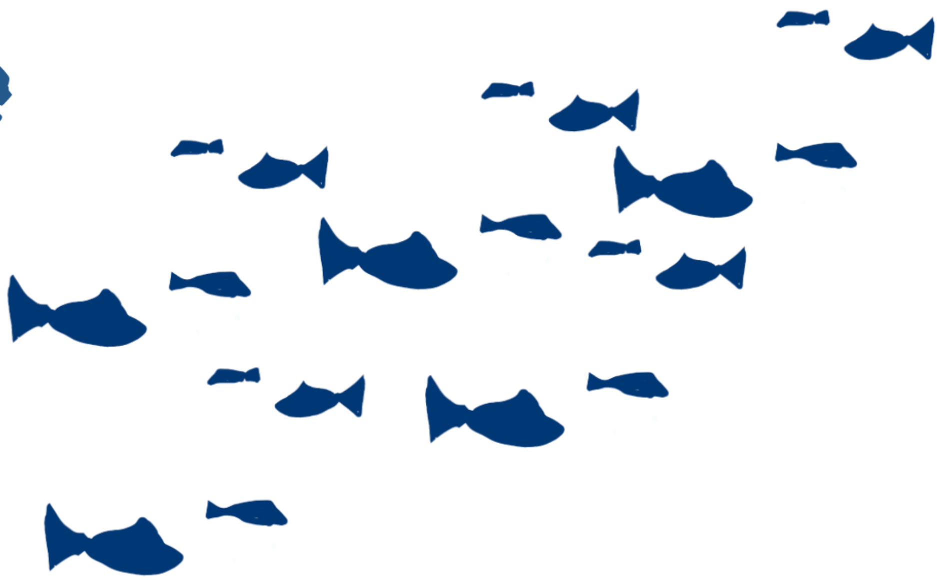
[40] Ibid.

Funded by the European Union (H2020 Grant Agreement no 862915). Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union. Neither the European Union nor the granting authority can be held responsible for them

Diving: As diving has no installation phase, the only impact happens during the operation. The overall impact is categorised to be quite low. In the Greek pilot, diving seems to have the biggest impact on mammals as well as reptiles due to the possibility of death or injury of the organisms by collision and the introduction of synthetic compounds. [41]

Table 22 Selected impact chains (activity-pressure-ecosystem component linkages) as a focus for the next phase and as a suggestion for monitoring and research[42] (UNITED Deliverable D4.3)

Activity	Phase	Pressure	Ecosystem Component
Finfish	Installation	Ghost nets and other litter causing entanglement	Benthic Habitat (soft and hard)
	Operation	Introduction of synthetic compounds	Soft Benthic Habitat, Fish & Cephalopods, Mammals, Reptiles
		Introduction of Microbial Pathogens	Birds, Fish & Cephalopods, Mammals, Reptiles
Diving	Operation	Death or injury by collision	Mammals, Reptiles
		Introduction of synthetic compounds	Soft Benthic Habitat, Fish & Cephalopods, Mammals, Reptiles



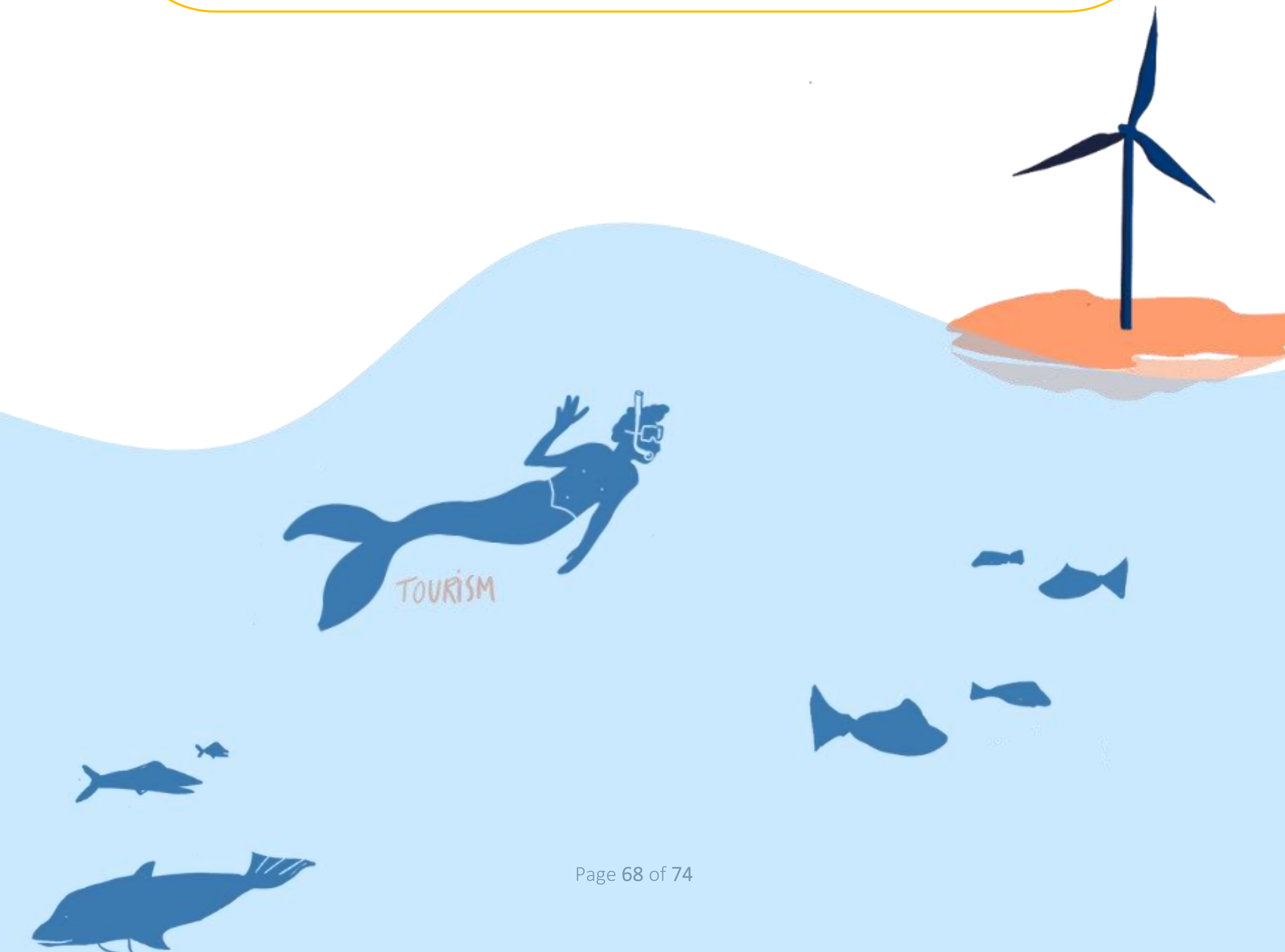
[41] Ibid.

[42] Ibid.

2) Multi-Use assessment

Table 23 Impacts of Aquaculture and Tourism MU on the environment

Positive Impacts	Negative Impacts
Sustainable food production: Coastal fish aquaculture, which supports local consumption, is likely to have a lower environmental impact compared to importing farmed fish.	**Increase of ocean plastic:** Extensive plastic use in materials like fish cages, buoys, ropes, PVC pipes, and shellfish farming bags has a polluting effect on the environment. The major contributors to plastic entering marine ecosystems from aquaculture include extreme weather events, inadequate waste management, the absence of harbor collection facilities, and, notably, deliberate discards.
Sustainable Livelihoods: These multi-use areas can provide sustainable economic opportunities for local communities, reducing the pressure on overfishing.	**Disturbance to Marine Life:** Human interaction and increased boat traffic from tourism can disturb marine wildlife, affecting their breeding and feeding patterns.
Conservation Awareness: Tourism provides an opportunity to educate visitors about marine conservation and the importance of sustainable aquaculture practices.	**Carbon Footprint:** Transportation to and from these sites, particularly if reliant on fossil fuels, can contribute to greenhouse gas emissions.



4.4.8. Social impacts and ensuring acceptance

Table 24 Potential social benefits from Tourism and Aquaculture Multi-Use

Social Benefits	Description
Acceptance of off-shore Aquaculture	Educational initiatives and first-hand experiences with aquaculture can shift perceptions, leading to increased acceptance of offshore-farmed seafood as a healthy, sustainable food source. This acceptance can drive demand and support for local aquaculture.
Community Engagement and Employment	Multi-use of oceans facilitates job creation in both sectors, leading to increased employment opportunities for locals. Engaging community members in tourism and aquaculture activities can foster a sense of ownership and pride in local development.
Educational Opportunities	Organised tours and activities provide educational experiences for both locals and tourists, increasing awareness and knowledge about marine ecosystems and sustainable practices.
Cultural Exchange and Preservation	Tourism linked with aquaculture offers a platform for cultural exchange, where tourists learn about local maritime traditions and customs, contributing to their preservation and appreciation.
Economic Diversification	The combination of tourism and aquaculture introduces new economic activities, reducing reliance on a single industry and thus enhancing economic stability for coastal communities.
Environmental Stewardship	Education on sustainable aquaculture promotes environmental stewardship among locals and visitors, leading to more sustainable behaviours and conservation efforts.
Improved Local Infrastructure	The development of aquaculture and tourism can lead to improved infrastructure and services, such as better transportation and recreational facilities.
Social Cohesion and Collaboration	Collaborative efforts in managing and benefiting from ocean resources strengthen social bonds and foster a collaborative spirit within the community.
Access to Fresh Seafood	The proximity of aquaculture farms can provide locals and tourists with access to fresh, sustainably farmed seafood, contributing to better nutrition and culinary experiences.
Empowerment of Local Businesses	By integrating tourism with aquaculture, local businesses such as dive shops, restaurants, and hotels can benefit from the increased visitor flow, leading to economic empowerment and growth.
Innovation and Knowledge Transfer	The interaction between the aquaculture and tourism industries can lead to innovation and the transfer of knowledge, enhancing practices in both sectors.

Danish Blue Community Gardens

In Denmark, local initiatives are creating blue community gardens along the Danish coast. Similar to terrestrial allotment gardens, the local population can get engaged and cultivate in a specifically allocated area. This hands-on involvement not only educates the community about sustainable aquaculture practices but also fosters a sense of ownership and connection to the coastal environment. By directly participating, locals gain a deeper understanding and appreciation of aquaculture, which can lead to increased acceptance and support for larger commercial aquaculture projects.

Fostering Social Acceptance Through a QR Code Hunt in the Greek UNITED pilot

The Greek MU pilot effectively increased the acceptance of farmed fish through an innovative outreach campaign. By involving the public and tourists in diving tours, alongside engaging activities like a "QR code underwater hunt," the project provided participants with a direct experience of the aquaculture site. The campaign successfully attracted 104 divers, many of whom had never before visited a fish farm.

Crucially, the divers were educated on the realities of aquaculture and its sustainability compared to unregulated fishing. Before and after the tours, their opinions were collected, revealing initial scepticism about farmed fish's health, stemming from preferences for wild fish and concerns over the use of antibiotics and unhealthy farming methods. However, following the educational component of the tours, which included viewing videos about multi-use aquaculture and discussions on the negative impacts of unregulated fishing, there was a noted improvement in perceptions. The hands-on experience, coupled with the educational efforts, lifted myths and demonstrated the benefits and healthiness of farmed fish, leading to a reported shift in divers' opinions.

4.4.9. Commercialisation

Combining aquaculture and tourism **offers economic potential**. This MU activity aligns with the growing interest in sustainable, locally based tourism. It not only promotes economic growth but also creates new jobs for trained offshore staff. It is, however, important to **keep the seasonal aspect of this combination during the operational phase in mind**. During the summer months, scuba diving tours are at their peak, creating a seasonally driven pattern for the multi-use activities.

Marketing

Targeted marketing efforts are crucial to ensure the success of this MU combination. Several strategies have proven to be effective in the Greek UNITED pilot and could be further explored.

- **Word of Mouth Marketing:** Word of mouth has proven to be a successful marketing component for the Greek UNITED pilot. This method relies on ensuring that tourists have an unforgettable and positive experience when they visit the aquaculture farm and participate in associated activities, such as diving. A satisfied tourist is more likely to share their experiences with friends and family, creating a ripple effect that can attract new visitors. Therefore, it is crucial to facilitate such memorable experiences through well-organised tours, informative guides, and engaging activities that leave a lasting impression.
- **Creative Engagement Activities:** Innovative engagement activities can engage different types of tourists and lead to further reach. For instance, incorporating a quiz or an underwater QR code hunt (like in the UNITED pilot) can significantly enhance the visitor experience. These activities are not only fun but also educational, leading to a deeper understanding and appreciation of the aquaculture process. By turning the visit into an interactive adventure, more tourists are likely to be attracted by the activity.
- **Building a strong online presence:** Social media platforms like Instagram, Facebook, and Twitter are indispensable tools for supporting word-of-mouth advertising. By encouraging tourists to post photos, videos, and reviews online, the marketing reach increases significantly. Creating shareable content tailored to these platforms can boost online presence and engagement. To facilitate this, the provision of visually

appealing spots for photos, hashtags related to the experience, and even Wi-Fi access at the site can encourage instant sharing. This strategy also capitalizes on the authenticity of user-generated content, which is highly valued. Engaging with followers, responding to queries, and regularly updating content with fresh experiences from the MU activities can keep the audience engaged and invested.

- **Collaboration with Local Businesses:** Partnerships with local businesses, particularly restaurants, can enrich the marketing campaign. For example, integrating an underwater QR code hunt that leads to a local dining experience adds a unique layer to the adventure. This not only benefits the MU activities but also promotes local gastronomy and contributes to the local economy.
- **Multi-Use Certifications:** Farmed fish grown in this MU environment can be uniquely branded and promoted as 'Multi-Use Fish' through the use of certification labels. This labelling strategy not only distinguishes the product but also communicates the sustainable and versatile nature of fish production within Multi-Use environments. Multi-use certifications can play a significant role in building trust in the product, especially when applied to farmed fish.

Recommendation for Commercialisation:

Diversify Marketing Channels: A balanced approach between digital marketing and traditional methods can reach a wider audience.

Develop Strong Partnerships With Local Businesses: Collaborating with i.e. local restaurants not only enhances the overall experience for customers but also creates a network that can support the project during challenges.

Develop Backup Plans: Have alternative online engagement strategies ready to offset any physical limitations to site visits.

Continuous Evaluation: Regular assessment of marketing strategies and their outcomes can help refine approaches for better engagement and economic returns.

Educational Campaigns: Continue to educate the public and tourists about the sustainability of aquaculture to improve its acceptance as a food source.

Year-Round Activities: Develop off-season activities and attractions to ensure a steady flow of tourists and revenue

4.4.10. Decommissioning

In the context of aquaculture, the decommissioning process involves the careful dismantling or relocation of aquaculture equipment, which encompasses cages, nets, and monitoring systems. The objective here is to mitigate any ecological impact and restore the marine environment to its natural state. On the other hand, the decommissioning of tourism infrastructure, which could entail the removal or repurposing of certain components such as vessels, might not always have to be pursuit. In multi-use settings where aquaculture sites play a central role, such as in the Greek pilot, diving activities may offer flexibility. Even if the aquaculture infrastructure is decommissioned or relocated, the diving aspect can often adapt by shifting to alternative sites, thus maintaining the dynamic appeal of the tourism component.

Extension of Aquaculture License in the Greek UNITED pilot

In Greece Aquaculture Law governs decommissioning, emphasizing the timely and environmentally friendly closure of aquaculture facilities. This includes the removal of aquatic animals, draining of water, dismantling of structures, and the restoration of the land. Decommissioning efforts need to be undertaken as soon the aquaculture facility is no longer in use. [1] The Kastelorizo site currently holds an aquaculture exploitation license valid until 2030. In the event of license expiration or certain unforeseen circumstances, decommissioning processes may be initiated. Nonetheless, there are strategic plans in place to ensure the site's operational continuity beyond the project's conclusion, with the intention to seek an extension of the license.

5. FINAL REMARKS

The UNITED Collection of Multi-use Blueprints compiles **practical demonstration experiences** derived from the UNITED project's pilots and other projects across the EU, to offer valuable insights, evidence, and guidance that can serve as an inspiration for industry stakeholders and public authorities to actively embrace the concept of ocean multi-use.

Identifying suitable incentives

Public authorities and policymakers play a pivotal role in facilitating multi-use initiatives. **These blueprints can serve spatial planners and policymakers as a resource for the development of the next round of maritime spatial plans, maritime strategies, and associated regulations**. By showcasing successful examples, they can inspire authorities to integrate multi-use into their planning and regulatory frameworks.

Multi-use can be economically and environmentally beneficial, but it often **requires the right incentives to encourage investment and participation**. These blueprints can help identify suitable incentives for various stakeholders, further promoting the adoption of multi-use practices.

Building confidence within the industry

By drawing on real-world experiences from the UNITED pilots and other relevant projects, these **blueprints serve to build confidence within the industry to invest in and develop multi-use projects.** They provide tangible evidence that multi-use concepts are not just theoretical but can be successfully implemented and generate positive outcomes.

Multi-use outcomes depending on the location and specific circumstances

While promising a variety of potential benefits, **multi-use projects can yield different outcomes depending on the location and specific circumstances.** Hence, while this report offers general guidance and advice, it is imperative to conduct a location-specific assessment of multi-use suitability. This assessment is necessary to determine the optimal configuration of uses and to consider potential indirect conflicts that may arise between multi-use projects and other current or future activities.

Application of the precautionary principle

When developing a multi-use project, it is crucial to conduct a comprehensive assessment of all **cumulative and in-combination impacts**, encompassing economic, social, and environmental aspects. In cases where data on potential impacts is lacking, the application of the **precautionary principle is recommended.**

FINAL REMARKS

6. REFERENCES

Barlow, J. et al. (2022). *Case specific report on risk management aspects within the confines of legal and insurance aspects – Deliverable 6.3.* UNITED project.

Declercq, A. et al. (2023). *Development and implementation of a decommissioning procedure – Deliverable 7.6.* UNITED project.

Falconer, L. et al. (2023). Planning and licensing for marine aquaculture. *Reviews in Aquaculture,* 15(4), 1374–1404. https://doi.org/10.1111/raq.12783Franzen, F. et al. (2017). *Case study 4: Multi-Use for local development focused on energy production, tourism and environment in Swedish waters (Island of Gotland – Baltic Sea).* MUSES project.

Gentry, R. R., et al. (2016). Offshore aquaculture: Spatial planning principles for sustainable development. *Ecology and Evolution*, *7*(2), 733–743. https://doi.org/10.1002/ece3.2637.

Lukic, I. et al. (2020). *Revision of the current environmental assessment and status of pilots – Deliverable 4.1.* UNITED project.

Lukic, I. et al. (2023a). *Multi-use commercialisation roadmap – Deliverable 9.6.* UNITED project.

Lukic, I. et al. (2023b). *Stakeholder interactions and engagement in pilots. - Deliverable 5.2.* UNITED project.

Maes, F. et al. (2023). *Report on legal aspects, governance and insurance issues of multi-use in pilots – Deliverable 6.2.* UNITED project.

McCann, J. (2022). *Ocean Multi-Use Blueprints Collection. Aquaculture, Recreational Fishing and Boating in Rhode Island, United States.* Multi-Frame.

MSP Platform (2021). *Conflict fiche 1: Maritime tourism (incl. local communities) and offshore wind.* European MSP Platform.

MSP Platform (2021b). *Conflict fiche 6: Aquaculture and maritime tourism*. European MSP Platform.

Przedrzymirska, J. et al. (2021). *Multi-Use of the Sea as a Sustainable Development Instrument in Five EU Sea Basins. Sustainability 13, no. 15: 8159. https://doi.org/10.3390/su13158159.*

Reimert, Z. et al. (2023). *Implementation plan for the operation and maintenance – Deliverable 8.5.* UNITED project.

Rozemeijer, M.J.C. et al. (2022). *Application of assessment framework within pilots – Deliverable 4.3.* UNITED project.

Schultz-Zehden, A. et al. (2018). *Ocean Multi-Use Action Plan.* MUSES project. Edinburgh.

Strothotte, E. et al. (2022). *Blueprint for the offshore site operation – Deliverable 7.2.* UNITED Project.

Sørensen, H.C. and J. F. Chozas (2023). *Danish Pilot Manual For Guides – Deliverable 7.4.* UNITED Project

UNITED project (n.d.). *Project website – Pilots – Denmark.* Retrieved December 18, 2023, from https://www.h2020united.eu/pilots-denmark.

Van Gerven, A. et al. (2023). *Environmental impact assessment models for the commercial rollout of Multi-Use Platforms – Deliverable 4.5*. UNITED project.

Van Gerven, A. et al. (2023b). *UNITED auditing procedures and TRL assessment manual – Deliverable 8.4.* UNITED project.

REFERENCES

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