



DELIVERABLE 6.3

CASE SPECIFIC REPORT ON RISK MANAGEMENT ASPECTS WITHIN THE CONFINES OF LEGAL AND INSURANCE ASPECTS

Work Package 6
Legal, Policy and Governance



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Abstract	This deliverable presents the results from five pilot risk analyses for the UNITED project. The analysis follows the SOMOS framework and provides an overview of the key risks faced by	

	multi-use platforms operating at sea. For each pilot, a risk analysis is undertaken and included in the annexes. Evidence is drawn from a literature review plus workshops and discussions with the pilot operators based on their experience of delivering the UNITED projects. The results are presented in Section 4 of the report.
Keywords	Multi-use platforms, offshore, risks, risk management, marine planning, Horizon 2020

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ACRONYMS

H2020	Horizon 2020 (European Commission funding programme)
H2Ocean	Development of a Wind-Wave Power Open-Sea Platform Equipped for Hydrogen Generation with Support for Multiple Users of Energy (FP7-Ocean 2011 funded project, 2012-2014)
H&S	Health and safety
MARIBE	Marine Investment for the Blue Economy (Horizon 2020 funded project, 2015-2016)
MERMAID	Innovative Multi-purpose Off-shore Platforms: Planning, Design and Operation (FP7-Ocean 2011 funded project, 2012-2016)
MU	Multi-use
MUPS	Multi-use platforms
MUSES	Multi-Use in European Seas (Horizon 2020 funded project, 2016-2018)
O&M	Operations and maintenance
OWF	Offshore Wind Farm
SOMOS	Technical Standards for Safe Production of Food and Feed from marine plants and Safe Use of Ocean Space (Lloyd's Register Foundation funded project, 2016-2018)
Space@Sea	Horizon 2020 funded project, 2017-2020
TRL	Technology Readiness Level
TROPOS	Modular Multi-use Deep Water Offshore Platform Harnessing and Servicing Mediterranean, Subtropical and Tropical Marine and Maritime Resources (FP7-Ocean 2011 funded project, 2012-2015)
UNITED	Multi-Use offshore platforms demoNstrators for boostIng cost-effectIve and Eco-friendly pro-Duction in sustainable marine activities (Horizon 2020 funded project, 2020-2023)
WinWind	Project funded by Dutch Topsector Energy, 2018-2020
WP	Work Package



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EXECUTIVE SUMMARY

This report identifies the hazards and risks that multi-use projects may face, considering the background and specific activities of each pilot involved in the UNITED project. This deliverable is developed in cooperation with UNITED consortium partners and is the result of work undertaken for Work Package (WP) 6, Task 6.3 focusing on the risks. Building on the other tasks within the work package, the report focuses on the legal and insurance aspects of risk. Using the framework for safety analysis from the perspective 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 in each of the pilots is implemented.

This task has followed a methodology based on three main steps which are represented in the workflow in the figure below.

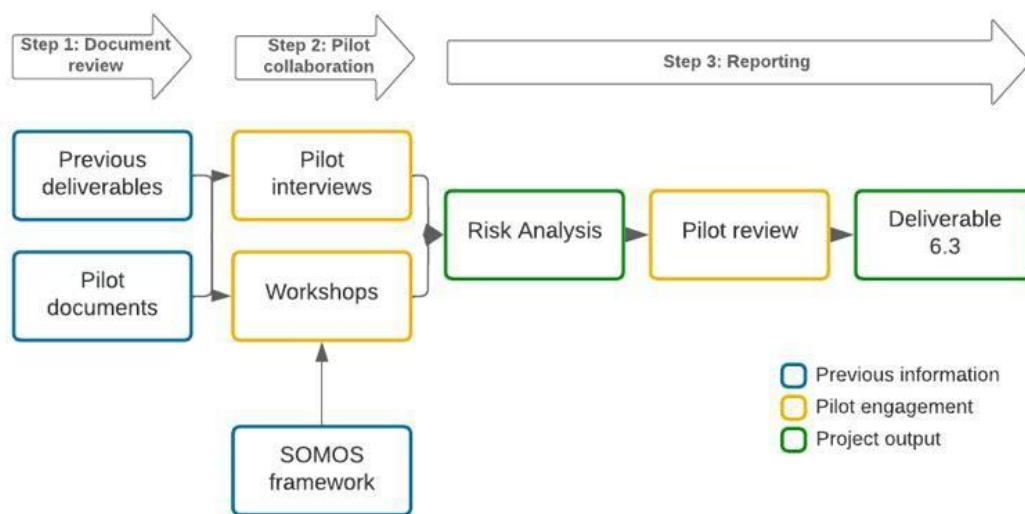


Figure E.1 - Workflow deliverable 6.3. Source: own figure

Table 2 below presents the top five risks for each pilot, before mitigation activities are undertaken. Insurance coverage and severe weather are the top two identified risks for all five pilots suggesting challenges regardless of the nature of the multi-use activity undertaken. The three to five highest risks identified are more varied with topics identified by multiple pilots including water quality, decommissioning, lack of specific regulations, and structural failures caused by multi-use activity equipment interacting. The detailed risk analyses included within the appendices show the small differences in the pre-mitigation risk scores for risks three to five for most pilots suggesting a similar size of risk for each risk item identified.

Risk No	German	Dutch	Belgian	Danish	Greek
1	Inadequate insurance coverage	Inadequate insurance coverage	Inadequate insurance	Inadequate insurance	Inadequate insurance
2	Severe weather	Severe storms	Environmental catastrophic events	Severe weather	Severe weather
3	Lack of qualified staff	Activity on the site by other multi-use partners	Decommissioning of assets	Presence of tourists and workers on the wind farm interacting with the infrastructure	Site water quality

4	Water quality at production site	Decommissioning of assets	Connectivity issues	Lack of specific technology knowledge	Anchoring boats near the site
5	Lack of regulations for multi-use at sea	Engineering design solutions interacting	Damage risks of mechanical loads and collisions with vessels/ships/fishing boats	Structure failure	Camera and sensors

Table E.1 - Top five pre-mitigation risks for each UNITED pilot.

Figure 3 below summarises the key findings from the pilot level risk analyses.

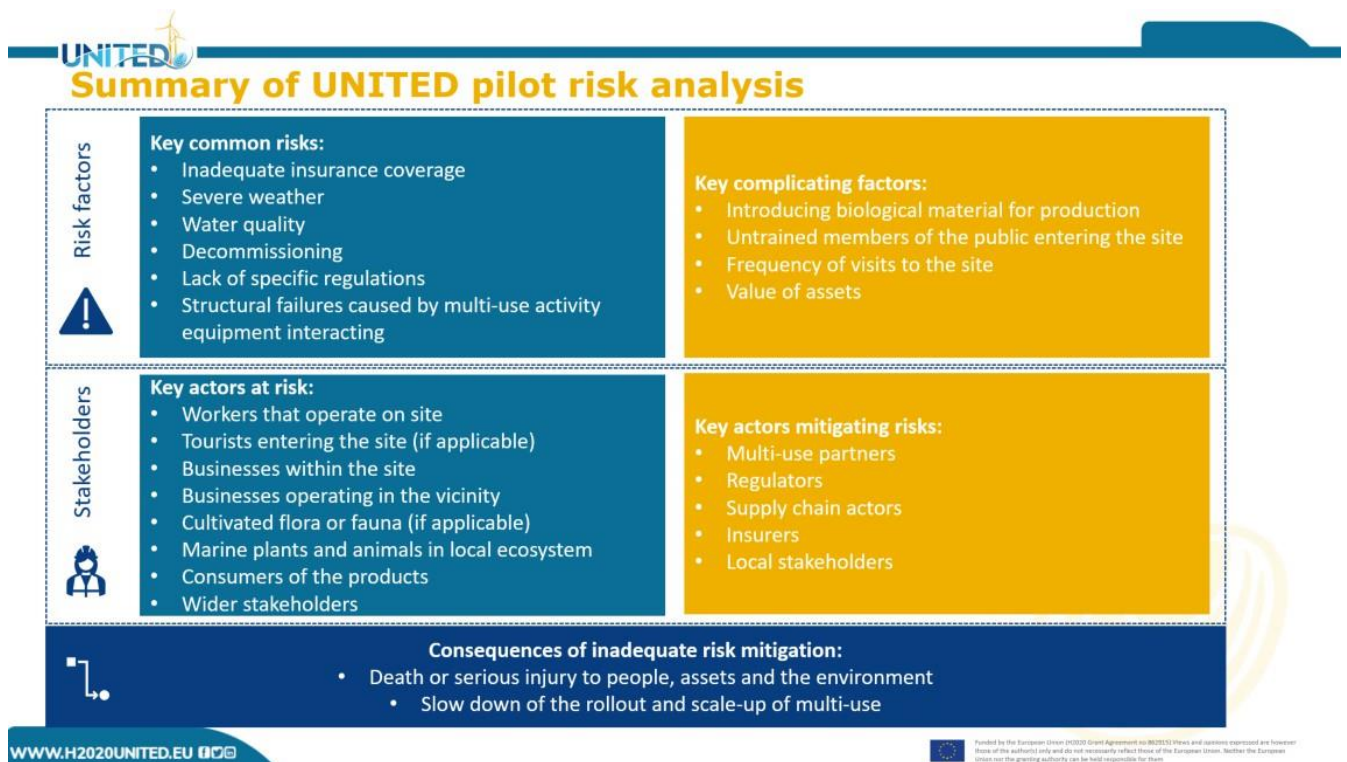


Figure E.2 - Summary of key findings. Source: own figure

The findings from this deliverable will be incorporated into D6.4 (Manuscript of Synthesis of Risk Governance) alongside the findings from D6.1 (Inventory of legal and insurance aspects, risks and risk management options and the wider governance context of risk management) and D6.2 (Case specific report on legal aspects and insurance issues).

1. INTRODUCTION

1.1 Background

The use of European seas is changing, under the influence of multiple major societal challenges. Concerns about climate change are triggering the development of renewable energy production from the sea, such as offshore wind, wave and tidal energy. Food and resource security drive research and development for producing biomass

from the seas. Tourism is a fast growing sector, for which coastal areas are of pivotal importance. Such new functions are added to the existing range of maritime activities, including transportation, ports, sand extraction, fisheries and oil and gas extraction. European coasts and seas are also an important natural habitat for flora and fauna. Combined, these developments lead to a higher intensity of use of the sea. This can, and sometimes already does, lead to conflicting claims for space. The conflicts have the potential exacerbate exiting or create new hazards and risks to operating at sea.

In this context, the concept of multi-use has gained popularity. Multi-use is seen having the potential to make use of scarce sea space in conditions with favourable areas, and deliver efficiency gains that improve the economic performance of sectors. The European Commission has sought to stimulate the development of multi-use of sea through various research topics including, but not limited to, TROPOS, H2OCEAN, MERMAID, MUSES and Space@Sea. These projects have sought to increase the Technology Readiness Level (TRL) of multi-use, from formulating the technology concept (TRL 2) to the validation of technologies in controlled conditions (TRL 4).

1.2 The UNITED project

The project “Multi-Use offshore platforms demonstrators for boosting cost-effective and Eco-friendly production in sustainable marine activities” (UNITED) will enhance the technology readiness level of the technology validated in relevant environment (TRL 5) to demonstration in an operational state (TRL 7+).

UNITED will enable the large-scale installation of the multi-uses of marine space through the development of pilots in the real environment, elaborating on five project pillars: technical, regulatory, economic, social and environmental viability. The project is demonstrating the benefits of the multi-use of marine space concept for multiple economic activities. Optimal multi-use concepts and co-location activities is being implemented in five pilots across European regional seas in close cooperation with local stakeholders and industrial actors. Figure 1 below shows the location of each of the five UNITED pilots and visualizes the activities foreseen.



Figure 1 - Map of and activities in UNITED pilot locations. Source: UNITED Pilots - <https://www.h2020united.eu/pilots>

1.3 Objective of this deliverable

This deliverable is developed in cooperation with UNITED consortium partners and is the result of work undertaken for Work Package (WP) 6, Task 6.3 focusing on the risks. Building on the other tasks within the work package, the report focuses on the legal and insurance aspects of risk. Using the framework for safety analysis from the perspective of food and feed, safety to man and equipment and environmental and cumulative aspects, as developed in the SOMOS project¹, an analysis of the multi-use safety in each of the pilots is implemented.

For identifying the risks the following working definition of hazards and risks is used. A hazard is *something that has the potential to harm you*. Risks refer to *a situation involving exposure to danger*. When a risk is identified as a barrier, it suggests the chances that somebody or something is exposed to danger are unacceptably high. Safety aspects are looked at from three perspectives: food and feed, people and equipment, and environment and cumulative aspects.

Health and safety issues, including the logistics, ancillary infrastructure and maintenance services are addressed. Using the framework, an analysis on safety aspects and hazards and ways to address these are developed. For each pilot the most appropriate way to develop risk management within the boundaries of legal and insurance aspects, and these case specific reports on risk management are assessed.

This report presents the risks as identified in previous multi-use projects and reported in interviews, workshops, the scientific literature and the questionnaire circulated among the UNITED pilot owners. It is used as input to inform technology development and to give insight in the risk assessments needed.

¹ More details of the SOMOS Framework can be found here: <https://www.h2020united.eu/themes/9-pillars/30-legal-policy-and-governance-pillar>

2. METHODOLOGY

2.1 Overview of the methods used

This report identifies the hazards and risks that multi-use projects may face, considering the background and specific activities of each pilot involved in the UNITED project. This task has followed a methodology based on three main steps which are represented in the workflow in Figure 2. In the first step, the existing information was gathered by consulting pilots documents and the following UNITED deliverables - D1.1, D1.3, D4.1, D4.2, D5.1 and D6.1. The second phase directly involved the pilots participants. Interviews on risk assessment and management were conducted and two workshops were held. The SOMOS framework was used to inform the interviewees and workshop participants in this project task. The SOMOS project, funded by Lloyd's Register Foundation, was developed through a collaboration between Wageningen Research and TNO in 2018. The framework aims to provide a comprehensive safety assessment framework considering the economic, environmental, marine, social and food aspects of multidisciplinary projects. The framework was used for the categorisation of hazard in the risk analysis, the main categories defined by SOMOS and adopted in this project are:

- Food & feed: to identify the relevant feed/food safety hazard with marine production, it also identifies public and private standards for food and feed safety that are relevant for marine production in multi-use settings.
- People & equipment: to identify hazards to people and the equipment they operate in multi project facilities.
- Environmental & Cumulative: to identify the possible hazard arising in the marine environment from the combination of new maritime activities. It looks at balancing ecological, economic and societal goals.

In the third step a risk analysis was performed for each pilot project. This identified the major risks that specific pilots may incur. The information was gathered through the pilot engagement. The analysis was validated and reviewed by each pilot to ensure that identified risks, hazards and proposed mitigations were reasonable and effective based on their experience. Subsequently, this report identified the top five risks for each pilot in terms of pre-mitigation risk and also highlights the risks that can be associated to the SOMOS framework. Finally, key recommendations for risk management are highlighted.

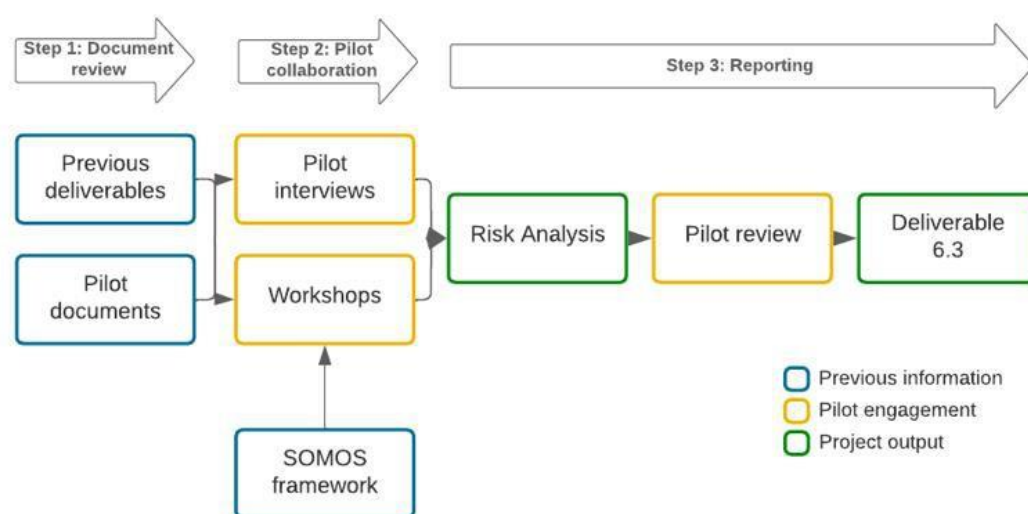


Figure 2 - Workflow deliverable 6.3. Source: own figure

2.2 Review of other UNITED deliverables

The information gathered within the other UNITED project deliverables was essential in determining a more comprehensive picture of the risks and hazards those specific activities may incur in order to conduct the risk analysis. Deliveries 1.1 and 1.3 contain specific background information for the pilots, and the interviews conducted within the task enabled the determination of general risk scenarios and barriers for each activity. Deliveries 4.1 allows the formulation of a background specifically related to environmental risks. Deliveries 6.1 and 6.2 in WP6 support the definition of the risks and hazards of the analysis.

2.3 Stakeholder engagement

The identification of hazards and risks is related to the specific activities of the multi-purpose pilots, that are:

- Offshore wind, blue mussels and seaweed production (Germany)
- Offshore wind, solar and seaweed cultivation (Netherlands)
- Offshore wind, flat oyster aquaculture and restoration, and seaweed cultivation (Belgium)
- Offshore wind and tourism (Denmark)
- Aquaculture and scuba diving (Greece)

The interviews conducted identified the main risks for the activities. In addition, information was gathered on each pilot's risk management strategy, the actors involved and the currently implemented practices. This was crucial for the drafting of mitigation proposals tailored to the specific situation. The interviews were conducted for the pilots of Germany, Denmark, Belgium and Greece, respectively. Information on hazards and risk management for the Dutch pilot was gathered within a workshop on 9 November 2021. A further workshop was held involving all the pilots on 26 January 2022, the main objective being to obtain an overall picture of the hazards and risks of marine activities. The workshops were structured around the SOMOS framework. Finally, the pilots were involved in reviewing the analysis and mitigation actions proposed in this report to ensure that the identified risks and mitigation recommendations were relevant and in line with the experiences of the pilots.

2.4 Analysis and reporting

The output from this task is the production of the risk analysis and this report. The risk analysis was carried out on the basis of available information and literature research. The risks identified in the analysis are based on potential and general situations that multi-activity project might face within given the nature of their activities at scale. To each identified risk a score has been assigned using an excel spreadsheet for the pre-mitigation and post-mitigation scenario. The score assigned is the combination of the Consequence Severity Rate (from 0 = zero impact to 5 = extensive impact.) on four different categories (People, Assets, Environment and Reputation) and the probability of the risk occurrence (from A = low probability to D = high probability). This report presents for each pilot the five risks with the highest pre-mitigation score identified through risk analysis and an overview of other pilot-related risks categorised by the SOMOS framework. Finally, for each hazard identified, mitigation recommendations were provided to address the risks and the risk scoring was repeated to assess the residual risk.

3. PILOT ASSESSMENTS

3.1 German Pilot

3.1.1 Description of the pilot

In the German pilot, the multi-use combination of offshore wind research and aquaculture (blue mussel/macroalgae) is being tested to demonstrate the feasibility of combining such activities in practice. The combination of offshore wind research and aquaculture has mainly been driven by the need to increase aquaculture production, a key component of the Common Fisheries Policy, Blue Growth Strategy and national policies and the already

existing user conflicts in coastal areas. Moreover, the multi-use of offshore sites is identified as an important opportunity in several policy documents (see UNITED D6.1 for more detail).

Given the large fixed costs associated with development and operation of any offshore activity, aquaculture developers consider the combination with Offshore Wind Farms (OWF) as an opportunity to make aquaculture more feasible and profitable. Cost savings can potentially be derived through shared operations and maintenance (O&M), infrastructure and logistics between the two sectors. Financial benefits to the OWF and aquaculture industries will be possible to test and demonstrate in theory and in practice at the FINO3 location by examining the shared use of several services, such as logistics, transportation, environmental monitoring data, permissions and licenses, etc.

In this pilot, a demonstration aquaculture farm is expected to potentially benefit from joint operations and maintenance, shared use of infrastructure by several users, and the joint use of data transmitting and monitoring systems.

This risk analysis draws primarily on a number of key sources:

- Previous deliverables within the UNITED project (such as D.1.1, D1.3, D5.1 and D6.1, D7.1, D7.2).
- Interviews with the pilot leadership team.
- Supplementary literature research about risks and potential mitigations in greater detail.

Once drafted, the risk analysis was reviewed and validated by the German pilot team to ensure that identified risks and hazards and proposed mitigations were reasonable and effective based on their experience operating the pilot.

Below is a summary of the risk analysis and the full version is in Annex 1. The top five risks are identified in terms of pre-mitigation risk before reviewing risks using the SOMOS framework of food and feed, safety to man and equipment, and environmental and cumulative impact. Finally, key recommendations for risk management are highlighted.

3.1.2 Hazards and risks identified

The top five highest risks, based on the magnitude of their impact and the probability of the risk occurring are presented below. They were determined according to the pre-mitigation score, calculated as described in Section 2.4, obtained in the risk analysis performed. Risks have been identified on the basis of pilot activity, in view of the future risks and hazards that scaled up multi-use activities of this nature could face. 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.

Risk item 1: insurance cost and coverage

The risk with the highest pre-mitigation risk score in the risk analysis is inadequate insurance coverage. Achieving full coverage is challenging and expensive for MUPs because of the highly diverse types of activities with differing purpose and risk levels. Although this risk was not a problem for the German pilot's operations, it could be a significant challenge for MUPs operating at scale. Currently there are no multi-use offshore projects operating in Germany making it difficult to predict and evaluate this risk for an up-scaled production scenario.

Lack of insurance cover is risky due to the consequences that it can cause. Not being fully insured does not increase the risk of each activity, but it does increase the consequences of an event for the operators, workers, and stakeholders. Lack of insurance is considered an issue that compounds the consequences of all other risks to individuals, the environment, and businesses as under-insurance can lead to an inability for operators to recover from risk events. However, each future operator will take their own decisions about an appropriate level of insurance. For some risks, the cost of insurance could be particularly expensive, potentially leading the company not to insure all elements of production.

Increased understanding of multi-use at sea on the part of the public sector and insurance companies could reduce the uncertainty that currently affects insurance decisions. Drafting detailed safety protocols for different activities and operators collaboratively working with insurance companies could make the insurance company understand the risk profile better and trust that the company can appropriately manage risks. This could allow for lower risk

premiums and greater coverage of risks allowing greater coverage. For risks with smaller damages, the multi-use businesses could create a self-insurance fund by building cash reserves and/or establishing flexible credit lines to be utilised in the event of the risk being realised. However, this may be a costly choice for the company, especially if it is a small to medium-sized enterprise with limited liquidity. Collaboration with third parties and insurers is needed to fully mitigate this risk, yet the multi-use operators can act alone to reduce the risk to an extent.

Risk item 2: severe weather

The risk with the second highest identified pre-mitigation risk score to address is severe weather conditions at sea. This risk item is potentially worsened due to increased extreme weather events observed in recent years due to climate change. Severe weather can be the cause of serious damage to the pilot structures itself as well as to the nearby windfarms and people working offshore. Aquaculture production facilities risk detachment of lines during storms, loss of products (mussels and seaweed), leading also to environmental damage due to non-degradable materials in the sea.

Severe weather conditions, particularly extreme weather, will always be a risk that is impossible to control, but to minimize the impact of this risk, the following actions could be implemented:

1. Design appropriate decision support systems, as developed in UNITED project, e.g. for monitoring weather forecasts.
2. Develop a system for flexible adaptation of operations based on the current situation and the collected information.
3. Feasibility evaluation and simulation of technical projects according to international standards for marine aquaculture.
4. Develop internal protocols to ensure staff safety and infrastructure in the event of severe weather.
5. Install offshore sensors directly at the location to support forecasting and understanding of site conditions additional to the available forecasts.
6. Monitor equipment regularly to avoid equipment damage and/or detachment.
7. Disaster recovery plans should be developed and in place for the operation to determine the best approach to stabilising and repairing the site in the event of severe damage.

Risk Item 3: lack of qualified staff

The third highest pre-mitigation risk identified is the potential lack of qualified staff to be included in the business. Being innovative, multi-use projects may run the risk of not being able to find skilled workers on labour market that match skill requirements. Poorly qualified and skilled staff can lead to serious injury to workers and equipment damage. In addition, the lack of qualified professionals also reduces the possibility of using advanced equipment or more efficient production techniques. Therefore, designing transparent safety protocols and continuous investments in staff training is crucial for the companies delivering multi-use at sea. This will also increase the staff expertise in handling incidents and damages.

Risk item 4: water quality at production site

The fourth highest pre-mitigation risk identified is production site water quality, in particular for aquaculture production. There is a potential risk of subsequent contamination from external factors such as other sites, boats and invasive species. Given the size of the German pilot and the location of the production, water quality is not considered a substantial risk by pilot leads for the German pilot. Poor water quality can affect yield adversely, either by reducing production or making it unsuitable for human consumption.

Key mitigation measures include:

1. Preventative site analyses can help in selecting a suitable site for production which minimises contamination risk.

2. Routine water testing can prevent extensive damage, e.g. contamination of produce may be able to be avoided through the arrangement of an anticipated harvest.
3. Offshore cultivation can be an option for the company, which would offer higher quality water compared to locations near the coast albeit at the cost of more challenging weather conditions.

Risk Item 5: lack of regulations for multi-use at sea

The fifth highest pre-mitigation risk is caused by a lack of regulations addressing multi-use at sea. This created significant delays for the start of the offshore activities, additional workload and high costs to meet the requirements. Future multi-use sites could observe market inefficiencies, legal problems and challenges expanding the industry. Inadequate intergovernmental regulations can also cause significant environmental risks that can arise from a lack of defined standards leading to inconsistent and potentially inadequate environmental protection approaches. Lack of regulation can make obtaining financing more difficult due to uncertainties in the business model caused by regulatory uncertainty.

Mitigation options include:

1. The company should establish internal protocols to mitigate risks at commencement on site that set high standards for the protection of the environment and people.
2. The licensing authorities should develop environmental and safety standards related to multi-use at sea.

This risk item can partially be mitigated by the multi-use operators, but will require support from regulatory bodies to fully address the issues.

3.1.2.1 Food and feed

The key risks for the SOMOS framework category food and feed are assessed in this sub-section. This category is critical in a company that produces seaweed and mussels for human consumption because detailed legal requirements have to be fulfilled. In Germany very stringent regulation is in place on the subject which the German pilot project team had to follow. The level of risk differs according to the potential risk of the respective product and its application.

- Mussels fall under a “high risk” category in Germany. They must meet quality requirements for production and storage. Therefore, each production area and in some cases each batch of mussels is tested before it reaches the consumers. Samples must be handed in to the authorities and if they do not meet the highest standards, selling is prohibited. This process seeks to guarantee a high level of safety for consumption.
- Seaweeds are considered a “low risk” product in Germany. The required standards are less stringent, as the substances contained are not considered to be highly harmful. The product must be properly stored in cold conditions. For this reason, the frequency of tests is lower. Product is tested randomly by the authorities and if it does not meet the food safety standard and contains contaminants, the product is recalled. It is always possible to perform internal tests to prevent product rejection.

The producer can be fined if the testing regulations were violated and the product was sold. This happens rarely, and seaweed are considered very safe for consumption in the German market. The periodic testing of aquaculture products can be expensive and time-consuming and a risk of delays in getting the product to the market remains. The key mitigation measure is keeping to the food regulation protocols to ensure production of a safe food product. Planning carefully ahead and considering the costs of food safety testing is fundamental. Furthermore, there is always the risk of delays, when the food safety control prevents selling the product. This can in the worst case lead to loss of a batch. Hence testing the batch before starting to harvest is highly advised. If the batch is harvested and does not get food safety clearing it can be brought to a cleaning facility and kept in clean water until the batch is safe for consumption. Planning is the key to a successful operation.

In addition, mussels can be exposed to specific risks such as toxic algae blooms. Toxins, accumulated in mussels, can be dangerous to human health and can also endanger the surrounding ecosystem. Algal growth in marine

waters is also determined by the level of nitrogen and phosphorous and to a lesser extent other inorganic compounds. Eutrophication leads to an increased algal growth which can cause: a reduction of sunlight penetrating the water to the seafloor ecosystems; oxygen deficiency in deeper waters impacting negatively fish and benthic fauna (animals living on the bottom of the sea or a lake); and ultimately a shift in the biodiversity and ecosystem balance (European Commission, 2012). In the event of eutrophication being triggered by aquaculture activity, a possible scenario is that the company may have to incur considerable expenses to clean up the site area. To mitigate this risk and have a better chance of meeting the requirements of food safety regulations, the company can monitor water quality, use environmentally friendly techniques, avoid disposing of epiphytes in the water and consult a water management expert for further site specific guidance. Finally, it might be beneficial to allocate a fund for clean-up or to take out insurance. Considering distance from the shore, water flow, aquaculture species cultivated, production size, and total biomass produced, not all recommended mitigation actions will be appropriate. Each new multi-use site will be responsible for undertaking its own risk analysis.

Finally, another key risk related to food production is the market uncertainties in the industry and the consequent risk of having significant unsold produce. The seaweed market in Europe is not yet well established, which creates uncertainty in sales and profits (van Den Burg et al., 2016). The mussel market on the other hand is well established and provides greater reliability for revenues.

3.1.2.2 Safety to man and equipment

Here the key risks of the SOMOS framework category safety to man and equipment are assessed. There are a number of situations that can cause an accident and injury to people and damage aquaculture and offshore wind farm infrastructure. The largest risk determining the safety aspects offshore, already discussed in 3.1.2, are severe weather conditions. Additionally, there is a risk related to energy supply and infrastructure that can be damaged. High tension energy transmission cables can be damaged, for example by loose anchoring materials as a result of a heavy storm. This leads to various safety risks for workers. In the event of an accident, structures can incur major damage, which is expensive to repair and can significantly affect the company's revenues. Therefore, it is beneficial to:

1. Have detailed and up-to-date safety protocols.
2. Provide training and instructions to staff.
3. Have a proper control and emergency system.
4. Perform feasibility evaluation and test materials certified according to international standards.

Each offshore activity involves vessels, which implies the possibility of a significant increase in maritime traffic, increasing the risk of collisions if national regulations are not followed correctly. This endangers the workers involved and the vessels that could be damaged during an accident, causing large economic losses to the companies. Boat accidents also increase the risk of oil spills and contamination of the environment, showing the overlap between human safety and environmental safety risks. It is therefore beneficial to have a navigation plan and to share it with other actors operating in the same area. There is a need to increase collaboration and cooperation between stakeholders in order to decrease risk of collisions and adopt safer navigation practices.

3.1.2.3 Environmental and cumulative impact

Here the key risks for the SOMOS framework category environmental and cumulative impact are assessed. Though no risks in the risk analysis are allocated primarily to the environmental category of the SOMOS framework, many of the risks identified could have environmental impacts. One of the major environmental risks for aquaculture enterprises is water contamination and pollution. This can include fuel spills, dispersal of material at sea, potential introduction of invasive species and disturbance of the local ecosystem.

In general boat noise pollution and wind farm infrastructure vibration can impact ecosystems and marine organisms (Saavedra & Samanta, 2015). Regarding contamination, it is beneficial to carry out water quality analysis frequently, adopt eco-friendly production techniques so as to minimise introduction of pollutants to the site, adopt internal environmental safety protocols and train staff to handle hazardous situations during their offshore activities. Finally, multi-use companies could set-up a fund for a possible environmental accident to clean up the affected area.

3.1.4 Key risk management recommendations

A number of broader recommendations can be drawn from the risks and mitigations identified through the German pilot and wider literature review. In the absence of more precise regulations on operational management, one recommendation for the companies is to equip themselves with detailed internal security and risk management protocols. These documents should be updated frequently, because risks and potential incidents may arise from new situations not previously considered. Staff training is crucial, they must have technical skill and knowledge to avoid infrastructure incidents and be trained in risk and incident management for their safety.

The installation of some technological tools on the offshore site can support forecasting operations onshore. This is important for weather conditions and water quality control. For that, the company must have a good system of connectivity and data transmission between the offshore and the onshore site. Improved maritime communication can support navigation within a high traffic area.

Finally, establishing effective communication with institutions and other local stakeholders can increase the companies' ability to minimise some of the risks associated with uncertainty due to imprecise or lack of regulations, price volatility, and social perception of the business. Sharing information and data with institutions allows agreements or policies to be reached to support the business. Collaborations can be established with other entities that benefit both, such as sharing equipment, warehouses, and outside activities.

3.2 Dutch Pilot

3.2.1 Description of the pilot

North Sea Farmers Offshore Test Site (OTS), previously called the North Sea Innovation Lab (NSIL), is an independent test site for research, pilots and the upscaling of innovations in the field of seaweed cultivation, floating solar and other renewable energy innovations, and co-use of wind farms. With the UNITED pilot, OTS aims to help industries develop amongst others large-scale offshore solar farms and address important bottlenecks that impede such implementations. It will also help OWF owners develop large-scale offshore seaweed farms in existing wind parks and develop new OWFs offering integrated wind/aquaculture activities in the tender phase. This risk analysis draws primarily on a number of key sources:

- Previous deliverables within the UNITED project (such as D.1.1, D1.3, D4.1, D4.2, D5.1 and D6.1).
- Interviews with the pilot leadership team and responsible leaders for the seaweed and solar farms.
- Supplementary desk-based research to understand the risks and potential mitigations in greater detail.

Once drafted, the risk analysis was reviewed and validated by the OTS pilot team and seaweed and solar experts from the partners to ensure that identified risks and hazards and proposed mitigations were reasonable and effective based on their experience delivering the pilot.

Below is a summary of the risk analysis which can be reviewed in full in Annex 2. The top five risks are identified in terms of pre-mitigation risk before reviewing risks using the SOMOS framework of food and feed, safety to man and equipment, and environmental and cumulative impact. Finally, key recommendations for risk management are highlighted.

3.2.2 Top risks identified

The top five highest risks, based on the magnitude of their impact and the probability of the risk occurring are presented below. They were determined according to the pre-mitigation score, calculated as described in Section 2.4, obtained in the risk analysis performed. Risks have been identified on the basis of pilot activity, in view of the future risks and hazards that scaled up multi-use activities of this nature could face. 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.

Risk item 1: inadequate insurance coverage

The risk with the highest pre-mitigation risk score is inadequate insurance coverage. Insurance for MUP activities must be able to cover at the same time multiple activities with different purposes and objectives (ie production methods, workers, equipment, etc). The novelty of MUP means the business elements that can be insured are often unclear. The interaction between parties should be covered to ensure no company is exposed with unmanageable liabilities. This insurance coverage could be prohibitive if there are revenue size differences and differences in capital asset value, as would likely be the case for aquaculture and energy production equipment. Some hazards are sometimes not insured such as storms or earthquakes, this is dangerous for companies operating offshore given the likelihood of the risk. Insurance is usually a risk mitigation activity. In some cases, as in the case of MUPs, uncertainty about insurance liability makes investment in these activities difficult. Too high a premium price resulting from a cautious approach from insurers can discourage business formation. In addition, the inability to insure for some weather and natural phenomena makes activities at sea riskier for the operator who must self-insure. Not being fully insured does not increase the risk of each activity, but it does increase the consequences of an event for the operators.

Mitigations include drafting detailed safety protocols for aquaculture and energy production activities. Collaboratively working with insurance companies could make the insurer understand the risk profile better and trust that the companies can appropriately manage risks. This could allow for lower risk premiums and greater coverage of risks. Self-insurance is an option for some less severe risks by building cash reserves and/or establishing flexible credit lines to be utilised in the event of the risk being realised.

Risk item 2: severe storms

The risk with the second highest pre-mitigation risk score is severe storms. Extreme weather comes in many varieties, such as black ice, hail, a snowstorm or a very severe storm. A very severe storm is usually shorter in duration (a number of hours), resulting in a smaller impact (assuming flood defences continue to function). The Netherlands National Institute for (National Institute for Public Health and the Environment, 2016) classifies extreme weather as likely with substantial to serious damage potential. A high energetic environment could make the site inaccessible during severe weather conditions with vessels and divers depending on low wind and wave conditions. Risks from a severe storm include trips/slips, injury and fatalities, hyperthermia, power outages, damage or destruction of assets, vessels drifting away, and damage to marine environment. Weather conditions can damage or corrode equipment polluting the environment with metals and plastics. Currents can wash material great distances to contaminate other marine environments while marine animals can ingest or become entangled in waste.

Mitigation actions include developing extensive protocols to ensure safety including at the port, on vessels, and at the site. Equipment installed should be reviewed and designed to minimise environmental hazard and likelihood of detachment. Long term impacts of ocean salinity should be considered for all materials used. Regular checks and remote monitoring with an alarm system should be undertaken to ensure equipment has not detached and reasonable efforts made to recover all equipment. Health and safety training should be mandatory for all workers and visitors to the site. The training should be refreshed regularly including emergency drill practices. The weather forecast should be monitored continually with appropriate protocols developed for each eventuality. As part of developing the protocols, consultation with the coast guard should be made. Insurance should be taken out to cover damage, working closely with insurance companies to identify an appropriate allocation of risk between the insurance company and the business. Disaster recovery plans should be developed to determine the best approach to stabilising and repairing the site in the event of severe damage.

Risk item 3: activity on the site by other multi-use partners

The risk with the third highest pre-mitigation risk score is activity on the site by and for other multi-use partners. To achieve multi-use, a large number of actors may need to enter the site. These workers may have limited familiarity with the operations of other multi-use partners and not be incentivised to protect the assets. Activity within the site, especially mooring of aquaculture systems, is challenging and failure could lead to damage to the monopiles or vessels nearby. This could cause harm to the local environment if equipment detaches from the site and enters to local ecosystem.

Mitigation measures include ensuring all workers entering the site receive training and briefing on site layout and safety protocols. Multi-use site managers can work collaboratively and openly to identify and mitigate risks including through a near miss reporting mechanism. Some training sessions could be combined to help transfer knowledge and build trust between the parties.

Risk item 4: decommissioning of assets

The risk with the fourth highest pre-mitigation risk score is decommissioning of assets. Decommissioning assets (especially fixed assets like offshore wind monopiles) is a highly intensive and expensive activity. If decommissioning is managed poorly, or inadequate funds are made available, there is risk of substantial contamination of the local environment and damage to nearby assets at sea. The increased number of assets at sea and, potentially, the difference in useful operating lifespan could increase the complexity of decommissioning and create more risks as a result.

To mitigate this risk, a decommissioning plan should be developed at project inception. Minimising complexity and impact during decommissioning should be considered at project design stage. One option could be to plan to decommission all assets at the same time. A sinking fund could be included in the business model to ensure adequate finances are available to decommission the site.

Risk item 5: engineering design solutions interacting

The risk with the fifth highest pre-mitigation risk score is engineering design solutions interacting. Structure failures in complex facilities such as those used in offshore wind and solar power, or seaweed aquaculture can occur from a variety of causes including: bird strikes, lightning strikes, rainfall, blade detachment, delamination, leading-edge corrosion or blade cracks. Structural failure of one multi-use infrastructure could lead to damage of other infrastructure on site. Energy production depends on the proper functioning of the structure. Structure failure could cause serious accidents to workers and damage to the environment if they involve leaks. Revenue will be lost and it could be difficult to cover production costs. Repair costs could also be very high.

Potential mitigations include developing a robust maintenance plan to ensure infrastructure is kept in good condition. Incident management protocols and staff trained to handle facility incidents can help limit damage. Remote monitoring can help the site management team make more informed decisions while onshore. Ensuring insurance coverage takes into account facility failures would help ensure costs are manageable for the businesses affected.

3.2.2.1 Food and feed

Here the key risks for the SOMOS framework category food and feed are assessed. Two key risks to food and feed are identified for the Dutch pilot. With seaweed production, toxic algae blooms could build up before the harvest leading to contamination of aquaculture product. The eco-system can also be contaminated leading to eutrophication. Harmful algae blooms can spread by cleaning of cultivating equipment or heavy storms releasing the toxic algae into the eco-system leading to eutrophication and risk of damaging the aquaculture crop. Additionally, contaminants from OWF equipment, boats, workers visiting sites can reduce production yield. Working practices of other multi-use partners could lead to contamination of the seaweed production site thereby also reducing production yield. Failure to fulfil customer orders may lead to short term loss in revenue and medium term reduced trust in the business from customers. There is also a health risk for customers if contamination is not identified.

Mitigation methods for the food and feed risks include monitoring the quantity of algae build-up on equipment, utilising eco-friendly practices such as forbidding improper introduction of invasive alien species and avoiding disposal of large amounts of epiphytes into the water to help minimize the potential contribution of seaweed cultivation to algae blooms. Developing alternative product applications for seaweed as a contingency would help ensure a financial return if the seaweed is identified to not meet quality requirements for food or feed. Additionally, designing multi-use production sites to minimise risk of contamination from alternative uses (e.g. accounting for tidal flows) and agreeing working practices with multi-use partner organisations can also minimise risk of contamination.

3.2.2.2 Safety to man and equipment

Here the key risks for the SOMOS framework category safety to man and equipment are assessed. There are a number of additional risks for safety to man and equipment to those already identified as top risks for this type of multi-use activity (severe storms, activity on the site by other multi-use partners, engineering design solutions interacting, and decommissioning of assets). These risks are:

- Power supply - a large range of equipment on site needs a reliable and with sufficient power supply;
- Earthquakes - the Netherlands National Institute for Public Health and the Environment (RIVM) classifies natural earthquakes as somewhat likely yet with limited damage potential.
- Drifting aquaculture construction - lines, floaters, mooring systems, and seaweed support systems drift and float around site creating risk of entanglement with vessels and solar or offshore wind assets.
- Connectivity issues – site-to-shore communications are critical to safe and efficient operations yet many at sea locations are poorly served (e.g. limited or poor 4G available on site).
- Cameras and sensors – the onshore team's understanding of site conditions relies upon functioning of cameras and sensors on site. If poorly installed or of low quality, malfunctioning could occur risking inappropriate response decisions by onshore team, injuries and fatalities, damage to assets, damage to marine ecosystems, damage to seaweed crop, and slow response times.
- Vessel equipment compatibility - Standard vessels within commercial fishing fleet may be inadequate for multi-use operations including anchoring technology, layout, and safety features.
- Trespassers into the isolated offshore site could collide with equipment, some of which is below the surface making it hard to see, risking significant damage being caused to the equipment or the trespassing vessel.

Mitigations can include ensuring the site is designed to minimise risk of entanglement and exposure of transmission cables. All workers entering the site should receive training and briefing on site layout and safety protocols including during rare events such as earthquakes. Multi-use site managers can work collaboratively and openly to identify and mitigate risks including through a near miss reporting mechanism. To check that the site power supply is adequate for the devices to work, the project team need to check the consumption of the devices and compare to the power supply options available on site in design proposals.

Equipment should be regularly inspected to ensure it is not damaged, especially after storms and other events at sea. Remote monitoring of assets from onshore can help identify damage. Remote monitoring should also be undertaken from a security perspective to identify and warn site trespassers. To ensure secure installation of cameras and sensors onto the aquaculture infrastructure, regular visits to the aquaculture site to plan and design proper installation including asking expert advice on the best way to install such devices to the existing infrastructure can be beneficial. Cleaning sensors according to equipment manufacturer guidance and purchasing high quality equipment with reliability levels appropriate for level of criticality of sensor are also an important risk mitigation.

Appropriate insurance levels should be procured to cover potential damage, working closely with insurance companies to identify an appropriate allocation of risk between the insurance company and the business. Disaster recovery plans should be developed to determine the best approach to stabilising and repairing the site in the event of severe damage.

3.2.2.3 Environmental and cumulative impact

Here the key risks for the SOMOS framework category environmental and cumulative impact are assessed. The multi-use activities creates a number of environmental risks that need to be mitigated. Higher volumes of marine traffic at and close to the site could increase risk of vessel collision with other multi-use vessels and with equipment. Collision could cause significant damage to individuals, the marine environment, and physical assets. Higher volumes of marine traffic also cause greater disturbance for the local ecosystem including underwater-noise. Shipping can harm the environment through discharges at sea (e.g. oil, wastewater, paints, ballast water, and marine litter), airborne emissions (e.g. engine exhaust, refrigerants, and other volatile chemicals), noise, and shipwrecks or scrapping. Higher marine traffic increases likelihood of dropped items into the sea and there is a risk from oil spills affecting the site. Effluent from oil production can have long-term negative impacts on oceanic ecosystems

and future provision of ocean resources. As activity intensifies, the risk from disruption during significant wave height grows as operation and maintenance activities cannot occur during this time.

Close coordination between multi-use businesses is required to minimise risk and disturbances to the ecosystem. This could include actions like: a) designing the site to minimise risk of collisions; b) sharing site visit schedules; c) reviewing other partners' equipment and working collaboratively to reduce risks; and d) sharing trips to site. Utilising new ships with motion stabilizers to guaranty safe transfers of personnel and material could enable vessels to operate under significant wave-height conditions of up to 3m. Monitoring water quality within the site to identify contaminations and testing seaweed for quality before human and animal consumption are important mitigations against oil spills. Utilising anchor pipe vibration embedment instead of pile driving for anchor system could lower noise levels during site construction.

3.2.4 Key risk management recommendations

There are a number of key risk management recommendations that can be applied to mitigate a large proportion of the risks faced by the Dutch pilot. These include:

- Designing the site to minimise and optimise interactions between the multi-use infrastructure.
- Developing robust safety protocols at the port, on vessels, and at the site for all eventualities including storms, earthquakes and daily hazards, and ensuring all entrants on site are adequately trained in safety procedures.
- Close co-ordination between multi-use actors to ensure each's operations are well understood and finding opportunities to minimise visits to the site.
- Working collaboratively with insurers and other stakeholders to find solutions throughout the supply chain, including in the provision of adequate insurance.

Combined, the risk mitigations identified in the risk analysis (Annex 2) will address a large proportion of risk of multi-use of seaweed, floating solar and OWF activities. Remaining residual will need to be carefully managed.

3.3 Belgian Pilot

3.3.1 Description of the pilot

This pilot focuses on integrating native (European) flat oyster (*Ostrea edulis*) production and restoration, and seaweed (*Saccharina latissima*) cultivation in wind parks. The project is carried out in two locations: offshore in the wind park of Belwind, and nearshore in Westdiep. Today, turbines are allocated in five Belgian wind farms, among which C-Power NV and Belwind NV. Within these two wind farms, an offshore mussel aquaculture pilot project Edulis was carried out between September 2016 and August 2019. As such, the wind parks have extensive experience with offshore longline systems and operational challenges.

The nearshore site of Westdiep has several longlines since April 2017. For the UNITED project, the nearshore site has been used for testing equipment and techniques suitable for oyster and seaweed cultivation as well as oyster restoration in the highly exposed offshore environment.

The pilot has two main objectives:

1. To evaluate wind farms as a location for restoring native flat oyster reefs in combination with culturing flat oysters for human consumption; and
2. To develop cultivation techniques allowing for offshore seaweed cultivation.

This risk analysis draws on a number of key sources:

- Previous deliverables within the UNITED project (D.1.1, D1.3, D4.1, D4.2, D5.1 and D6.1).
- Interviews with the pilot leadership team.
- Supplementary desk-based research to understand the risks and potential mitigations in greater detail.

Once drafted, the risk analysis was reviewed and validated by the Belgian pilot team to ensure that identified risks and hazards and proposed mitigations were reasonable and effective based on their experience delivering the pilot.

Below is a summary of the risk analysis which can be reviewed in full in Annex 2. The top five risks are identified in terms of pre-mitigation risk before reviewing risks using the SOMOS framework of food and feed, safety to man and equipment, and environmental and cumulative impact. Finally, key recommendations for risk management are highlighted.

3.3.2 Hazards and risks identified

The top five highest risks, based on the magnitude of their impact and the probability of the risk occurring are presented below. They were determined according to the pre-mitigation score, calculated as described in Section 2.4, obtained in the risk analysis performed. Risks have been identified on the basis of pilot activity, in view of the future risks and hazards that scaled up multi-use activities of this nature could face. 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.

Risk item 1: inadequate insurance

The risk with the highest pre-mitigation risk score is inadequate insurance coverage. Insurance for MU activities must be able to cover at the same time multiple activities with different purposes and objectives (i.e. production methods, workers, equipment, etc). The novelty of MUP means the business elements that can be insured are often unclear. The interaction between parties should be covered to ensure no company is exposed with unmanageable liabilities. This insurance coverage could be prohibitive if there are revenue size differences and differences in capital asset value, as would likely be the case for aquaculture and energy production equipment. Some hazards are sometimes not insured such as storms or earthquakes, this is dangerous for companies operating offshore given the likelihood of the risk being realised. Additionally, insurance for loss of product due to events such as a storm, harmful algae blooms, and oil spills would also strengthen the resilience of the business model yet can be hard to obtain. Insurance is usually a risk mitigation activity. In some cases, as in the case of MU, uncertainty about insurance liability makes investment in these activities difficult. Too high a premium price resulting from a cautious approach from insurers can discourage business formation. In addition, the inability to insure for some weather and natural phenomena makes activities at sea riskier for the operator who must self-insure. Not being fully insured does not increase the risk of each activity, but it does increase the consequences of an event for the operators.

Mitigations include drafting detailed safety protocols for aquaculture and energy production activities. Collaboratively working with insurance companies could make the insurer understand the risk profile better and trust that the companies can appropriately manage risks. This could allow for lower risk premiums and greater coverage of risks. Self-insurance is an option for some less severe risks by building cash reserves and/or establishing flexible credit lines to be utilised in the event of the risk being realised.

Risk item 2: environmental catastrophic events

The risk with the second highest pre-mitigation risk score is damage due to extreme adverse environmental catastrophic events such as storms or underwater earthquakes. A very severe storm is usually shorter in duration (a number of hours), resulting in a smaller impact. The Belgian National Crisis Centre (NCC) identifies that extreme weather phenomena, such as severe thunderstorms, occur several times a year. The NCC expect that storm risks will become more frequent and have greater impact in the future, influenced by climate change. The NCC explains that in Belgium, there are many earthquakes that are barely noticeable, yet devastating earthquakes with a magnitude of up to 6.0 cannot be ruled out. Risks from a severe storm include trips/slips, injury and fatalities, hyperthermia, power outages, damage or destruction of assets, damage to marine environment, loss of equipment and

difficulties to install and retrieve equipment. While the Belgian NCC assess the probability of thunderstorms to be very likely, the assessed impact is typically low. Earthquakes in Belgium are assessed to be likely with a low impact by the Belgian NCC. Mitigations include developing extensive protocols to ensure safety including at the port, on vessels, and at the site. Equipment installed should be reviewed and designed to minimise environmental hazard and likelihood of detachment. Long-term impacts of ocean salinity should be considered for all materials used. Regular checks should be made to ensure equipment has not detached and reasonable efforts made to recover all equipment. Health and safety training should be mandatory for all workers and visitors to the site. The training should be refreshed regularly including emergency drill practices. The weather forecast should be monitored continuously with appropriate protocols developed for each eventuality. As part of developing the protocols, consultation with the coast guard should be made. Insurance should be taken out to cover damage, working closely with insurance companies to identify an appropriate allocation of risk between the insurance company and the business. Disaster recovery plans should be developed to determine the best approach to stabilising and repairing the site in the event of severe damage.

Risk item 3: decommissioning of assets

Decommissioning assets (especially fixed assets like offshore wind monopiles) is a highly intensive and expensive activity. Multi-use creates uncertainty about the ability of one party to continue if the others enter its decommissioning phase (e.g. legal status of the activities or the share of decommissioning costs). If decommissioning is managed poorly, or inadequate funds are made available, there is the risk of substantial contamination of the local environment and damage to nearby assets at sea.

Mitigations include a decommissioning plan developed at project inception while minimising the complexity and impact during decommissioning should be considered at design stage. A sinking fund could be included in the business model to ensure adequate finances are available to decommission the site. The sinking fund would require businesses to regularly set aside money for the gradual repayment of a debt or replacement of a stranded asset and would need to conform to mandatory rules on decommissioning of assets at sea in Belgium.

Risk item 4: connectivity issues

A well-functioning Data Acquisition and Control System (DACS) and communication system rely upon internet connection to the DACS for data retrieval and/or reconfiguration of mission control. Site-to-shore communications are critical to safe and efficient operations yet many at sea locations are poorly served (e.g. limited or poor 4G available on site). Connectivity failure could lead to a number of risks including malfunctioning equipment, poor understanding of site conditions leading to inappropriate response decisions by the onshore team, injuries and fatalities, damage to assets, and slow response times. Consequences of miscommunications are higher when additional hazards are present (i.e. during a storm).

Potential mitigations include alternative connectivity protocols and transmission systems to transmit data from site devices to shore.

Risk item 5: damage risks of mechanical loads and collisions with vessels/ships/fishing boats

Multi-use increases the number of trips required to the site by workers and boats. Crews coming onto the site may not have the specialist/knowledge and equipment required to safely interact with equipment from other multi-use businesses. This increases risks of vessel collision with other multi-use vessels and with equipment. Collision could cause significant damage to individuals, the marine environment, and physical assets. Higher volumes of marine traffic also cause greater disturbance for the local ecosystem. Shipping can harm the environment through discharges at sea (e.g. oil, wastewater, paints, ballast water, and marine litter), airborne emissions (e.g. engine exhaust, refrigerants, and other volatile chemicals), noise, and shipwrecks or unmanaged scrapping of equipment. Intensified marine traffic also increases the likelihood of dropped items into the sea.

Mitigations include planning and close coordination between multi-use businesses to minimise risks and disturbances to the ecosystem. This could include actions like: a) designing the site to minimise risk of collisions; b) sharing site visit schedules; c) reviewing other partners' equipment and working collaboratively to reduce risks; and d) sharing trips to site (e.g. for monitoring/sampling).

Exploring opportunities for remote control operation of the site with high durability automated monitoring devices could reduce need to visit the site.

3.3.2.1 Food and feed

Here the key risks for the SOMOS framework category food and feed are assessed. The key risk identified for the European flat oyster (*Ostrea edulis*) is the potential presence of parasites such as *Bonamia* and *Marteilia*, of which the presence in the Belgian part of the North Sea is unknown (status unknown). The parasites create a threat to the flat oysters. Quick response/fast track food (for human consumption) and fodder (animal feed) quality tests are not yet established within the EU meaning that it can be challenging to identify all types of contamination in a timely way. It usually takes up to a week to confirm the diagnosis of the presence of parasites. With regards to seaweeds, the evidence base is still emerging for diseases and harmful parasites in European waters that could result in loss of biomass, quality or food safety. Potential risks include excessive levels of arsenic, cadmium, lead and mercury in the biomass². Quick response/fast track food and fodder quality tests are not yet established within the EU meaning that it can be challenging to identify all types of contamination in a timely way. Failure to fulfil customer orders leads to short-term loss in revenue and medium-term reduced trust in the business from customers. There is also a health risk for customers if contamination is not identified.

Potential mitigations include ensuring the design of the multi-use production site minimises risk of cross-contamination between the multi-use activities (e.g. accounting for tidal flows) and working collaboratively with testing facilities to improve testing procedures. Establishing agreed working practices with multi-use partner organisations that minimise risk of contamination could also be beneficial. Controlled, frequent monitoring, working with wider public and private sector stakeholders is critical to ensuring quality and safety of the food and feed produced. World Organisation for Animal Health (OIE) and Ifremer guidelines for the detection of parasites can give a strong basis for designing appropriate protocols.

3.3.2.2 Safety to man and equipment

Here the key risks for the SOMOS framework category safety to man and equipment are assessed. There is a number of additional risks for safety to man and equipment to those already identified as top risks for this type of multi-use activity (damage due to extreme adverse environmental catastrophic events, connectivity issues, decommissioning of assets, and damage risks from mechanical loads and collisions). These risks are:

² See for example: Banach J et al (2020) Food safety hazards in the European seaweed chain - <https://ift.onlinelibrary.wiley.com/doi/full/10.1111/1541-4337.12523>

- Lack of general technological and technical knowledge available from the industry involved in MU such as knowledge of the time and scale of spat fall, growth rates of oysters and seaweed, lack of access to all available data for project marine scientists, and limited knowledge on behaviour of some of the test equipment in the open sea.
- Lack of general technological readiness level of all the parties involved with the MU as offshore marine equipment can be technically complex, expensive and safety is critical.
- Risk of damage in case of mooring failure due to standard vessels within the commercial fishing fleet often being inadequate for multi-use operations.
- Drifting aquaculture equipment such as oyster cages attached to the backbone with weights. Biofouling and corrosion affecting the functioning of equipment on site, including monitoring equipment operated by third parties. Biofouling risks can cause lines to increase in weight and if structures become completely covered adequate water and feed-supply to the animals could be constricted (e.g. when the meshes of baskets close up due to fouling, the animals inside might lose access to water which brings oxygen and feed and therefore die due to lack of those). Potential mitigations focused on the people involved in the MU include: investing in training for employees to ensure equipment and processes are well understood; investing in research and development; participation in projects that aim to share information and experience; undertaking simulations; ensuring the project teams include adequate commercial expertise to ensure financial business impact are well managed; and working with governmental actors and other businesses to support development of the whole value chain to help develop implementable technical solutions that address the risks identified.

Additionally, mitigations focused on the equipment utilised including optimised design to minimise risk of entanglement including during mooring and damage during storms; regularly inspecting equipment to ensure it is not damaged, especially after storms and other events at sea; regularly cleaning to prevent biofouling build-up; and selecting equipment/material that is resistant to biofouling and corrosion to reduce cleaning requirements and risk of critical failures.

3.3.2.3 Environmental and cumulative impact

Here the key risks for the SOMOS framework category environmental and cumulative impact are assessed. The key risk identified from biomass production and the real and perceived potential conflicts among marine ecosystem flora and fauna due to artificial introduction of invasive species. Biomass production could also attract unwanted invasive species at the location of the MU. Introduction of seaweed and oysters could each alter the local marine ecosystem positively or negatively. Risks include mating with native species (if future multi-use sites introduced species that are genetically distinct to native species) and competing with native species for space and light. If managed poorly, this could hurt the ecosystem balance in the area. Potential mitigations include undertaking environmental impact assessments that comply with local permitting legislation and inform on appropriate species mix, quantities of production, and mitigation measures to limit risks for the local ecosystem. Monitoring ecosystem health during construction and operations would help identify any actions that may be necessary.

3.3.4 Key risk management recommendations

There are a number of key risk management recommendations that can be applied to mitigate a large proportion of the risks faced by the Belgian pilot. These include:

- Designing the site to minimise and optimise interactions between the infrastructure used for each multi-use activity.
- Optimising design to select equipment that is resistant to biofouling and corrosion and to minimise risk of entanglement including during mooring.
- Developing robust safety protocols at the port, on vessels, and at the site for all eventualities including storms, earthquakes and daily hazards, and ensuring all entrants on site are adequately trained in safety procedures. One approach is through preparing method statements prior to every action at sea to ensure safety of personnel and the infrastructure present.
- Close co-ordination between multi-use actors to ensure each's operations are well understood and finding opportunities to minimise visits to the site.
- Working collaboratively with insurers and other stakeholders to find solutions throughout the supply chain, including in the provision of adequate insurance.
- Investing in predictive models for accurate weather forecasting for a longer period in advance as well as growth prediction of aquaculture species.

Combined, the risk mitigations identified in the risk analysis (Annex 3) will address a large proportion of risk of multi-use of seaweed, OWF, and restoration activities. Remaining residual risk will need to be carefully managed.

3.4 Danish Pilot

3.4.1 Description of the pilot

The Middelgrunden Wind pilot considers multi-use of tourism and offshore wind in shared sea space with joint on and offshore infrastructure and operational activities. Activities include detailed lectures and explanations about offshore wind and wind energy developments in Denmark, guided tours to Middelgrunden wind farm including sightseeing boat tours and getting on top of the foundations, and shared onshore facilities where to find virtual tours of the wind farm developed for the general tourism.. Middelgrunden Wind is an unusual OWFs operator for allowing tourism boats to approach the turbine closely and allowing visitors to climb the nacelle. The combination of tourism and offshore wind is increasingly gaining interest in Europe as shown in project like TROPOS, MUSES, etc., as it can derive long-term benefits for local communities by encouraging and promoting innovation, entrepreneurship and job growth. This may especially be a good opportunity for rural and areas in need of an economic boost through tourism development. This pilot is expected to increase the TRL level of the multi-use solution and to expand tourism activities related to offshore wind (boat tours, leisure fishing and diving) in such a way that it can be a part of the general tourism offer in Copenhagen and the region. The pilot is to serve as a demonstrator of the improved multi-use information technology (boat scheduling system) and physical technology (facilities for divers on the platform) and advise the health and safety (H&S) practices, regulation, safety zone measures, and demonstrate operability and profitability of the multi-use solution.

This risk analysis draws primarily on a number of key sources:

- Previous deliverables within the UNITED project (such as D.1.1, D1.3, D4.1, D4.2, D5.1 and D6.1).
- Interviews with the pilot leadership team.
- Supplementary desk-based research to understand the risks and potential mitigations in greater detail.

Once drafted, the risk analysis was reviewed and validated by the Middelgrunden Wind pilot team to ensure that identified risks and hazards and proposed mitigations were reasonable and effective based on their experience delivering the pilot.

Below is a summary of the risk analysis which can reviewed in full in Annex 4. The top five risks are identified in terms of pre-mitigation risk before reviewing risks using the SOMOS framework of food and feed, safety to man and equipment, and environmental and cumulative impact. Finally, key recommendations for risk management are highlighted.

3.4.2 Risks identified

The top five highest risks, based on the magnitude of their impact and the probability of the risk occurring are presented below. They were determined according to the pre-mitigation score, calculated as described in Section 2.4, obtained in the risk analysis performed. Risks have been identified on the basis of pilot activity, in view of the future risks and hazards that scaled up multi-use activities of this nature could face. 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.

Risk item 1: inadequate insurance

The risk with the highest pre-mitigation risk score is inadequate insurance. It is challenging to define the insurance responsibilities of this activity. Regarding the tourist business, there are several stakeholders: the owners, the staff, the tourists, and the boat drivers. In addition to this, wind power generation insurance needs to cover staff and infrastructure. Some infrastructure can be particularly at risk with high financial costs to repair damage, such as sea cables connecting to the monopiles are at high risk of boat collisions. The result is that the cost of insurance is high because it must cover simultaneously two completely different activities. The problem of not achieving full insurance coverage could cause major consequences to the company particularly due to outside, untrained individuals visiting the site. Not being fully insured does not increase the risk of each activity, but it does increase the consequences of an event for the operators. As a result, lack of insurance is considered an issue that compounds the consequences of all other risks to individuals, the environment, and businesses as under-insurance can lead to an inability for operators to recover from risk events.

Drawing up detailed safety protocols for different activities and operators could help insurance companies better understand the MUPs' risk profile and trust the companies' ability to manage risks appropriately. In this way, premiums for full coverage could be lowered and broader coverage achieved. It is also possible for minor risks to create a self-insurance fund within the company.

Risk item 2: severe weather

The risk with the second highest pre-mitigation risk score is severe weather which puts both individuals and the environment at serious risk. Bad weather endangers the wind farm infrastructure, which can be damaged and in the worst cases, detachment can occur. If material is lost at sea, the environmental and ecological damage is high, and the company will have to bear the repair costs and clean-up costs. Furthermore, bad weather endangers tourists and staff. They may be in put at serious injury risk if they were on the site or boats during an extreme weather event. Cancellations will result in participants being reimbursed, which can lead to liquidity problems for the company. In addition, if the boat service is performed externally, this incurs a cost to the tourism company because it will still have to pay for the rental.

Extensive protocols should be developed to ensure safety including at the port, on vessels, and at the site. Equipment installed should be reviewed and designed to minimise environmental hazard and likelihood of detachment. Regular checks should be made to ensure equipment has not detached and reasonable efforts made to recover all equipment. Health and safety training should be mandatory for all workers on the site. Tourists should receive basic instructions on safety rules and how to behave in an emergency, before entering the site. The training should be refreshed regularly including emergency drill practices. The weather forecast should be monitored continually with appropriate protocols developed for each eventuality. Installing on-site sensors can help with information gathering, and it is also possible to collaborate with forecasting experts in the area. As part of developing the protocols, consultation with the coast guard should be made. Insurance should be taken out to cover damage, working closely with insurance companies to identify an appropriate allocation of risk between the insurance company and the business. Disaster recovery plans should be developed to determine the best approach to stabilising and repairing the site in the event of severe damage. A marketing plan could help mitigate the impact of visits cancelled by severe weather conditions. In case of a cancellation due to external causes (weather or storm), it is important to adopt a customer care approach, proposing an alternative to the visitors, which will increase customer loyalty, satisfaction and corporate reputation.

Risk item 3: presence of tourists and workers on the wind farm interacting with the infrastructure

The risk with the third highest pre-mitigation risk score is the presence of tourists and workers on the wind farm interacting with the infrastructure. This situation leads to several technical, administrative, practical, and legal issues that must be considered. Opening the wind farm to tourists increases the risk of personal injury since tourists are untrained members of the public. Hazards on site can be various and include the presence of tourists at height, boarding the site by climbing a ladder, transporting tourists by boat at which points there is a risk of falling into the water or hitting a structure component and getting injured. At any point on a visit, there could be trips/slips/falls. Incidents due to the tourist of OWF operating company's negligence can have great consequences for reputation and social acceptance of the business as well as legal liabilities.

Appropriate mitigations include precise safety protocols for staff and tourists. Risk management procedures must be reviewed frequently, because new issues may arise that were not previously considered. Staff must be trained to manage risks and incidents at the site for their own safety and the safety of outside visitors. Arranging comprehensive injury insurance coverage is important to limit consequences of legal action.

Risk item 4: lack of specific technology knowledge

The risk with the fourth highest pre-mitigation risk score is lack of specific technology knowledge. Given the nature of MUPs in which two (or more) different activities form the core business it can be challenging to find appropriately qualified/experienced staff to hire. A lack of technological knowledge of how the windfarm operates could cause serious damage to people and infrastructure as untrained tourists enter the site.

Therefore, it is necessary to develop precise and detailed protocols for behaviour within and for journeys to/from the site. Both the OWF company and the tourism company can also invest in training staff on how to interact with others within the windfarm site and the infrastructure to ensure equipment and processes are well understood. Some training sessions could be combined to help transfer knowledge and build trust between the parties.

Risk item 5: structure failure

The risk with the fifth highest pre-mitigation risk score is structure failure. Structure failures in complex facilities such as those used in wind power can occur from a variety of causes including: bird strikes, lightning strikes, rainfall, blade furniture detachment, delamination, leading-edge corrosion or blade cracks. Energy production depends on the proper functioning of the structure and structure failure could also cause serious accidents to visitors and damage to the environment if they involve leaks. Revenue will be lost and it could be difficult to cover production costs. Repair costs could be very high. The multi-use pilot project adds the risk that untrained tourists may accidentally damage some of the more vulnerable parts of the structure.

Mitigations include developing a robust operation and maintenance plan which incorporates created by and to tourists visiting the OWF. Incident management protocols, staff trained to handle facility incidents, and ensure insurance coverage includes facility failures are other beneficial mitigations.

3.4.2.1 Food and feed

Here the key risks for the SOMOS framework category food and feed are assessed. No food or feed risks have been identified due to no biomass production on site.

3.4.2.2 Safety to man and equipment

Here the key risks for the SOMOS framework category safety to man and equipment are assessed. Most risks identified for this multi-use pilot related primarily to safety to man (staff and tourists). Highest risks of severe weather, interacting with infrastructure, structure failure, and lack of technical knowledge all fit this category and have been discussed in 3.4.2. The OWF was founded in 2000, which means the turbines are now 22 years old. Equipment, such as the gearboxes, control system, and power electronic system, may be coming to the end of their useful operating lifespan and so need to be replaced. However, this entails a major cost to the OWF operator that it can only bear if the selling price of the electricity produced by the wind farm is high enough. The price of electricity is volatile and dependent on external factors such as geopolitical events. Obsolete equipment is more likely to break down, potentially causing severe incidents, not only to infrastructure but also to people (staff and tourists). The presence of tourists in the structure increases the risk of injury. It is necessary to check the maximum weight capacity of the platform, also considering the years of structure lifespan.

To mitigate the impacts, a good infrastructure asset management plan can enable a timely infrastructure change. The replacement plan should be developed at the beginning of the project. A sinking fund could be included in the business model to ensure that adequate funds are available for site renewal and decommissioning. Also, to mitigate the risk of incidents involving tourists, it is important to have dedicated and trained guides who carefully monitors tourists' behaviour. It is also beneficial for the tourists to receive basic training about the appropriate behaviour inside the facility.

Restrictions due to COVID-19, especially the regulation of interpersonal distance and people mobility may create problems for tourism. It is therefore necessary to keep up to date with the regulations set by the Danish government. The tour includes sharing spaces such as the boat and in-side the turbine that could increase the chances of infection among tourists. It is complicated to predict case increase, and this creates uncertainty in ticket sales. For periods when restrictions are in place, a marketing plan can be devised to continue to attract people's interest, e.g. developing an attractive website, advertising on social networks, offering discounts to be used when reopening to the public to help stimulate demand after restrictions are softened. Furthermore, it is possible to consider outsourcing social media functions to improve visibility.

3.4.2.3 Environmental and cumulative impact

Here the key risks for the SOMOS framework category safety to man and equipment are assessed. The primary environmental risk of the Middelgrunden pilot project are related to the polluted condition of the site, which after being used as a dump in 1975, analysis shows the presence of heavy metals in the water. Polluted water affects the environment by contaminating living organisms such as plants and fish that are then consumed by humans (Sankhla et al., 2016). High levels of heavy metals can cause risk of acute and chronic toxicity, liver, kidney, and intestinal damage, anaemia, and cancer. This prevents the company from scaling up by adding new activities such as aquaculture (fish, shellfish, seaweed) to its multi-use project because there may be a risk of product contamination. Other more tourism-related activities may also be difficult to implement as diving and recreational fishing for the same reason.

Another issue closely related to equipment replacement is its renewal and disposal. It is important for the company to follow a disposal plan by complying with all institutional guidelines so as not to affect the environment during this operation.

The company, after conducting proper analysis, could consider a plan to clean up the area, but this could be a prohibitive cost. It is important to establish practices to prevent human contamination by the water.

3.4.4 Key risk management recommendations

The Danish pilot is an already established OWF. The new multi-use added is the cooperation with the tour company. This creates new risk due to untrained individuals entering the site and interacting with the infrastructure. To mitigate the new risks, the OWF and tour companies should develop detailed internal protocols for how all participants should act within and journeying to/from the site. Protocols should also account for abnormal situations such as severe weather. OWF operator and tour company can work together to ensure staff have a strong understanding of each other's processes and equipment to minimise risk of damage and accidents. Collaboration with insurance providers can also help strengthen understanding of new risks and so lower insurance premiums and broaden coverage.

3.5 Greek Pilot

3.5.1 Description of the pilot

This pilot aims to combine aquaculture and tourism activities in marine space. KASTELORIZO AQUACULTURE SA is a company that operates in production marketing and exploitation of fish farms with many varieties of fish, shell- fish in fresh or frozen form as well as distribution of product at Greek premises and abroad. The company operates a fish-farming unit, on floating facilities in the marine area near islet Patroklos (the islet is located near the coast, 850 meters from the shore). There is strong tourist interest in the area, as many tourists visit the coasts of Patroklos islet mostly with private boats, while in the summer a boat provides the service of transferring tourists to the island. The islet is private property but it is allowed to visit Patroklos beaches to swim. Scuba-diving is also very popular in that area, as there are many underwater attractions. One of them is a shipwreck, as well as ancient

artefacts that can be traced in the seabed of the area. Other ways in which the aquaculture and tourism activities may be combined is by organising (seafood) boat tours of the marine area, cooperating with aquaculturists as speakers on these tours and providing the opportunity for tourists to taste their product.

One issue that should be taken into consideration, is that island Patroklos is a private property that has also been characterized as an archaeological area and placed in a zone of protection which prohibits any kind of construction. Other possible barriers to realizing multi-use that were identified in the pilot document include economic concerns (opportunity costs, disruption of farming operations and balancing value and expectations with costs), societal concerns (disapproval of the aquaculture operation by the local community) and environmental issues (risk of excessive feeding of fish, impact on stress levels of fish).

This risk analysis draws primarily on a number of key sources:

- Previous deliverables within the UNITED project (such as D.1.1, D1.3, D4.1, D4.2, D5.1 and D6.1).
- Interviews with the pilot leadership team.
- Supplementary desk-based research to understand the risks and potential mitigations in greater detail.

Once drafted, the risk analysis was reviewed and validated by the Kastelorizo pilot team to ensure that identified risks and hazards and proposed mitigations were reasonable and effective based on their experience delivering the pilot.

Below is a summary of the risk analysis which can reviewed in full in Annex 5. The top five risks are identified in terms of pre-mitigation risk before reviewing risks using the SOMOS framework of food and feed, safety to man and equipment, and environmental and cumulative impact. Finally, key recommendations for risk management are highlighted.

3.5.2 Hazards and risks identified

The top five highest risks, based on the magnitude of their impact and the probability of the risk occurring are presented below. They were determined according to the pre-mitigation score, calculated as described in Section 2.4, obtained in the risk analysis performed. Risks have been identified on the basis of pilot activity, in view of the future risks and hazards that scaled up multi-use activities of this nature could face. 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.

Risk item 1: inadequate insurance

The risk with the highest pre-mitigation risk score is inadequate insurance. Covering several activities is complicated and often expensive, hence MUPs projects find it challenging to achieve full coverage. In this specific case, the insurance must cover the aquaculture activity and the risk of people diving. Insurance companies are often unwilling to cover damages due to bad weather that put companies' profits at risk, as there are increasingly frequent extreme weather events. Failure to achieve full coverage can have significant consequences, since tourists are involved and there could be serious injuries, which would also undermine the company's reputation and image. Not being fully insured does not increase the risk of each activity, but it does increase the consequences of an event for the operators. As a result, lack of insurance is considered an issue that compounds the consequences of all other risks to individuals, the environment, and businesses as under-insurance can lead to an inability for operators to recover from risk events.

To mitigate this issue, it is necessary to draft up internal security protocols. Tourists must be informed of all safety rules. They can be asked to sign a form to share individual responsibility while diving. The procedures need to be updated frequently, because new issues may arise over time, and it is important that these are included promptly. Drafting detailed protocols of safety rules for different activities and operators and collaboratively working with insurance companies could help the insurance company understand the risk profile better and trust that the com-

pany can appropriately manage risks. If obtaining comprehensive insurance turns out to be too costly or complicated, one option for the Greek pilot in which the two businesses still operate independently is to maintain its separate insurance in order to have both businesses covered. This could result in higher costs.

Risk item 2: severe weather

The risk with the second highest pre-mitigation risk score is severe weather. Severe storms can cause high losses to aquaculture farmers due to damage to infrastructure, leading to high damage recovery costs (Canadian Institute for Climate Studies, 2000). For example, storms and waves can cause severe damage to aquaculture cages. Detachment and its subsequent loss at sea could occur, resulting in serious ecological as well as economic damage. Therefore, the increasingly frequent occurrence of abnormal storm surges, waves and cyclones is considered a threat to aquaculture production and other coastal activities (Hamdan et al., 2012). Weather conditions are also important for tourism.

Extensive protocols should be developed to ensure safety including at the port, on vessels, and at the aquaculture site. Equipment installed should be reviewed and designed to minimise environmental hazards and likelihood of detachment. Long term impacts of ocean salinity should be considered on all materials used. Regular checks should be made to ensure equipment has not detached and reasonable efforts made to recover all equipment. Health and safety training should be mandatory for all workers and visitors to the site. The training should be refreshed regularly including emergency drill practices. The weather forecast should be monitored continually with appropriate protocols developed for each eventuality. As part of developing the protocols, consultation with the coast guard should be made. Under severe conditions diving must be cancelled to avoid risking injuries. Insurance should be taken out to cover damage, working closely with insurance companies to identify an appropriate allocation of risk between the insurance company and the business. Disaster recovery plans should be developed to determine the best approach to stabilising and repairing the site in the event of severe damage.

Risk item 3: site water quality

The risk with the third highest pre-mitigation risk score is the site water quality. Fish are highly sensitive to changes in parameters such as toxic substances, pH, temperature and presence of gas. The quality of the water in the aquaculture can significantly affect the organism's health and the costs associated with getting a product to the market. Water contamination could make the whole stock unsuitable for human consumption. This can lead to a large loss of revenue for the company. Diving in contaminated water can endanger the health of divers if precautions are not taken (Quemerais, 2015). In addition, water pollution can cause serious damage to the ecosystem. It is necessary for the farm to monitor pollution produced directly from the fish farm. Various problems may arise (Martinez-Porchas et al., 2012):

1. Accumulation of fish in the same area can cause damage to the environment as nutrient and waste accumulation occurs. This can deplete the water of oxygen, creating algal blooms and dead zones.
2. Introducing exotic species into the farm could put the local ecosystem at serious risk.
3. Nitrate released from the decomposition of uneaten food and dead specimens can release toxins dangerous to marine organisms and humans.
4. Fish overmedication (hormones, antibiotics, and parasiticides) can cause imbalances in the ecosystem.

During the planning stages of the activity, a feasibility study should be conducted to define the area in which to farm. It is important that frequent analysis be done on the water and fish in the farm to prevent the development and spread of diseases. This can be costly and time-consuming for the company, which could rely on technological tools such as sensors or detectors to mitigate the risk. In addition, it is important to follow all present aquaculture regulations to avoid creating water pollution. Avoiding substances harmful to the environment and implementing ecological practices can improve water properties and ecosystem well-being. It is necessary for the company to regularly monitor water parameters and develop an action plan to restore water quality if it becomes polluted. It is possible to dedicate a fund within the company to clean up the area. Finally, it is important to have staff updated on local and international regulations for the welfare of the environment and animals.

Risk item 4: anchoring boats near the site

The risk with the fourth highest pre-mitigation risk score is anchoring boats near the site. Improper anchoring can cause damage to vessels, infrastructure, and the environment. Losses from groundings and collisions due to dragging or loss of anchor can be significant and cause serious environmental problems. Problems with anchoring can also endanger workers and divers. Fuel leakage could also occur, which must be cleaned up implying a cost to the company and significant damage on the ecosystem.

In order to mitigate this risk, it is necessary to have robust anchoring procedures that align with the anchoring equipment used, and trained and qualified staff.

Risk item 5: camera and sensors

The risk with the fifth highest pre-mitigation risk score is camera and sensors. The onshore team's understanding of site conditions within the cages relies upon functioning cameras and sensors on site. If poorly installed or of low quality, or not maintained/cleaned, malfunctioning could occur. Camera/sensor failure could lead to a number of risks including poor understanding of site conditions leading to inappropriate response decisions by onshore team, injuries and fatalities, damage to assets, damage to marine ecosystems, damage to aquaculture fish, and slow response times. Consequences of malfunctions are higher when additional risks are in effect (ie during a storm). In addition, if not fixed well to the aquaculture cages, cameras and sensors could be lost to the environment.

3.5.2.1 Food and feed

Here the key risks for the SOMOS framework category food and feed are assessed. Water quality is a key factor in fish aquaculture operations. Poor water quality reduces growth and affects fish health. It is the third highest pre-mitigation risk and is discussed in 3.5.2. To the extent that they affect the quality and safety of the aquaculture produce, many of the other risks identified impact food and feed, but were not identified primarily as this category of risk.

3.5.2.2 Safety to man and equipment

Here the key risks for the SOMOS framework category safety to man and equipment are assessed. In addition to weather conditions, anchoring of vessel issues and cameras and sensors, already discussed in 3.5.2, connectivity issues and power supply are risks identified to safety to man and equipment. Connectivity with internet and other communication means such as mobile phones can be complicated to set up offshore but essential for operational and safety communications. Lack of communication at sea can put both staff and tourists at risk. In addition, the lack of direct connectivity does not allow for timely action on any damage to the infrastructure, risking more serious damage that is costly to repair. Equipment on the site needs a reliable and sufficient capacity power supply. This includes cameras, sensors, and lights. Activity at the site could damage the cables. The site relies upon power supply.

Mitigation measures include research into new connectivity and data transmission alternatives such as LoRA, ZigBee, wifi, in order to transmit data from site devices. To check that site power supply is adequate for the devices to work, project team need to check the consumption of the devices and compare to the power supply options available on site in design proposals. If inadequate, the team should consider alternative power options or lower power usage options. Research into new sources of electricity for the aquaculture infrastructure could be beneficial (e.g. solar panels).

3.5.2.3 Environmental and cumulative impact

Here the key risks for the SOMOS framework category environmental and cumulative impact are assessed. A number of the other risks identified pose a threat to the environment but were not categorised primarily as environmental risks. Water pollution in particular can represent a significant environmental. Earthquakes was also identified as an environmental risk. Greece is located on a seismic zone of the earth making it an earthquake-prone area. In marine areas earthquakes can turn into strong waves that could damage the infrastructure, injure people (workers and tourists), and disperse debris into the sea, creating great ecological damage.

The unpredictability of earthquakes makes them very difficult to mitigate. Developing good safety protocols for workers and tourists in the event of an earthquake and taking out appropriate insurance levels to cover damage, and disaster recovery plans are all potential mitigations.

3.5.4 Key risk management recommendations

The analysis conducted identified several risks and possible mitigation strategies. Ensuring adequate insurance, developing safety protocols for severe weather, monitoring and ensuring water quality, and ensuring anchoring and monitoring equipment are safely deployed are the critical safety activities. In addition to what has already been highlighted, it is possible to increase stakeholder engagement so as to understand where other local stakeholders may be disturbed by the companies' activities.

4. CONCLUSIONS AND RELEVANCE FOR UNITED

4.1 Conclusions

Undertaking the five pilot risk analyses have revealed a large number of common risks for multi-use at sea and also distinct risks based on the nature of the multi-use activities being undertaken. Table 2 below presents the top five risks for each pilot, before mitigation activities are undertaken. Insurance coverage and severe weather are the top two identified risks for all five pilots suggesting challenges regardless of the nature of the multi-use activity undertaken. The three to five highest risks identified are more varied with topics identified by multiple pilots including water quality, decommissioning, lack of specific regulations, and structural failures caused by multi-use activity equipment interacting. The detailed risk analyses included within the appendices show the small differences in the pre-mitigation risk scores for risks three to five for most pilots suggesting a similar size of risk for each risk item identified.

Risk No	German	Dutch	Belgian	Danish	Greek
1	Inadequate insurance coverage	Inadequate insurance coverage	Inadequate insurance	Inadequate insurance	Inadequate insurance
2	Severe weather	Severe storms	Environmental catastrophic events	Severe weather	Severe weather
3	Lack of qualified staff	Activity on the site by other multi-use partners	Decommissioning of assets	Presence of tourists and workers on the wind farm interacting with the infrastructure	Site water quality
4	Water quality at production site	Decommissioning of assets	Connectivity issues	Lack of specific technology knowledge	Anchoring boats near the site
5	Lack of regulations for multi-use at sea	Engineering design solutions interacting	Damage risks of mechanical loads and collisions with vessels/ships/fishing boats	Structure failure	Camera and sensors

Table 2 - Top five pre-mitigation risks for each UNITED pilot.

A number of complicating factors that increase the level of risk within a multi-use site can be identified from the five pilot risk analyses. Increasing the number of distinct business activities operating within the multi-use site increases the complexity of the operations, however particularly challenging is when a new multi-use activity introduces:

- Production of biological material such as seaweed, mussels, oysters, or fish to the site as this means all multi-use activities must be aware of the impact of their activities on the produce being cultivated. This includes implications for food safety, yield and quality considerations. The biological material also introduces new hazards and risks onto the site such as biofouling on the site equipment.
- A business need for members of the public to enter the site for tourist reasons as this introduces risks from individuals that have not undergone extensive health and safety training interacting with the multi-use site equipment.

The frequency of visits to the site required is an additional important driver of risk. If the multi-use activity requires frequent visits to the site as it changes the volume of vessel traffic and the number of people within the multi-use site. The value of the assets also drives the size of the risk as it changes the financial impacts of an accident at sea and the cost and willingness of insurers to provide insurance coverage.

In the event of a risk event being realised, harm can occur to many different parties. Key actors at risk are: the workers that operate on site; tourists entering the site (if applicable); the businesses operating within the site (in the event of revenue disruption or unforeseen costs); the businesses operating in the vicinity of the site when their operations are affected; the flora or fauna being cultivated (if applicable); marine plants and animals in the local ecosystem; consumers of the products being produced within the site; and wider stakeholders such as local residents.

Identified risk mitigations also require the involvement of numerous actors to address these risks identified. Some risk mitigations require external collaboration with multi-use partners, regulators, supply chain actors, insurers, and local stakeholders to overcome. The risk analyses suggest however that even with limited collaboration, productive risk mitigation is possible such as developing site safety protocols in the event of severe weather. Various skillsets and expertise areas are required to mitigate risks including in the areas of site management, engineering, life sciences, commercial, stakeholder management, and policy and regulation development. Most risks should be considered at the project design stage and monitored throughout the multi-use assets lifecycle through to decommissioning.

Two different types of risk can be identified. Direct and indirect risks. Direct risks can immediately cause damage to people, assets, and the environment such as entanglement from detached equipment at sea. Indirect risks cause damage over time such as if an event causes a reduction in business viability harming investor confidence and thereby reducing financial resources that can be used to invest in operations and safety. The SOMOS risk categories of food and feed, safety to man and equipment, and environmental and cumulative impact broadly align to many hazards and risks identified, though there is considerable overlap across the categories as several items cause risk in multiple categories. An additional risk category to consider for future SOMOS framework risk analyses could be business viability, in order to better capture indirect risks that affect business operations more than they affect the site.

The risks identified have the potential to slow down the rollout and scale-up of multi-use at sea as they increase the costs of delivering multi-use projects, the complexity of the sites, and the capability requirements for workers operating within the site. Where multi-use proceeds with inadequate risk mitigation, consequences can be catastrophic including death or serious injury to people, assets, and the environment. The risk analyses however suggest that most risks identified can be mitigated well, leaving a substantially smaller residual risk for the multi-use sites.

Figure 3 below summarises the key findings from the pilot level risk analyses.

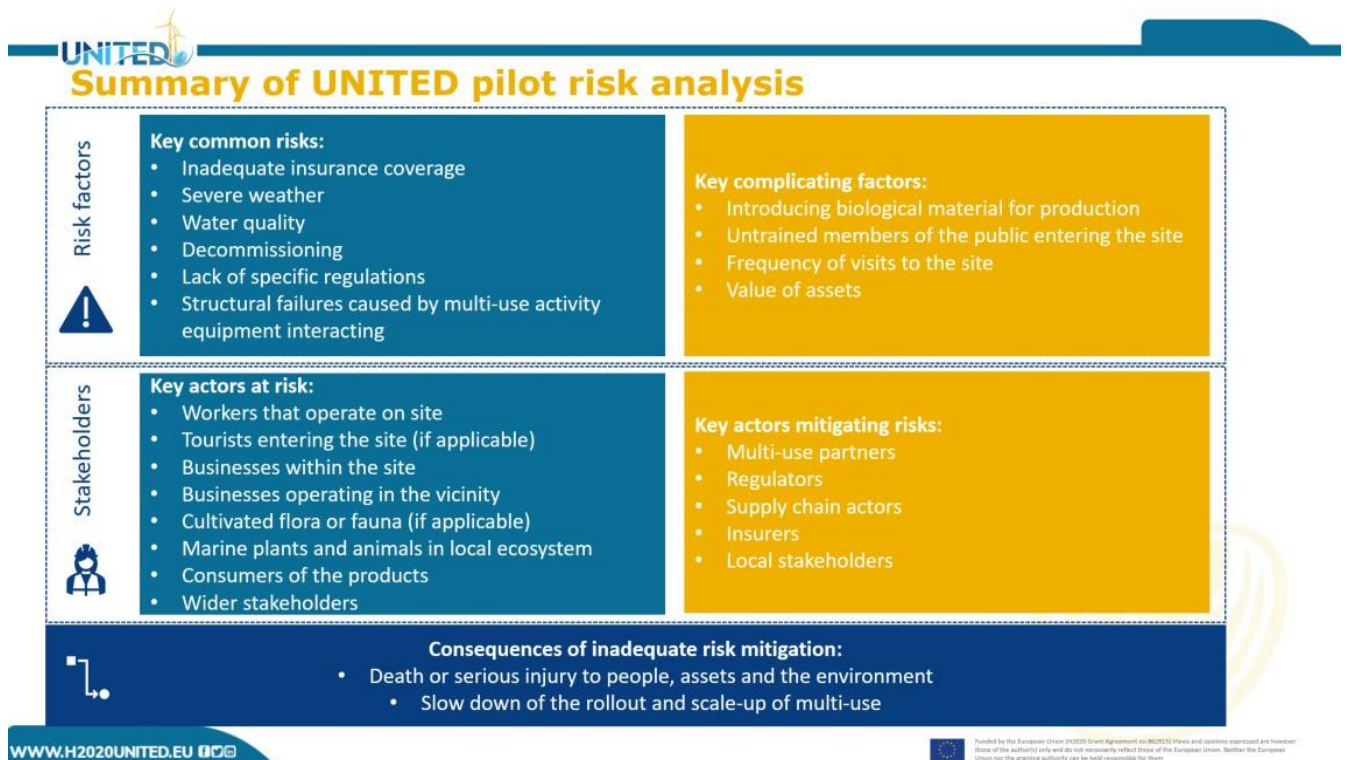


Figure 3 - Summary of key findings. Source: own figure

4.2 Relevance for UNITED

This deliverable provides an overview of the key risks identified for each of the five UNITED pilots as well as identifying potential risk mitigation activities that could reduce the residual risk faced. The UNITED risk analyses are expected to provide a starting point for businesses and stakeholders considering developing multi-use at sea projects in the future. Each future multi-use site will need a thorough and systematic, site and business model specific approach to risk appraisal in order to ensure risks are minimised. By identifying the risks, the deliverable should facilitate future design of multi-use projects and allow delivery partners, policy makers, and stakeholder to make better informed decisions about the investment opportunities.

The findings from this deliverable will be incorporated into D6.4 (Manuscript of Synthesis of Risk Governance) alongside the findings from D6.1 (Inventory of legal and insurance aspects, risks and risk management options and the wider governance context of risk management) and D6.2 (Case specific report on legal aspects and insurance issues).

ANNEX 1

See overleaf the German pilot risk analysis. The pre-mitigation risk analysis is presented first, followed by the post-mitigation risk analysis which shows the level of residual risk once suggested mitigations are implemented. While this risk analysis can be used as a starting point, all future multi-use pilot projects should undertake their own risk analysis as hazards, risks and appropriate mitigations are highly context specific.

ID	Hazard	Hazard description	Risk description	SOMOS Framework	What are the consequences (on 1 - small to 5 - major scale)?				What is the probability (A is small, D is highest)				Pre-risk mitigation Risk Score
					People	Assets	Environment	Reputation	People	Assets	Environment	Reputation	
1	Lack of specific regulation for MUP	There is a lack of specific policy support in the form of regulation for multi-use projects (e.g., multi-use requirements for offshore wind farms, facilitated access to permits for offshore wind farms with a multi-use component, assistance in project design, facilitation of cooperation among operators). At the present time a clear regulation of multi use is missing at national level for the German pilot. It is possible to obtain individual licences for different activities, but it is not possible to obtain a general licence for the multi-use activity.	The lack of specific regulation for MUPs can create market inefficiencies, legal problems and failure to expand the industry. Possible impacts include: significantly delayed start of the offshore operation, additional workload, additional unforeseen costs to fulfill the unknown requirements, highly insecure planning and challenges promoting projects to investors. Finally there is difficulty in obtaining permits which can lead to a slow and complex process and project delays. In Germany, MUPs do not obtain licences for their overall activity, but are regulated individually (fishery, aquaculture and wind energy), which makes sufficient regulatory coverage possible. Hence, there is regulatory coverage for single activities, but limited interaction between them, which could lead to problems of different sizes.	Other	3 Major injury	3 Local damage	2 Minor effect	5 Major international impact	B	B	B	C	31
2	Lack of financial incentives	Financial markets and funds from private investors can be volatile. Many private investors and banks may not be aware of multiuse projects because they are still in the research and testing stage and incur high costs. Government financing programs are scarce, slow to implement and susceptible to political uncertainty.	Failure to secure full capital or revenue financing could lead to project failure, delays, unsustainable loans, inflationary pressures, contractual disputes with suppliers, and project/business failures. If the company accepts a loan with particularly punitive terms, it risks not being able to meet payments on time. In addition, it is challenging to have long-term business vision under conditions of financial uncertainty, and this could lead to underperforming investments.	Other	1 Slight injury	2 Minor damage	2 Minor effect	3 Considerable impact	A	B	B	C	18
3	Insurance cost and coverage	Insurance in MUP activities must be able to cover at the same time activities with different purposes and objectives (ie production methods, workers, equipment, etc) meaning the business elements that can be insured are often unclear. Some hazards are often not insured such as storms or earthquakes, this is dangerous for companies operating offshore given the likelihood of the risk.	Insurance is usually a risk mitigation activity. In some cases, as in the case of MUPs, uncertainty about insurance liability makes investment in these activities difficult. Too high a premium price resulting from a cautious approach from insurers can discourage business formation. In addition, the inability to insure for some weather and natural phenomena makes activities at sea riskier for the operator who must self-insure. While it is common practice for many companies to choose not to insure all elements of the business where insurance cover does not add sufficient value relative to the magnitude of the risk, not being fully insured does not increase the risk of each activity by increasing the consequences of an event for the operators.	Other	4 Single fatality	4 Major damage	3 Local effect	4 Major national impact	C	C	C	C	45
4	Aquaculture products market	European market for mussels is well established. The market for macroalgae, is still underdeveloped. This means there are significant market uncertainties for businesses focusing on seaweed production.	The absence of a mature and regulated market for seaweed products makes investment uncertain and creates volatility in the price of products. This risks businesses focusing on seaweed not being able to generate enough revenue to cover production costs. The market for mussels on the other hand is well developed in Europe and holds big revenue possibilities. Production size must be considered. This will make the companies uncompetitive and risk them going out of business. Jobs will be lost and there is a risk of abandonment of facilities in the sea, which could then harm the environment.	Other	2 Minor injury	2 Minor damage	3 Local effect	2 Limited impact	A	C	B	A	16

5	COVID-19	The COVID-19 pandemic caused a market slowdown, rising cost of raw materials, and general shortage of resources and labour. In addition, sales of some goods have declined significantly, particularly goods considered 'luxury'.	Some products such as mussels may remain unsold due to the expenditure restrictions due to COVID-19. High cost and unavailability of materials could cause a delay or cancellation of foreseen installations and prevent timely intervention following damage or malfunction. Lack of labour also risks affecting production and harvest. Depending on the location of the site, local conditions and the species chosen, some crops may survive longer and be sold in the future.	Other	2 Minor injury	3 Local damage	3 Local effect	2 Limited impact	B	B	B	B	20
6	Cost and availability of external services	Offshore MUPs depend on external service providers, such as charter of specialised ships or divers. The costs for these services are high and availability is limited, especially in some ports.	For some activities such as seaweed cultivation, the risk of not seeding or harvesting in time risks affecting the entire yield. It is important to install the seed longlines/nets and harvest at the right time, otherwise, if the waters get too warm and if there are storms the operator risks losing the whole yield.	Other	1 Slight injury	4 Major damage	1 Slight effect	3 Considerable impact	A	C	A	B	20
7	Food safety regulation	Strict food safety regulations mean that periodic testing of aquaculture products can be expensive and time-consuming.	Cost and complexity to obtain safety certification risks delays in getting product to market.	Food and feed	5 Multiple fatalities	2 Minor damage	1 Slight effect	3 Considerable impact	C	B	A	C	29
8	Weather conditions	In areas suitable for wind energy production, weather conditions can be very challenging. Intense weather conditions make the site inaccessible to the project team as boats cannot operate in extreme conditions.	Risks from a severe storm include cancelled trips, slips, injury and fatalities, hyperthermia, power outages, damage or destruction of assets, and damage to marine environment. Missions are generally not organised during the weather alert, but the nature of the danger and the area (North Sea) make it difficult to predict weather patterns with complete certainty.	Safety to man and equipment	5 Multiple fatalities	4 Major damage	4 Major effect	3 Considerable impact	C	C	C	B	45
9	Power supply	For the OWF part within a multi-use "aquaculture wind" scenario: the site relies on power supply to operate safely and transmission cables to transfer wind-generated energy to the grid. Activity at the site could damage	The risk of anchoring vessels damaging power supply cables. Halts to power transmission to shore and/or cuts electricity supply to site hurt revenue generation. Health and safety risk and risk of damage to assets if alternative power supply not available on site.	Safety to man and equipment	3 Major injury	5 Extensive damage	2 Minor effect	2 Limited impact	A	B	B	B	21
10	Social acceptance	Aquaculture is not socially accepted by some citizens because of negative examples derived mainly from fish aquaculture. People are often not aware that non-fed aquaculture (mussels, macroalgae aquaculture) can be more sustainable than fed aquaculture (fish). Offshore wind farms can be difficult for some local residents to accept because of the noise they generate and the visual impact on the landscape.	Risks from lack of social acceptance include: delays in acquiring or rejections of permit applications; restrictions to activities that prevent the site operating at potential; disruption and damage caused by protests. Lack of social acceptance also risks undermining the company's ability to finance operations, particularly with respect to local and private lenders. This could discourage scaling up the business. If the company suffers from a bad reputation among locals it may struggle to establish itself	Other	1 Slight injury	2 Minor damage	1 Slight effect	4 Major national impact	A	B	A	C	18
11	Lack of technical knowledge in MUP	Lack of general knowledge about technologies by managers and employees can generate inefficient production processes that lead to lower production volume and profit.	Low net operating surplus or losses lead to inability to scale. The risk of not adopting efficient technologies like other market players means operations may not be efficient enough to create sufficient revenue to cover costs. In addition, lack of technological knowledge can also have technical failure environmental and human impacts in case of platform accidents.	Other	3 Major injury	3 Local damage	2 Minor effect	3 Considerable impact	C	B	B	C	28
12	Lack of qualified staff	Skillsets required to operate within a multi-use site will likely be more broad than a single use site. As multi-use is a new activity, such skillsets will not be readily available on the labour market. Technical training to obtain the necessary skills and certifications to operate multi-use offshore can be expensive and time-consuming.	Poorly qualified and skilled staff can lead to serious injury and equipment and environment damage. Lack of skilled professionals also reduces the likelihood for further innovation.	Safety to man and equipment	4 Single fatality	4 Major damage	2 Minor effect	3 Considerable impact	C	C	B	C	37

13	Water quality	Water quality describes the condition of water, including chemical, physical, and biological characteristics. This parameter is crucial for aquaculture and a healthy ecosystem.	Poor water quality near the aquaculture site (algae and shellfish) puts the entire crop at risk. If the water is contaminated, the product fails food safety tests, so it cannot be sold for this purpose. A polluted site damages the surrounding ecosystem and if undetected potentially dangerous to the health of workers and/or final product consumers.	Food and feed	3 Major injury	2 Minor damage	4 Major effect	3 Considerable impact	B	B	D	B	32
14	Toxic algae blooms	Toxic algal blooms are the rapid growth of algae or cyanobacteria that can produce algae toxins and can cause harm to people, animals, or the local ecosystem. Harmful algal blooms cause thick, green muck that impacts clear water, recreation, businesses and property values.	Toxic algae blooms are caused by high water temperatures and high nutrient levels. Cultivation of mussels and algae lead to a certain extent to an uptake of nutrients and decreases eutrophication, but at the same time they produce residues that accumulate in the bottom of the seabed and could create problems for the ecosystem. The likelihood of toxic algae formation depends on water flow, species selection and scale of production. In the event of occurrence, mussel and seaweed production may be at risk. Injury to workers can occur when they are directly exposed to toxic algae via prolonged direct skin contact or ingestion.	Food and feed	3 Major injury	2 Minor damage	3 Local effect	2 Limited impact	A	A	B	A	13
15	Increased vessel traffic	The increase in offshore activities and different operators increases the presence of boats at sea. Marine traffic disturbs ecosystems and could endanger people.	If maritime traffic increases there is a greater risk of accidents at sea occurring. In case of an accident, rescuers could be slower to reach the location. This can also increase the grounds for conflict with other activities in the area. In addition, the noise of boats disturbs the flora and fauna in the area. Shipping can harm the environment through discharges at sea (e.g. oil, wastewater, paints, antifouling substances, ballast water, and marine litter), airborne emissions (e.g. engine exhaust, refrigerants, and other volatile chemicals), noise, and shipwrecks or scrapping. Higher marine traffic also increases likelihood of dropped items	Safety to man and equipment	3 Major injury	2 Minor damage	3 Local effect	2 Limited impact	C	B	B	B	23

ID	Hazard	Mitigation	Actions		What are the consequences (on 1 - small to 5 - major scale)?				What is the probability (A is small, D is highest)				Post-risk mitigation Risk Score
			Action By	Action When	People	Assets	Environment	Reputation	People	Assets	Environment	Reputation	Risk Score after Mitigation
1	Lack of specific regulation for MUP	If policymakers decide to support and permit MUP, the company should establish internal protocols to mitigate risks at commencement on site that set high standards for the protection of the environment and people. A detailed business plan can help secure project funding/financing. Finally, establishing a good working relationship with the public sector through the exchange of data and information can help to ensure emerging regulations and standards meet company business requirements.	Project commercial managers and site managers	Business development and operations	1 Slight injury	2 Minor damage	2 Minor effect	2 Limited impact	A	A	A	A	7
2	Lack of financial incentives	Priority should be given to credible partners and investors. Consider insurance measures (when convenient to be undertaken) or collaboration with public sector entities so as to share the business risk. Also, it is important to consider the possibility of obtaining grants from international bodies so as to overcome the lack of state funding. Having a good business plan supported by data from past years of operations to present to investors could increase mutual trust.	Business development and project management teams	Project development and fundraising	1 Slight injury	1 Slight damage	1 Slight effect	1 Slight impact	A	A	A	A	4
3	Insurance cost and coverage	Drafting detailed safety protocols for different activities and operators and collaboratively working with insurance companies could help the insurance company understand the risk profile better and trust that the multi-use companies can appropriately manage risks. This could allow for lower risk premiums and greater coverage of risks. Selfinsurance is an option for some less severe risks by building cash reserves and/or establishing flexible credit lines to be utilised in the event of the risk being realised. More pilot cases would deliver more experience and data for the insurance companies to calculate the risks.	Project managers and project commercial managers	Project development	2 Minor injury	2 Minor damage	2 Minor effect	2 Limited impact	C	C	C	C	24
4	Aquaculture products market	It is important to form a competitive European aquaculture industry through cooperation with other market players in the value chain. To maximise profits in international markets, seasonal and geographical fluctuations can be exploited by selling products flexibly into the most profitable markets. Good marketing and advertising campaigns can increase the products' reputation and consumption. Diversification of use of aquaculture products can also help the formation of a stable market.	Business development managers and project commercial managers	Business development and operations	1 Slight injury	2 Minor damage	1 Slight effect	1 Slight impact	B	B	A	C	10
5	COVID-19	Detailed market studies and diversification can support sales. Regarding the unavailability of materials and labour, collaboration with other operators in the area could help create economies of scale and resilience by, for example, sharing equipment or contracting with outside firms. Comprehensive insurance coverage can also help during periods of restrictions due to COVID-19. At the design stage, consideration should be given to minimising risks in the eventuality that regular maintenance and control of the structure is prevented.	Business development managers and site managers	Project development and operations	1 Slight injury	2 Minor damage	1 Slight effect	1 Slight impact	A	A	A	A	5
6	Cost and availability of external services	Advantageous collaboration contracts can be made with multi-use partners and other operators in the area to gain access to resources. Opening a dialogue with public representatives can facilitate collaboration. It is also possible to internalise some facilities such as the algae hatchery within the operator with due consideration to costs.	Business development managers	Project development	1 Slight injury	2 Minor damage	2 Minor effect	1 Slight impact	A	B	A	A	8
7	Food safety regulation	Follow national and international regulations and carry out frequent tests.	Business development	Project development	1 Slight injury	1 Slight damage	1 Slight effect	2 Limited impact	A	A	A	B	7

8	Weather conditions	Extensive protocols should be developed to ensure safety including at the port, on vessels, and at the site. Equipment installed should be reviewed and designed to minimise environmental hazard and likelihood of detachment. Long term impacts of ocean salinity should be considered on all materials used. Regular checks should be made to ensure equipment has not detached and reasonable efforts made to recover all equipment. Health and safety training should be mandatory for all workers and visitors to the site. The training should be refreshed regularly including emergency drill practices. The weather forecast should be monitored continually with appropriate protocols developed for each eventuality. As part of developing the protocols, consultation with the coast guard should be made. Insurance should be taken out to cover damage, working closely with insurance companies to identify an appropriate allocation of risk between the insurance company and the business. Disaster recovery plans should be developed to determine the best approach to stabilising and repairing the site in the event of severe damage.	All multi-use site managers	Project development and operations	2 Minor injury	2 Minor damage	2 Minor effect	2 Limited impact	B	B	B	A	14
9	Power supply	To check that existing power supply site is adequate for the devices to work, project team need to check the consumption of the devices and compare to the power supply options available on site. Careful design of the site and area can delineate the route of the boats to avoid damaging the cables and structure. Ensure adequate and reliable emergency back-up generating capacity included on site for emergencies.	Offshore wind farm site manager & aquaculture site managers.	Design and operation of the site	1 Slight injury	1 Slight damage	2 Minor effect	1 Slight impact	A	B	B	A	8
10	Social acceptance	Options to improve social acceptance include: - Disseminating knowledge on benefits brought by these activities. - Workshops with students and other stakeholders benefits and challenges to developing multi-use offshore - Utilizing a 3-pointed stakeholder engagement process:	Business managers and marketing office	Marketing plan	1 Slight injury	1 Slight damage	1 Slight effect	2 Limited impact	A	A	A	B	7
11	Lack of technical knowledge in MUP	Invest in on the job training for employees to ensure equipment and processes are well understood. Investment in research and development, participation in projects that aim to share information, data and experience that can help in the creation of stronger know-how even in such a new field.	Project managers	Research and development, project design, project operation	2 Minor injury	2 Minor damage	1 Slight effect	2 Limited impact	B	B	A	B	13
12	Lack of qualified staff	Deliver internal staff training through specialized courses. Outsource some business processes that require qualified staff that are difficult or uneconomic to hire full time. Consider investing in research and development to digitize and automate processes where it's hard to find skilled employees.	Project managers and HR team	Project development and operations	2 Minor injury	3 Local damage	1 Slight effect	2 Limited impact	B	B	A	A	13
13	Water quality	During the planning stages of the activity, a detailed feasibility study should be conducted to define the area in which to farm. In Germany, to produce food products it is mandatory to carry out a sanitary survey, in order to identify potential risk and source of contamination if contamination is suspected (oil spill, ship wreckage, water discoloration). Authorities have to be informed and countermeasures have to be implemented. Staff should be informed of potential dangers.	Project managers	Project and business design	1 Slight injury	2 Minor damage	2 Minor effect	2 Limited impact	A	B	B	A	11
14	Toxic algae blooms	Utilise eco-friendly practices, such as forbidding improper introduction of invasive alien species and avoiding disposal of large amount of epiphytes into the water to help minimize the potential contribution of seaweed cultivation to algae blooms. Monitoring of water quality by satellite imagery and scheduled testing of algae and mussels as laid out in the food safety regulations is recommended. Follow national and international standards for testing as in Germany they give stringent guidelines to avoid injury to consumers (especially for mussels).	Seaweed production site manager	Throughout growing period, particularly prior to cultivation.	2 Minor injury	2 Minor damage	2 Minor effect	1 Slight impact	A	A	B	A	9
15	Increased vessel traffic	If traffic is not regulated by local institutions, it is possible to establish agreements with other maritime activities in the area. In addition, using new generation boats reduces risks of spills and dampens noise. Some operations may be remote monitored and therefore not done on site. Close coordination between multiuse businesses required to minimise risk and disturbances to the ecosystem. This could include actions like: a) sharing site visit schedules; b) working collaboratively to reduce risks; c) sharing trips to	Project manager	Operation of the site	2 Minor injury	1 Slight damage	2 Minor effect	1 Slight impact	B	A	B	A	10

ANNEX 2

See overleaf the Dutch pilot risk analysis. The pre-mitigation risk analysis is presented first, followed by the post-mitigation risk analysis which shows the level of residual risk once suggested mitigations are implemented. While this risk analysis can be used as a starting point, all future multi-use pilot projects should undertake their own risk analysis as hazards, risks and appropriate mitigations are highly context specific.

ID	Hazard	Hazard description	Risk description	SOMOS Framework	What are the consequences (on 1 - small to 5 - major scale)?				What is the probability (A is small, D is highest)				Pre-risk Score	Risk Score
					People	Assets	Environment	Reputation	People	Assets	Environment	Reputation		
1	Harmful algae blooms	Toxic algae blooms could build up before the harvest potentially leading to contaminations of aquaculture product. The eco-system can also be contaminated leading to eutrophication.	Harmful algae blooms spread by cleaning of cultivating equipment or heavy storms releases the toxic algae into the eco-system leading to eutrophication and risk damaging the aquaculture crop.	Food and feed	3 Major injury	3 Local damage	3 Local effect	Considerable impa	B	B	B	B	24	
2	Contaminents from multi-use equipment, boats, workers visiting sites	Conditions on the site can reduce production yield	Working practices of other multi-use partners lead to contamination of the seaweed production site, thereby reducing production yield. Failure to fulfill customer orders leads to short term loss in revenue and medium term reduced trust in the business from customers. There is also a health risk for customers if contamination is not identified.	Food and feed	3 Major injury	4 Major damage	3 Local effect	Considerable impa	B	B	A	B	23	
3	Activity on the site by other multi-use partners	To achieve multi-use, a large number of actors may need to enter the site. These workers may have limited familiarity with the operations of other multi-use partners and not be incentivised to protect the assets.	Activity within the site, especially mooring of aquaculture systems is challenging and failure could lead to damage to the monopiles or vessels nearby. This could cause harm to the local environment if equipment detaches from the site and enters the local ecosystem.	Safety to man and equipment	4 Single fatality	4 Major damage	3 Local effect	2 Limited impact	C	C	B	B	34	
4	Engineering design solutions interacting	Structure failures in complex facilities such as those used in wind and solar power, or seaweed aquaculture can occur from a variety of causes including: bird strikes, lightning strikes, rainfall, blade furniture detachment, delamination, leading-edge corrosion or blade cracks.	Structural failure of one multi-use infrastructure could lead to damage of other infrastructure on site. Energy production depends on the proper functioning of the structure. Structure failure could cause serious accidents to workers and damage to the environment if they involve leaks. Revenue will be lost and it could be difficult to cover production costs. Repair costs could	Safety to man and equipment	4 Single fatality	4 Major damage	3 Local effect	2 Limited impact	B	C	C	B	33	
5	Power supply	A large range of equipment on the site needs a reliable and sufficient capacity power supply. This includes cameras, sensors, lights, and emergency lighting. Activity at the site could damage the cables. The site relies upon power supply to operate safely and on transmission cables to transfer energy to the grid.	Shore-side electricity generation for the multi-use activities and the risk of anchoring vessels damaging power supply cables could halt power transmission to shore and/or cut electricity supply to site. This would hurt revenue generation, create health and safety risks and the risk of damage to assets if alternative power supply is not available on site. Inadequate power supply could lead to critical systems failures and issues as seen in risk item 13 (connectivity issues) and 14 (camera and sensors).	Safety to man and equipment	4 Single fatality	2 Minor damage	2 Minor effect	2 Limited impact	A	B	B	B	16	
6	Earthquakes	Largest historic earthquakes in the Netherlands in the south (North Brabant and Limburg) and north (Groningen). A 6.1 magnitude earthquake was recorded in the Dogger Bank area of the North Sea in 1931. The Netherlands National Institute for Public Health and the Environment (RIVM) classifies natural earthquakes as somewhat likely yet with limited damage potential.	An earthquake in the North Sea could damage structures either through the tremours or increased wave velocity. Without planning, dangers on site could be considerable during and immediately after an earthquake. It could also cause serious injuries to site workers.	Safety to man and equipment	5 Multiple fatalities	4 Major damage	3 Local effect	Considerable impa	A	A	A	A	15	
7	Drifting aquaculture construction	Lines, floaters, mooring systems, seaweed support systems drift and float around site.	Creates risk of entanglement with vessels and solar or offshore wind assets.	Safety to man and equipment	4 Single fatality	3 Local damage	3 Local effect	2 Limited impact	A	C	B	B	23	
8	Decommissioning of assets	Decommissioning assets (especially fixed assets like offshore wind monopiles) is a highly intensive and expensive activity.	If decommissioning managed poorly, or inadequate funds are made available, risk of substantial contamination of the local environment and damage to nearby assets at sea.	Safety to man and equipment	4 Single fatality	4 Major damage	4 Major effect	Considerable impa	A	C	C	B	34	

9	Severe storm	Extreme weather comes in many varieties, such as black ice, hail, a snowstorm or a very severe storm. A very severe storm is usually shorter in duration (a number of hours), resulting in a smaller impact (assuming flood defences continue to function). The Netherlands National Institute for Public Health and the Environment (RIVM) classifies extreme weather as likely with substantial to serious damage potential. A high energetic environment could make the site inaccessible during severe weather conditions with vessels and divers depending on low wind and wave conditions.	Risks from a severe storm include trips/slips, injury and fatalities, hyperthermia, power outages, damage or destruction of assets, and damage to marine environment. Weather conditions can damage or corrode equipment polluting the environment with metals and plastics. Currents can wash material great distances to contaminate other marine environments while marine animals can ingest or become entangled in waste. Not being fully insured does not increase the risk of each activity, but it does increase the consequences of an event for the operators. As a result, lack of insurance is considered an issue that compounds the consequences of all other risks to individuals, the environment, and businesses as under-insurance can lead to an inability for operators to recover from risk events.	Safety to man and equipment	5 Multiple fatalities	4 Major damage	4 Major effect	Considerable impact	C	C	C	B	45
10	Insurance cost and coverage	Insurance for MUP activities must be able to cover at the same time multiple activities with different purposes and objectives (ie production methods, workers, equipment, etc). The novelty of MUP means the business elements that can be insured are often unclear. Some hazards are sometimes not insured such as storms or earthquakes, this is dangerous for companies operating offshore given the likelihood of the risk.	Insurance is usually a risk mitigation activity. In some cases, as in the case of MUPs, uncertainty about insurance liability makes investment in these activities difficult. Too high a premium price resulting from a cautious approach from insurers can discourage business formation. In addition, the inability to insure for some weather and natural phenomena makes activities at sea riskier for the operator who must self-insure. Not being fully insured does not increase the risk of each activity, but it does increase the consequences of an event for the	Other	5 Multiple fatalities	5 Extensive damage	4 Major effect	Considerable impact	C	C	C	C	51
11	MU Finance risk	Financial markets and investor sentiment can be volatile. Government partnership funding schemes can be slow to implement and susceptible to political uncertainties. Contractual arrangements with suppliers may include financial risks such as late payment clauses.	Failure to secure full capital or revenue funding arrangements could lead to project delays, unsustainable borrowing, inflationary pressures, contractual disputes with suppliers, and project/business failure leading to stranded assets at sea. If site abandoned, stranded assets could cause a risk to other operators at sea or the marine environment.	Other	1 Slight injury	3 Local damage	3 Local effect	Considerable impact	A	B	B	B	19
12	Economic feasibility	Budgeting for capital projects and business operations subject to uncertainties including inflation (general and industry specific), unclear prices for certain goods and services; and optimism bias. Optimism bias can be caused by many factors including procurement issues; project design issues; funder, client and contractor interface issues; environmental conditions; and changing external influences (e.g. changing regulation). Revenue from the project can also be hard to forecast (e.g. due to rapidly fluctuating spot prices in energy markets).	Underestimate of the project complexity and costs or overestimate of revenue potential makes project financially non-viable. This could halt construction, or cause the business to make a temporary or indefinite operating loss. Financial bankruptcy could have substantial consequences if poorly managed including stranded assets that could cause a risk to other operators at sea or the marine environment.	Other	1 Slight injury	3 Local damage	3 Local effect	Considerable impact	A	B	B	B	19
13	Connectivity issues	Site-to-shore communications critical to safe and efficient operations yet many at sea locations are poorly served (e.g. limited or poor 4G available on site).	Connectivity failure could lead to a number of risks including malfunctioning equipment, poor understanding of site conditions leading to inappropriate response decisions by onshore team, injuries and fatalities, damage to assets, and slow response times. Consequences of miscommunications higher when additional hazards present (ie during a storm).	Safety to man and equipment	4 Single fatality	4 Major damage	3 Local effect	2 Limited impact	B	C	C	A	31
14	Cameras and sensors	Onshore team's understanding of site conditions relies upon functioning of cameras and sensors on site. If poorly installed or of low quality, malfunctioning could occur.	Camera/sensor failure could lead to a number of risks including poor understanding of site conditions leading to inappropriate response decisions by onshore team, injuries and fatalities, damage to assets, damage to marine ecosystems, damage to seaweed crop, and slow response times. Consequences malfunctions higher when additional hazards present (ie during a storm).	Safety to man and equipment	4 Single fatality	4 Major damage	3 Local effect	2 Limited impact	C	B	C	A	31
15	Vessel equipment compatibility	Standard vessels within commercial fishing fleet may be inadequate for multi-use operations including anchoring technology, layout, and safety features.	Risk of damage to equipment or people during loading equipment onto floating transportation vessels. Damage risks include to mechanical loads, collisions with vessels/ships/fishing boats, and risks of anchoring vessels damaging power supply cables.	Safety to man and equipment	3 Major injury	4 Major damage	3 Local effect	2 Limited impact	B	C	C	B	31

16	Higher volumes of marine traffic at and close to the site	Multi-use increases the number of trips required to site by workers and boats without specialist/knowledge and equipment for other multi-use businesses.	Increases risk of vessel collision with other multi-use vessels and with equipment. Collision could cause significant damage to individuals, the marine environment, and physical assets. Higher volumes of marine traffic also cause greater disturbance for the local ecosystem. Shipping can harm the environment through discharges at sea (e.g. oil, wastewater, paints, ballast water, and marine litter), airborne emissions (e.g. engine exhaust, refrigerants, and other volatile chemicals), noise, and shipwrecks or scrapping. Higher marine traffic also increases likelihood of <u>drifted items into the sea.</u>	Environmental and cumulative	3 Major injury	3 Local damage	3 Local effect	Considerable impact	B	C	B	B	27
17	Underwater-noise	The marine ecosystem is sensitive to underwater noise disturbance which changes the habitat conditions.	Disturbance during the construction phase by increased transport/ship traffic to and from the site. Ecological risks, such as underwater-noise disturbance of marine mammals, disturbance of the seabed sediments and seabed communities; collision risks to birds and bats above water, and attraction of invasive species.	Environmental and cumulative	1 Slight injury	1 Slight damage	3 Local effect	Considerable impact	A	A	C	B	17
18	Risk of oil spills	There are large numbers of closed, decommissioned, operational or under construction oil and gas installations in the Dutch North Sea and English Channel. Oil contamination of the sea can occur during routine operation of offshore facilities during multiple phases, including exploration, development, production, transport, or well-abandonment.	There is a risk from oil spills affecting the site. With this mix of multi-use activities there is no oil production on site. Effluent from oil production can have long-term negative impacts on oceanic ecosystems and future provision of ocean resources. Oil contamination can also come from vessels, see risk item 16 (Higher volumes of marine traffic at and close to the site) for more details of this type of risk. Seaweed product quality is also at risk from oil spills.	Environmental and cumulative	2 Minor injury	3 Local damage	4 Major effect	Major national impact	A	B	B	A	20
19	Significant wave height	O&M visits are usually carried out when wave heights are less than or equal to 1.5m. Each support vessel has a maximum allowable significant wave height for operations.	As multi-use activity intensifies, the risk from disruption during significant wave height grows as O&M activities cannot occur during this time. The possibility of larger wave heights will require new systems for safe O&M personnel transfer. If transfers are restricted to wave heights of 1.5m, this will limit potential offshore work days a year. Increasing overall accessibility can lead to cost reduction of wind energy production.	Environmental and cumulative	3 Major injury	3 Local damage	2 Minor effect	2 Limited impact	A	B	B	B	17
20	Governance and legal administrative issues	There is a lack of clear guidelines and regulatory structure and framework regarding multi-use, as well as a lack of consistency in policy and procedures between national level governments. Specific governance issues include: an unclear legal status for multi-use; strict security regulations that discourages setting up a MUP; lack of dialogue between stakeholders; lack of established safety assessments; lack of crossborder cooperation; complex permitting procedures; timing issues related to consultation timeframes for permitting in different multi-use use cases; insufficient coordination between different policy levels; lack of guidance for decommissioning phase; more participants in the O&M process leads to a more complex organization and more	Risks emerging from governance issues are manifold including: delays to securing permits causing funding and financing issues for projects; failure to secure permits if government bodies cannot accurately assess the risk; uncertain legal outcomes from legal disputes between parties; environmental risks that can arise from a lack of defined standards leading to inconsistent and potentially inadequate environmental protection approaches; unclear legal liability risk allocation during legal disputes; expensive insurance premiums; and high risk premiums applied to project development budgets making them unviable.	Other	1 Slight injury	3 Local damage	1 Slight effect	Considerable impact	A	C	A	C	20
21	Trespassers	Offshore site isolated with no barriers preventing entry of trespassing vessels	Sailing vessels, pleasure craft, and fishing vessels in particular have been observed to regularly access the Dutch offshore test site either by accident or deliberately. If collision occurs with equipment, some of which is below the surface making it hard to see from a boat, risk of significant damage being caused to the equipment or the trespassing vessel and potential risks to person or environment if damaged assets cause entangle or collide with other objects at sea. Infringements observed frequently yet collision incidence rare. OWF turbines may reduce incidence of accidental trespassing due to	Safety to man and equipment	4 Single fatality	3 Local damage	3 Local effect	1 Slight impact	A	C	C	A	23

22	Lack of social acceptance	Social acceptability of offshore wind and aquaculture has been identified as a challenge for a number of pilots (though considered a smaller issue for the Dutch context by Dutch pilot project team). Social acceptability issues often cited include impacts on landscapes and seascapes of turbines and/or associated infrastructure such as on/offshore substations. Additionally, for some stakeholders, the reputation of aquaculture needs improving.	Risks from lack of social acceptance include: delays in acquiring or rejections of permit applications; restrictions to activities that prevent the site operating at potential; and disruption and damage caused by protests. Lack of social acceptance also risks undermining the company's ability to finance operations, particularly with respect to local and private lenders. This could hinder scaling up the business.	Other	2 Minor injury	2 Minor damage	2 Minor effect	Considerable impact	A	B	A	C	17
23	Lack of expertise	Lack of general knowledge about business models and best practice by managers and employees can generate inefficient production processes that lead to lower production volume and profit as well as increasing the risk of industrial accidents.	Low net operating surplus or losses lead to inability to scale operations. The risk of not adopting efficient technologies like other market players means could lead to inadequate revenue to cover costs.	Other	2 Minor injury	4 Major damage	2 Minor effect	2 Limited impact	B	C	B	B	24

ID	Hazard	Mitigation	Action By	Action When	What are the consequences (on 1 - small to 5 - major scale)?				What is the probability (A is small, D is highest)				Post-risk Risk Score after Mitigation
					People	Assets	Environment	Reputation	People	Assets	Environment	Reputation	
1	Harmful algae blooms	Utilise eco-friendly practices, such as forbidding improper introduction of invasive alien species and avoiding disposal of large amounts of epiphytes into the water to help minimize the potential contribution of seaweed cultivation to algae blooms. Explore opportunities to monitor quantity of algae build-up on equipment. Test seaweed for quality before human and animal consumption. Develop alternative product applications for seaweed as a contingency to help ensure a financial return if the seaweed is identified to not meet quality requirements for food or feed.	Seaweed production site manager	Throughout growing period, particularly prior to cultivation.	1 Slight injury	1 Slight damage	1 Slight effect	1 Slight impact	A	A	A	A	4
2	Contaminants from multi-use equipment, boats, workers visiting sites	Design multi-use production site to minimise risk of contamination from alternative uses (e.g. accounting for tidal flows). Agree working practices with multi-use partner organisations that minimise risk of contamination.	Seaweed production site designer and manager	Site design stage and operations	1 Slight injury	2 Minor damage	1 Slight effect	2 Limited impact	A	A	A	A	6
3	Activity on the site by other multi-use partners	Ensure all workers entering the site receive training and briefing on site layout and safety protocols. Multi-use site managers can work collaboratively and openly to identify and mitigate risks including through a near miss reporting mechanism. Some training sessions could be combined to help transfer knowledge and build trust between the parties.	Offshore wind farm site manager & solar and seaweed	Operation of the site	2 Minor injury	2 Minor damage	3 Local effect	2 Limited impact	B	B	B	B	18
4	Engineering design solutions interacting	Develop a robust maintenance plan. Have incident management protocols and staff trained to handle facility incidents. Ensure insurance coverage takes into account facility failures.	Project design team and site	Design and operation of the site	2 Minor injury	2 Minor damage	1 Slight effect	1 Slight impact	A	B	B	A	9
5	Power supply	Ensure site designed to minimise exposure of transmission cables. Ensure all workers entering the site receive training and briefing on site layout and safety protocols. Multi-use site managers work collaboratively and openly to identify and mitigate risks including through a near miss reporting mechanism. To check that site power supply is adequate for the devices to work, project team need to check the consumption of the devices and compare to the power supply options available on site in design proposals. If inadequate, must consider alternative power options or lower power usage options. Ensure adequate and reliable emergency back-up generating capacity included on site for emergencies. Design solutions should look for opportunities to ensure power outages do not affect all multi-uses at once	Multi-use site designers and site managers	Design and operation of the site	1 Slight injury	1 Slight damage	1 Slight effect	1 Slight impact	A	B	B	B	7
6	Earthquakes	Ensure site designed to minimise impact of earthquake including increased wave velocity. Ensure all workers entering the site receive training and briefing on site layout and safety protocols in the event of an earthquake. Appropriate insurance levels should be considered to cover damage, working closely with insurance companies to identify an appropriate allocation of risk between the insurance company and the business. Disaster recovery plans should be developed to determine the best approach to stabilising and repairing the site in the event of severe damage.	All multi-use site designers and managers	Design and operation of the site	2 Minor injury	2 Minor damage	1 Slight effect	1 Slight impact	A	A	A	A	6
7	Drifting aquaculture construction	Seaweed site design should be optimised to minimise risk of entanglement. Equipment should be regularly inspected including with remote monitoring with an alarm system to ensure not damaged, especially after storms and other events at sea.	Seaweed site design team and seaweed production site manager	Design and operation of the site	2 Minor injury	1 Slight damage	1 Slight effect	1 Slight impact	A	B	B	A	7
8	Decommissioning of assets	Decommissioning plan should be developed at project inception. Minimising complexity and impact during decommissioning should be considered at project design stage. One option could be to plan to decommission all assets at the same time. A sinking fund could be included in the business model to ensure adequate finances are available to decommission the site.	All multi-use site designers. Decommissioning team. Owners of business	Design, construction, and decommissioning	1 Slight injury	1 Slight damage	1 Slight effect	1 Slight impact	A	A	A	A	4

9	Severe storm	Extensive protocols should be developed to ensure safety including at the port, on vessels, and at the site. Equipment installed should be reviewed and designed to minimise environmental hazard and likelihood of detachment. Long term impacts of ocean salinity should be considered for all materials used. Regular checks should be made to ensure equipment has not detached and reasonable efforts made to recover all equipment. Health and safety training should be mandatory for all workers and visitors to the site. The training should be refreshed regularly including emergency drill practices. The weather forecast should be monitored continually with appropriate protocols developed for each eventuality. As part of developing the protocols, consultation with the coast guard should be made. Insurance should be taken out to cover damage, working closely with insurance companies to identify an appropriate allocation of risk between the insurance company and the business. Disaster recovery plans should be developed to determine the best approach to stabilising and repairing the site in the event of serious damage.	All multi-use site designers and managers	Design and operation of the site	2 Minor injury	2 Minor damage	2 Minor effect	2 Limited impact	B	B	B	A	14
10	Insurance cost and coverage	Mitigations include drafting detailed safety protocols for aquaculture and energy production activities. Collaboratively working with insurance companies could make the insurer understand the risk profile better and trust that the companies can appropriately manage risks. This could allow for lower risk premiums and greater coverage of risks. Self-insurance is an option for some less severe risks by building cash reserves and/or establishing flexible credit lines to be utilised in the event of the risk being realised.	Project managers and project commercial managers	Project development	2 Minor injury	2 Minor damage	2 Minor effect	2 Limited impact	B	B	B	B	16
11	MU Finance risk	Funding/financing arrangements should be carefully considered to increase robustness. Credible partners and investors should be prioritised. Consider insurance measures or working with public sector bodies to underwrite a proportion of funding/financing risks. Develop business models with resilience to delays in payments (e.g. securing a flexible credit line). Ensure site always safe in case of sudden work stoppages.	Business development and project management teams	Project development and implementation	0 Zero injury	1 Slight damage	1 Slight effect	1 Slight impact	A	A	A	A	3
12	Economic feasibility	Funding/financing arrangements should be carefully considered to increase robustness. Credible partners and investors should be prioritised. Consider insurance measures or working with public sector bodies to underwrite a proportion of funding/financing risks. Consider risk/reward sharing arrangements with contractors to distribute risk through the supply chain. Develop business models with resilience to delays in payments (e.g. securing a flexible credit line). Ensure site safe and secure in case of sudden work stoppages.	Business development and project management teams	Project development and implementation	1 Slight injury	1 Slight damage	1 Slight effect	1 Slight impact	A	A	A	A	4
13	Connectivity issues	Consider alternative connectivity protocols and transmission systems such as LoRA, ZigBee, wifi, in order to transmit data from site devices to an in-between node that would be closer to a 4G network.	Project development and implementation	Design and operation of the site	1 Slight injury	1 Slight damage	2 Minor effect	1 Slight impact	A	B	B	A	8
14	Cameras and sensors	To ensure secure installation of camera and sensors onto the aquaculture infrastructure, make regular visits to the aquaculture site to plan and design proper installation including asking expert advice on the best way to in-stall such devices to the existing infrastructure. Clean sensors according to equipment manufacturer guidance. Purchase high quality equipment with reliability levels appropriate for level of criticality of sensor.	All multi-use site designers and managers	Project development and implementation	1 Slight injury	1 Slight damage	1 Slight effect	1 Slight impact	A	B	B	A	6
15	Vessel equipment compatibility	Special anchoring technology required to approach OWF platform (e.g. by sailing boats, transport and maintenance vessels). Opportunities to share of vessel equipment should be reviewed for safety for each individual use case. Ensure all individuals boarding the vessels receive training and briefing on vessel safety protocols.	All multi-use site designers and managers	Project development and operations	1 Slight injury	1 Slight damage	2 Minor effect	1 Slight impact	A	B	B	A	8
16	Higher volumes of marine traffic at and close to the site	Close coordination between multi-use businesses required to minimise risk and disturbances to the ecosystem. This could include actions like: a) designing the site to minimise risk of collisions; b) sharing site visit schedules; c) reviewing other partners' equipment and working collaboratively to reduce risks; d) sharing trips to site.	All multi-use site designers. All multi use site managers.	Project development and operations	1 Slight injury	1 Slight damage	1 Slight effect	2 Limited impact	A	B	A	A	6
17	Underwater-noise	Consider using anchor pipe vibration embedment instead of pile driving for anchor system to lower noise levels during site construction.	All multi-use site designers. All multi use site managers.	Project development	1 Slight injury	1 Slight damage	2 Minor effect	1 Slight impact	A	A	C	B	10
18	Risk of oil spills	Monitor water quality within the site to identify contaminations. Test seaweed for quality before human and animal consumption. Develop alternative product applications for seaweed as a contingency to help ensure a financial return if the seaweed is identified to not meet quality requirements for food or feed.	All multi-use site designers. All multi use site managers.	Project development and operations	2 Minor injury	2 Minor damage	3 Local effect	Considerable impact	A	B	B	A	15
19	Significant wave height	Utilise new ships with motion stabilizers to guarantee safe transfers of personnel and material. Use of multi-purpose support vessels, capable to operate under significant wave-height conditions of up to 3m	All multi-use site designers. All multi use site managers.	Project development and operations	1 Slight injury	1 Slight damage	1 Slight effect	2 Limited impact	A	A	A	A	5

20	Governance and legal administrative issues	Develop a facilitation policy to enable multi-use at a strategic and project level. This includes, enabling exchange of information between different developers on environmental impacts to help advise future Environmental Impact Assessment requirements; developing and deploying joint licensing procedures for multi-use development throughout entire life cycles; identifying and addressing gaps in current knowledge about safety, benefits and drawbacks; and creating decision support systems. Government bodies should work to formalize public policies. Adequate time and contingency needed to obtain permissions and licences that comply with existing legal standards.	All multi-use site designers. All multi use site managers. Government regulators.	Project development	1 Slight injury	2 Minor damage	1 Slight effect	2 Limited impact	A	B	A	B	10
21	Trespassers	Identify party to monitor security of the site (e.g. outsource to an external party), who monitors the trespassing of boats in the area. Collaboration between multi-use partners and other offshore sites in the area could increase the surveillance coverage.	All multi-use site managers.	Project operations	2 Minor injury	2 Minor damage	2 Minor effect	1 Slight impact	A	B	B	A	11
22	Lack of social acceptance	Options to improve social acceptance include: - Disseminating knowledge on responsible farming and sustainable energy production. - Workshops with students and other stakeholders benefits and challenges to developing multi-use offshore - Utilizing a 3-pointed stakeholder engagement process: 1) a stakeholder analysis in which relevant stakeholders will be identified. 2) inclusion of stakeholder in the pertinent steps in the pilot development process. 3) utilizing stakeholders needs to propel the design of MUCL activities.	All multi-use site designers.	Project development	1 Slight injury	1 Slight damage	1 Slight effect	2 Limited impact	A	A	A	B	7
23	Lack of expertise	Invest in on the job training for employees to ensure equipment and processes are well understood. Investment in research and development, participation in projects that aim to share information, data and experience that can help in the creation of stronger know-how even in such a new field. Ensure project teams include adequate commercial expertise.	ent and site project	Research and development, project design, project operations	1 Slight injury	2 Minor damage	1 Slight effect	1 Slight impact	A	B	A	A	7

ANNEX 3

See overleaf the Belgian pilot risk analysis. The pre-mitigation risk analysis is presented first, followed by the post-mitigation risk analysis which shows the level of residual risk once suggested mitigations are implemented. While this risk analysis can be used as a starting point, all future multi-use pilot projects should undertake their own risk analysis as hazards, risks and appropriate mitigations are highly context specific.

ID	Hazard	Hazard description	Risk description	SOMOS Framework Category	What are the consequences (on 1 - small to 5 - major scale)?				What is the probability (A is small, D is highest)				Pre-risk mitigation Score
					People	Assets	Environment	Reputation	People	Assets	Environment	Reputation	
1	Damage due to extreme adverse environmental catastrophic events (storms or underwater earthquakes)	Extreme weather comes in many varieties, such as black ice, hail, a snowstorm or a very severe storm. A very severe storm is usually shorter in duration (a number of hours), resulting in a smaller impact. The Belgian National Crisis Centre (NCC) identifies that extreme weather phenomena, such as severe thunderstorms, occur several times a year. The NCC expect that storm risks will become more frequent and have greater impact in the future, influenced by climate change. The NCC explains that in Belgium, there are many earthquakes that are barely noticeable, yet devastating earthquakes with a magnitude of up to 6.0 cannot be ruled out.	Risks from a severe storm include trips/slips, injury and fatalities, hyperthermia, power outages, damage or destruction of assets, damage to marine environment, loss of equipment and difficulties to install and retrieve equipment. While the Belgian NCC assess the probability of thunderstorms to be very likely, the assessed impact is typically low. Earthquakes in Belgium are assessed to be likely with a low impact by the Belgian NCC.	Safety to man and equipment	5 Multiple fatalities	4 Major damage	4 Major effect	3 Considerable impact	C	C	C	B	45
2	Lack of general technological and technical knowledge available from the industry involved in MU in general	Technological knowledge challenges identified include: insufficient existence of biological location data (e.g. time and scale of spat fall, growth rates of oysters and seaweed); access to all available data for project marine scientists; insufficient knowledge on behaviour of some of the test equipment in the open sea; and not enough knowledge on existing technological solutions. Similarly, there is a lack of expertise with business models and best practices.	Inadequate knowledge could lead to a number of risks including: accidents caused by poorly fitting or maintained equipment damaging people or the environment; project delays; expensive equipment solutions being required; low operating efficiency; high insurance costs due to lack of experience in co- location/MU projects and inherent risk associated with multiple use of the same platform; and damaging of oyster spat during collection or grow-out reducing yields.	Safety to man and equipment	3 Major injury	3 Local damage	3 Local effect	2 Limited impact	B	B	C	B	25
3	Lack of general technological readiness level of all the parties involved with the MU	Offshore marine equipment can be technically complex and expensive. Safety is critical. Regulations for design and manufacturing processes can differ based on a number of factors, including project complexity and high requirement standards of material/equipment etc. Design standards and guidelines exist for conventional equipment and structures yet are less well understood for multi-use operations. Other technological challenges include sampling & monitoring at depth, insufficient knowledge on behaviour of some of the test equipment in open sea.	Misunderstanding of the technological, regulatory, or operating environmental can result in failure. Consequences could include: critical damage to infrastructure leading to injury and/or damage to the local environment, failure to receive funding/financing if funding partners do not see a commercial opportunity, slow approval of or refusal of permits.	Safety to man and equipment	4 Single fatality	3 Local damage	3 Local effect	2 Limited impact	C	B	B	B	28
4	Risk of damage in case of mooring failure/anchoring	Standard vessels within commercial fishing fleet may be inadequate for multi-use operations due to anchoring technology. Costs for grid connection are high and an important economic barrier to generating power offshore.	Damage risks include to mechanical loads, collisions with vessels/ships/fishing boats/turbines. Additionally, risks of anchoring vessels damaging power supply cables.	Safety to man and equipment	3 Major injury	4 Major damage	3 Local effect	2 Limited impact	A	C	C	B	28

5	Damage risks of mechanical loads and collisions with vessels/ships/fishing boats	Multi-use increases the number of trips required to site by workers and boats without specialist/knowledge and equipment for other multi-use businesses.	Multi-use increases the number of trips required to the site by workers and boats. Crews coming onto the site without may not have the specialist/knowledge and equipment required to safely interact with equipment from for other multi-use businesses. Collision could cause significant damage to individuals, the marine environment, and physical assets. Higher volumes of marine traffic also cause greater disturbance for the local ecosystem. Shipping can harm the environment through discharges at sea (e.g. oil, wastewater, paints, ballast water, and marine litter), airborne emissions (e.g. engine exhaust, refrigerants, and other volatile chemicals), noise, and shipwrecks or scrapping unmanaged scrapping of equipment. Intensified Higher marine traffic also increases	Safety to man and equipment	3 Major injury	3 Local damage	3 Local effect	3 Considerable impact	B	C	C	B	30
6	Drifting aquaculture construction	Equipment such as oyster cages attached to the backbone with weights could drift and float around site.	Aquaculture equipment could strike the turbine foundation or get stuck around the turbine foundation, increasing the risk of entanglement with vessels and offshore wind assets. This could lead to effect of culture systems on sea mammals, effect of paint release due to loose aquaculture systems rubbing against the turbines, collision of crew vessels with loose aquaculture systems, and fuel leakage.	Safety to man and equipment	4 Single fatality	3 Local damage	3 Local effect	2 Limited impact	A	C	B	B	23
7	Biofouling and corrosion	Offshore areas potentially pose less conflict with co-users than onshore. At the same time, offshore areas and offshore constructions are prone to high technical risks through corrosion, and biofouling. The expected lifetime of an offshore structure is substantially affected by the risk of failures.	Operation and maintenance (O&M) activities typically represent a large proportion of total costs for offshore wind farms. One of the main hurdles that hinders use of offshore wind energy is the high cost for O&M. Cleaning of assets to avoid critical failures raises operating costs and reduces viability. Biofouling risks can cause lines to increase in weight and if structures become completely covered adequate water and feed-supply to the animals could be constricted (e.g. when the meshes of baskets close up due to fouling, the animals inside might lose access to water which brings oxygen and feed and therefore die).	Safety to man and equipment	1 Slight injury	4 Major damage	3 Local effect	1 Slight impact	A	C	B	A	20
8	Connectivity issues	A well-functioning Data Acquisition and Control System (DACS) and communication system rely upon internet connection to the DACS for data retrieval and/or reconfiguration of mission control. Site-to-shore communications are critical to safe and efficient operations yet many at sea locations are poorly served (e.g. limited or poor 4G available on site).	Connectivity failure could lead to a number of risks including malfunctioning equipment, poor understanding of site conditions leading to inappropriate response decisions by onshore team, injuries and fatalities, damage to assets, and slow response times. Consequences of miscommunications higher when additional hazards are present (ie during a storm).	Safety to man and equipment	4 Single fatality	4 Major damage	3 Local effect	2 Limited impact	B	C	C	A	31
9	Regulatory challenges	It can take a long time to get the necessary permits from the government.	Delays to securing permits could cause funding and financing issues for projects. This is worsened if there is uncertainty as to whether permits will be granted if government bodies cannot accurately assess the risk. Primarily a risk to project viability and reputation of multi-use as an opportunity rather than to people, assets or the environment.	Other	1 Slight injury	2 Minor damage	1 Slight effect	3 Considerable impact	A	B	B	C	16

10	Presence of parasites	Risk of presence of bonamia and maritella which previously were not in the Belgian North Sea. Quick response/fast track food (for human consumption) and fodder (animal feed) quality tests are not yet established within the EU meaning that it can be challenging to identify all types of contamination in a timely way. It usually takes up to a week to confirm the diagnosis of the presence of	Contamination of the seaweed production site, thereby reducing production yield. Failure to fulfil customer orders leads to short term loss in revenue and medium term reduced trust in the business from customers. There is also a health risk for customers if contamination is not identified.	Food and feed	3 Major injury	4 Major damage	3 Local effect	3 Considerable impact	B	B	A	B	23
11	Biomass production	European flat oyster (<i>Ostrea edulis</i>) is the potential presence of parasites such as <i>Bonamia</i> and <i>Marteilia</i> , of which the presence in the Belgian part of the North Sea is unknown (status unknown). The parasites create a threat to the flat oysters. With regards to seaweeds, the evidence base is still emerging for diseases and harmful parasites in European waters that could result in loss of biomass, quality or food	Potential risks include excessive levels of arsenic, cadmium, lead and mercury in the biomass. Quick response/fast track food and fodder quality tests are not yet established within the EU meaning that it can be challenging to identify all types of contamination in a timely way. Failure to fulfil customer orders leads to short-term loss in revenue and medium-term reduced trust in the business from customers. There is also a health risk for customers if contamination is not identified.	Environmental and cumulative	1 Slight injury	1 Slight damage	4 Major effect	3 Considerable impact	A	A	C	C	23
12	Decommissioning of assets	Decommissioning assets (especially fixed assets like offshore wind monopiles) is a highly intensive and expensive activity. Multi-use creates uncertainty about the ability of one party to continue if the other enters its decommission phase (e.g. legal status of the activities or the share of decommissioning costs).	If decommissioning managed poorly, or inadequate funds are made available, there is the risk of substantial contamination of the local environment and damage to nearby assets at sea.	Safety to man and equipment	4 Single fatality	4 Major damage	4 Major effect	3 Considerable impact	A	C	C	B	34
13	Lack of public awareness about implications of multi-use	Social acceptability of offshore wind and aquaculture has been identified as a challenge. Social acceptability issues often cited include impacts on landscapes and seascapes of turbines and/or associated infrastructure such as on/offshore substations. Additionally, for some stakeholders, the reputation of aquaculture needs improving.	Risks from lack of social acceptance include: delays in acquiring or rejections of permit applications; restrictions to activities that prevent the site operating at potential; and disruption and damage caused by protests. Lack of social acceptance also risks undermining a company's ability to finance operations, particularly with respect to local and private lenders. This could hinder scaling up the business.	Other	2 Minor injury	2 Minor damage	2 Minor effect	3 Considerable impact	A	B	A	C	17
14	Insurance cost and coverage	Insurance for MU activities must be able to cover at the same time multiple activities with different purposes and objectives (ie production methods, workers, equipment, etc). The novelty of MU means the business elements that can be insured are often unclear. Some hazards are sometimes not insured such as storms or earthquakes, this is dangerous for companies operating offshore given the likelihood of the risk being realised. Additionally, insurance for loss of product due to events such as a storm, harmful algae blooms, and oil spills would also strengthen the resilience of the business model, yet can be	Insurance is usually a risk mitigation activity. In some cases, as in the case of MU, uncertainty about insurance liability makes investment in these activities difficult. Too high a premium price resulting from a cautious approach from insurers can discourage business formation. In addition, the inability to insure for some weather and natural phenomena makes activities at sea riskier for the operator who must self-insure. Not being fully insured does not increase the risk of each activity, but it does increase the consequences of an event for the operators.	Other	5 Multiple fatalities	5 Extensive damage	4 Major effect	3 Considerable impact	C	C	C	C	51
15	Workers operating at sea	Several activities are performed from the vessel deck such as installation of restoration tables and longlines.	There is a risk of man overboard during the activities mainly performed on the vessel deck. In the event there is a risk of drowning, hypothermia, exhaustion, and attacks by marine life.	Safety to man and equipment	4 Single fatality	4 Major damage	4 Major effect	2 Limited impact	C	B	B	A	30

16	Man made objects brought into marine environment	Metalic, fabric, and plastic objects brought on board vessels present a hazard when brought into a marine environment.	Risk of objects falling into the sea (from the vessel) could cause damage to local marine animals and plant through entanglement, collision or contamination. If equipment lost is critical to operations (e.g. communications equipment), could additionally cause risk to personnel operating at sea.	Environmental and cumulative	2 Minor injury	3 Local damage	3 Local effect	1 Slight impact	A	A	C	A	15
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ID	Hazard	Actions			What are the consequences (on 1 - small to 5 - major scale)?				What is the probability (A is small, D is highest)				Post-risk mitigation
		Mitigation	Action By	Action When	People	Assets	Environment	Reputation	People	Assets	Environment	Reputation	Risk Score after Mitigation
1	Damage due to extreme adverse environmental catastrophic events (storms or underwater earthquakes)	Extensive protocols should be developed to ensure safety including at the port, on vessels, and at the site. One approach is through preparing method statements prior to every action at sea to ensure safety of personnel. Equipment installed should be reviewed and designed to minimise environmental hazards and likelihood of detachment. Long-term impacts of ocean salinity should be considered for all materials used. Regular checks should be made to ensure equipment has not detached and reasonable efforts made to recover all equipment. Health and safety training should be mandatory for all workers and visitors to the site. The training should be refreshed regularly including emergency drill practices. The weather forecast should be monitored continuously with appropriate protocols developed for each eventuality. As part of developing the protocols, consultation with the coast guard should be made. Insurance should be taken out to cover damage, working closely with insurance companies to identify an appropriate allocation of risk between the insurance company and the business. Disaster recovery plans should be developed to determine the best approach to stabilising and repairing the site in the event of severe damage. Investing in predictive models	All multi-use site designers and managers	Design and operation of the site	2 Minor injury	2 Minor damage	2 Minor effect	2 Limited impact	B	B	B	A	14
2	Lack of general technological and technical knowledge available from the industry involved in MU in general	Invest in on the job training for employees to ensure equipment and processes are well understood. Investment in research and development, participation in projects that aim to share information (e.g. on biotic/abiotic factors) experience that can help in the creation of stronger know-how. Undertake simulations and based best available long-term data recordings. Ensure project teams include adequate commercial expertise to ensure financial business impact are well managed.	Development site project managers	Research and development, project design, project operations	1 Slight injury	2 Minor damage	1 Slight effect	1 Slight impact	A	B	A	A	7
3	Lack of general technological readiness level of all the parties involved with the MU	Investment in research and development, participation in projects that aim to share information (e.g. on biotic/abiotic factors) can help in the creation of stronger know-how (e.g. new tools for monitoring offshore activities and new technology to enhance connection between offshore and coast). Equipment/material also needs to be designed to be resistant to: fouling, high forces (waves, tides, current, storms, mooring), high salinity & corrosion. Work with governmental actors and other businesses to support development of the whole value chain to help develop implementable technical solutions that address the risks identified.	Development site project managers	Research and development, project design, project operations	1 Slight injury	2 Minor damage	1 Slight effect	1 Slight impact	A	B	A	A	7
4	Risk of damage in case of mooring failure/anchoring	Special anchoring technology required to approach OWF platform (e.g. by sailing boats, transport and maintenance vessels). Ensure all individuals boarding the vessels receive training and briefing on vessel safety protocols.	Development site project managers	Project design, project	1 Slight injury	1 Slight damage	2 Minor effect	1 Slight impact	A	B	B	A	8
5	Damage risks of mechanical loads and collisions with vessels/ships/fishing boats	Mitigations include planning and close coordination between multi-use businesses to minimise risk and disturbances to the ecosystem. This could include actions like: a) designing the site to minimise risk of collisions; b) sharing site visit schedules; c) reviewing other partners' equipment and working collaboratively to reduce risks; and d) sharing trips to site (e.g. for monitoring/sampling). Exploring opportunities for remote control operation of the site with high durability automated monitoring devices could reduce need to visit the site.	All multi-use site designers. All multi-use site managers.	Project development operations	1 Slight injury	1 Slight damage	1 Slight effect	2 Limited impact	A	B	A	A	6
6	Drifting aquaculture construction	Aquaculture equipment design should be optimised to minimise risk of entanglement. Equipment should be regularly inspected to ensure not damaged, especially after storms and other events at sea.	Aquaculture design team and seaweed production site manager	Design and operation of the site	2 Minor injury	1 Slight damage	1 Slight effect	1 Slight impact	A	B	B	A	7

7	Biofouling and corrosion	Select equipment/material that is resistant to biofouling and corrosion to reduce cleaning requirements and risk of critical failures.	Offshore wind site design	Design the site	1 Slight injury	2 Minor damage	1 Slight effect	1 Slight impact	A	B	A	A	7
8	Connectivity issues	Consider alternative connectivity protocols and transmission systems to transmit data from site devices to shore.	Project development implementation	Design and operation of the site	1 Slight injury	1 Slight damage	2 Minor effect	1 Slight impact	A	B	B	A	8
9	Regulatory challenges	Adequate time and contingency needed to obtain permissions and licences that comply with existing legal standards. Work with government agencies to share data and evidence to support permitting process.	All multi-use site designers. All multi-use site managers. Government	Project development	1 Slight injury	1 Slight damage	1 Slight effect	2 Limited impact	A	A	A	B	7
10	Presence of parasites	Design multi-use production site to minimise risk of contamination from alternative uses (e.g. accounting for tidal flows) and working collaboratively with testing facilities to improve testing procedures. Agree working practices with multi-use partner organisations that minimise risk of contamination. World Organisation for Animal Health (OIE) and Ifremer guidelines for the detection of parasites can give a strong basis for designing	Seaweed production site designer and manager	Site design stage and operations	1 Slight injury	1 Slight damage	1 Slight effect	2 Limited impact	A	A	A	B	7
11	Biomass production	Undertake environmental impact assessments that comply with local permitting legislation and inform on appropriate species mix, quantities of production, and mitigation measures to limit risks for local ecosystem. Monitor ecosystem health during construction and operations to identify any actions that may be necessary. Controlled, frequent monitoring, working with wider public and private sector stakeholders is critical to ensuring quality and safety of the food and feed produced.	Seaweed production site designer and manager	Site design stage and operations	1 Slight injury	1 Slight damage	3 Local effect	2 Limited impact	A	A	B	A	10
12	Decommissioning of assets	Decommissioning plan should be developed at project inception. Minimising complexity and impact during decommissioning should be considered at design stage. Sinking fund included in business model to ensure adequate finances available to decommission the site. The sinking fund would require businesses to regularly set aside money for the gradual repayment of a debt or replacement of a stranded asset and would need to conform to mandatory rules on decommissioning of assets at sea in Belgium.	All multi-use site designers. Decommissioning team. Owners of business	Design, construction, decommissioning	1 Slight injury	1 Slight damage	1 Slight effect	1 Slight impact	A	A	A	A	4
13	Lack of public awareness about implications of multi-use	Options to improve social acceptance include: - Disseminating knowledge on responsible farming and sustainable energy production. - Workshops with students and other stakeholders benefits and challenges to developing multi-use offshore - Utilizing a 3-pointed stakeholder engagement process: 1) a stakeholder analysis in which relevant stakeholders will be identified. (2) inclusion of stakeholder in the pertinent steps in the pilot development	All multi-use site designers.	Project development	1 Slight injury	1 Slight damage	1 Slight effect	2 Limited impact	A	A	A	B	7
14	Insurance cost and coverage	Mitigations include drafting detailed safety protocols for aquaculture and energy production activities. Collaboratively working with insurance companies could make the insurer understand the risk profile better and trust that the companies can appropriately manage risks. This could allow for lower risk premiums and greater coverage of risks. Self-insurance is an option for some less severe risks by building cash reserves and/or establishing flexible credit lines to be utilised in the event of the risk being realised.	Project and project commercial managers	Project development	2 Minor injury	2 Minor damage	2 Minor effect	2 Limited impact	B	B	B	B	16
15	Workers operating at sea	Risk assessment and method statements prepared and shared with personnel; use of correct PPEs. Health and safety training for all staff at sea. Safety rules vary greatly nearshore versus offshore meaning training should differentiate between the environment operated in.	HSSE and Project managers	Project/activity preparation	3 Major injury	2 Minor damage	2 Minor effect	1 Slight impact	B	A	A	A	11
16	Man made objects brought into marine environment	Ensure vessel design optimised to minimise risk of objects falling into the ocean such as by securing all loose objects and installing buoys at the end of ropes.	HSSE and Project managers	Project/activity preparation	1 Slight injury	2 Minor damage	2 Minor effect	1 Slight impact	A	A	B	A	8

ANNEX 4

See overleaf the Danish pilot risk analysis. The pre-mitigation risk analysis is presented first, followed by the post-mitigation risk analysis which shows the level of residual risk once suggested mitigations are implemented. While this risk analysis can be used as a starting point, all future multi-use pilot projects should undertake their own risk analysis as hazards, risks and appropriate mitigations are highly context specific.

ID	Hazard	Hazard description	Risk description	SOMOS Framework Category	What are the consequences (on 1 - small to 5 - major scale)?				What is the probability (A is small, D is highest)				Pre-risk mitigation Risk Score
					People	Assets	Environment	Reputation	People	Assets	Environment	Reputation	
1	Lack of technology knowledge	Given the nature of MUPs in which two (or more) different activities form the core business it can be challenging to find appropriately qualified/experienced staff to hire.	Lack of technological knowledge of how the windfarm operates could cause serious damage to people and infra-structure as untrained tourists enter the site.	Safety to man and equipment	4 Single fatality	3 Local damage	3 Local effect	3 Considerable impact	B	C	C	B	32
2	Lack of investment	Financial markets and funds derived from private investors can be volatile. Government financing programs may be slow to implement and susceptible to political uncertainty. In addition, subsidies are complicated to obtain.	Failure to secure full capital or revenue financing could result in project delays, unsustainable loans, inflationary pressures, contract disputes with suppliers, and project/business failures.	Other	2 Minor injury	3 Local damage	2 Minor effect	2 Limited impact	A	C	B	B	19
3	Insurance cost and coverage	Insurance in MUP activities must be able to cover at the same time activities with different purposes and objectives (ie production methods, workers, equipment, etc) meaning the business elements that can be insured are often unclear. Some hazards are not insured such as storms or earthquakes, this is risky for companies operating offshore given the likelihood of the hazard occurring. Some infrastructure can be particularly at risk with high financial costs to repair damage, such as sea cables connecting to the monopiles are at high risk of boat collisions.	Insurance is usually a risk mitigation activity. In some cases, as in the case of MUPs, uncertainty about insurance liability makes investment in these activities difficult. Too high a premium price resulting from a cautious approach from insurers can discourage business formation. In addition, the inability to insure for some weather and natural phenomena makes activities at sea riskier for the operator who must self-insure. Not being fully insured does not increase the risk of each activity, but it does increase the consequences of an event for the operators.	Other	5 Multiple fatalities	5 Extensive damage	4 Major effect	3 Considerable impact	C	C	C	C	51
4	Energy price	High energy prices and volatility make investment choices difficult.	The risk is that the business will not be sustainable when the price of electricity reaches very high levels. High prices reduces profits, meaning the companies could struggle to meet their financial obligations with employees and suppliers. This also could postpone important investments such as maintenance and replacement of some obsolete equipment that should be upgraded to be more efficient in terms of safety, energy, or productivity.	Other	2 Minor injury	4 Major damage	3 Local effect	2 Limited impact	A	C	B	A	22
5	COVID-19	Pandemic rules and restrictions, particularly those on interpersonal distance, can create problems for the usability of the tourism service of the business platform.	The spacing rules can make visits by groups of tourists impossible (or very complicated), as it is necessary to share spaces such as the boat and the compartment inside the turbine, areas where the risk of contagion is greatest. When the rules are enforced, it is possible to have many service cancellations that represent a cost to the company. Finally, mobility restrictions can cause the company to lose customers.	Safety to man and equipment	3 Major injury	2 Minor damage	1 Slight effect	3 Considerable impact	C	B	B	C	24
6	Equipment renewal	Refurbishment and subsequent disposal of assets (especially fixed assets such as offshore wind monopiles) is a highly intensive and costly activity.	If action is not taken promptly to upgrade production infrastructure at the end of its useful lifespan, there is a risk that it will become obsolete and break down, causing large unexpected losses to production. In addition dated infrastructure is often inefficient and there is a risk of not being competitive on the market. Finally, improper disposal of equipment could contaminate the surrounding environment and/or damage other multi-use activities nearby.	Safety to man and equipment	1 Slight injury	4 Major damage	4 Major effect	2 Limited impact	B	C	C	B	30

7	Heavy metal contamination	Site contamination reduces the possibility of business expansion to new activities (e.g., seaweed cultivation, fishing, underwater tourism) as these are activities unsuited to be carried out in polluted waters. Environment and people can also report severe damage from this condition.	Site contamination threatens to hold back the company's scale-up, which cannot start new production activities that would be affected by water contamination. Clean-up costs can be very high to bear. Operating on a contaminated site also can be dangerous to workers' health such as if divers do not take appropriate precautions. The damage on ecosystems and the environment	Environmental and cumulative	3 Major injury	2 Minor damage	4 Major effect	3 Considerable impact	A	B	C	B	25
8	Weather condition	In areas suitable for wind energy production, weather conditions are very unpredictable. Intense weather conditions make it inaccessible to pilot the wind infrastructure and visit tourists. Boats cannot operate in extreme conditions.	Weather conditions can damage or corrode equipment by polluting the environment with metals and plastics. Furthermore, in severe weather conditions, visits to the infrastructure are not possible, boats cannot operate, and landing on the platform is not safe for tourists. Visits will have to be refunded, in case of delays this could affect the reliability and reputation of the company.	Safety to man and equipment	5 Multiple fatalities	4 Major damage	4 Major effect	3 Considerable impact	C	C	C	B	45
9	Infrastructure on site	Activity within the site could cause accidents involving staff or tourists as they interact with the infrastructure. Particular risks for tourist visitors as they are untrained members of the public. Hazards on site include working at height; boarding the site; and transporting tourists by boat.	Opening the wind farm to tourists increases the risk of personal injury. The dangers are during the trip on the boat, during the climb and descent up the turbine, passage to/from the boat, and inside the wind infrastructure. At any point on a visit, there could be trips/slips/falls. Incidents due to the company's negligence can have great consequences for reputation and social acceptance of the business as well as legal liabilities.	Safety to man and equipment	5 Multiple fatalities	4 Major damage	2 Minor effect	4 Major national impact	C	B	A	C	37
10	Lack of social acceptance	Offshore wind farms can be difficult for some local residents to accept because of the noise they generate and the visual impact on the landscape.	Risks from lack of social acceptance include: delays in acquiring or rejections of permit applications; restrictions to activities that prevent the site operating at potential; disruption and damage caused by protests. Lack of social acceptance also risks undermining the company's ability to finance operations. Finally, in the case of public-facing activities (tourist visits), the low social acceptance could limit the number of customers.	Other	2 Minor injury	2 Minor damage	1 Slight effect	4 Major national impact	A	B	B	C	20
11	Lack of specific regulation for MUP	There is a lack of specific policy support in the form of regulation for multi-use projects (e.g., multi-use requirements for offshore wind farms, facilitated access to permits for offshore wind farms with a multi-use component, assistance in project design, facilitation of cooperation among operators).	The lack of specific regulation for MUPs can create market inefficiencies, legal problems and failure to expand the businesses. It can also cause significant environmental problems that can arise from a lack of defined standards leading to inconsistent and potentially inadequate environmental protection approaches. Finally, lack of regulation can make obtaining financing more difficult due to uncertainties in the industry and business model.	Other	3 Major injury	3 Local damage	3 Local effect	3 Considerable impact	A	B	B	B	21
12	Structure failure	Structure failures in complex facilities such as those used in wind power can occur from a variety of causes including: bird strikes, lightning strikes, rainfall, blade furniture detachment, boat collisions, delamination, leading-edge corrosion or blade cracks. The multi-use pilot adds the risk of untrained tourists damaging the infrastructure.	Energy production depends on the proper functioning of the structure. The risk is that structure failure causes serious accidents to people and damage to the environment if they involve leaks. Revenue may be lost and it could be difficult to cover production costs. Repair costs could be very high.	Safety to man and equipment	4 Single fatality	4 Major damage	2 Minor effect	2 Limited impact	B	C	B	B	28

Danish
Date completed:
Post-mitigation

Completed by:Elisa

15/12/2022

ID	Hazard	Actions			What are the consequences (on 1 - small to 5 - major scale)?				What is the probability (A is small, D is highest)				Post-risk mitigation Risk Score after Mitigation
		Mitigation	Action By	Action When	People	Assets	Environment	Reputation	People	Assets	Environment	Reputation	
1	Lack of technology knowledge	Develop precise and detailed protocols for behaviour within and for journeys to/from the site. Both the OWF company and the tourism company can also invest in training staff on how to interact with others within the windfarm site and the infrastructure to ensure equipment and processes are well understood. Some training sessions could be combined to help transfer knowledge and build trust between the parties.	Business development managers, site project managers	Research and development, project design, project operations	1 Slight injury	2 Minor damage	2 Minor effect	1 Slight impact	A	A	A	A	6
2	Lack of investment	Financing arrangements should be carefully considered to increase robustness. Priority should be given to credible partners and investors. Consider insurance measures or collaboration with public sector entities so as to share the business risk. Also, it is important to consider the possibility of obtaining grants from international organisations so as to overcome local funding/financing shortages.	Business development teams and commercial managers	Project development and fund raising	1 Slight injury	1 Slight damage	1 Slight effect	1 Slight impact	A	B	A	A	5
3	Insurance cost and coverage	Drafting detailed safety protocols for different activities and operators and collaboratively working with insurance companies could help the insurance company understand the risk profile better and trust that the company can appropriately manage risks. This could allow for lower risk premiums and greater coverage of risks. Self insurance is an option for some less severe risks by building cash reserves and/or establishing flexible credit lines to be utilised in the event of the risk being realised.	Project managers and project commercial managers	Project development	2 Minor injury	1 Slight damage	2 Minor effect	2 Limited impact	B	B	B	B	14
4	Energy price	Diversifying the market and not relying on one buyer of the product can help to deliver more stable profits. In addition, good insurance coverage can contain losses from a collapse of energy prices in the market. Finally, diversification in multi-use enterprises also creates opportunities for profits from the high electricity price to sustain activities on site (i.e., through sale of electricity).	Business development and commercial managers	Business development and operations	1 Slight injury	3 Local damage	2 Minor effect	2 Limited impact	A	B	B	B	15
5	COVID-19	Establish advertising and operations plans that keeps the attraction of the tourist activity high even during periods of restriction. In addition, a marketing program could help control market irregularity during restrictions by offering discounts during to be used when reopening to the public to help stimulate demand after restrictions are softened. Setting up an online visitation service can also be an alternative during periods when it is not possible to receive tourists.	Business development managers and marketing advisor	Project development	2 Minor injury	1 Slight damage	1 Slight effect	2 Limited impact	B	B	A	B	11
6	Equipment renewal	A good infrastructure asset management plan can enable timely infrastructure renewals. The replacement plan should be developed at the beginning of the project. A sinking fund could be included in the business model to ensure that adequate funds are available for site renewal and	All multi-use site designers. Decommissioning team. Owners of business	Design and operation of the site	1 Slight injury	2 Minor damage	2 Minor effect	1 Slight impact	A	B	B	B	11

7	Heavy metal contamination	Design the site to minimize the risk of contamination from alternative uses (e.g., taking into account tidal flows, waves, etc.). Establish work practices that minimize the risk of human exposure. Establish a fund that can be used for cleanup in case of accidents. Conduct site analysis frequently.	Production site designer and manager	Site design stage and operations	1 Slight injury	1 Slight damage	2 Minor effect	1 Slight impact	A	B	B	A	8
8	Weather condition	Extensive protocols should be developed to ensure safety including at the port, on vessels, and at the site. Equipment installed should be reviewed and designed to minimise environmental hazard and likelihood of detachment. Long term impacts of ocean salinity should be considered on all materials used. Regular checks should be made to ensure equipment has not detached and reasonable efforts made to recover all equipment. Health and safety training should be mandatory for all workers and visitors to the site. The training should be refreshed regularly including emergency drill practices. The weather forecast should be monitored continually with appropriate protocols developed for each eventuality. Installing on-site sensors can help with information gathering, and it is also possible to collaborate with forecast-ing experts in the area. As part of developing the protocols, consultation with the coast guard should be made. Insurance should be taken out to cover damage, working closely with insurance companies to identify an appropriate allocation of risk between the insurance company and the business. Disaster recovery plans should be developed to determine the best approach to stabilising and repairing the site in the event of	All multi-use site managers	Project development and operations	2 Minor injury	2 Minor damage	2 Minor effect	2 Limited impact	B	B	A	B	14
9	Infrastructure on site	Establish a safety protocol for visits. Clearly explain all risks to tourists, ask them to sign a form acknowledging the safety rules. Frequently update conditions and instructions. Train staff on risk management and what to do in case of an accident. Arrange comprehensive insurance coverage for injuries on site.	Safety managers and owners of business	Design and operation of the site	2 Minor injury	1 Slight damage	1 Slight effect	2 Limited impact	B	A	A	B	10
10	Lack of social acceptance	Options to improve social acceptance include: - Disseminating knowledge on benefits brought by these activities. - Workshops with students and other stakeholders benefits and challenges to developing multi-use offshore - Utilizing a 3-pointed stakeholder engagement process: 1) a stakeholder analysis in which relevant stakeholders will be identified, (2) inclusion of stakeholder in the pertinent steps in the pilot development process and	Business manager and marketing office	Marketing phase, project design	1 Slight injury	1 Slight damage	1 Slight effect	2 Limited impact	A	A	A	B	7
11	Lack of specific regulation for MUP	It is important for the company to have internal regulatory protocols at commencement on site that set high standards for protection of the environment and people. A detailed business plan can help secure project funding/financing. Finally, establishing a good working relationship with the public sector through the exchange of data and information can help to ensure emerging regulations and standards meet company business requirements.	Project commercial managers and site managers	Business design and project operation	1 Slight injury	2 Minor damage	2 Minor effect	1 Slight impact	A	A	A	A	6
12	Structure failure	Develop a robust operation and maintenance plan which incorporates created by and to tourists visiting the OWF. Ensure insurance coverage takes into account facility failures.	Business managers	Project development and operations	2 Minor injury	3 Local damage	2 Minor effect	1 Slight impact	B	B	A	A	13

ANNEX 5

See overleaf the Greek pilot risk analysis. The pre-mitigation risk analysis is presented first, followed by the post-mitigation risk analysis which shows the level of residual risk once suggested mitigations are implemented. While this risk analysis can be used as a starting point, all future multi-use pilot projects should undertake their own risk analysis as hazards, risks and appropriate mitigations are highly context specific.

ID	Hazard	Hazard description	Risk description	SOMOS Framework Category	What are the consequences (on 1 - small to 5 - major scale)?				What is the probability (A is small, D is highest)				Pre-risk mitigation Risk Score
					People	Assets	Environment	Reputation	People	Assets	Environment	Reputation	
1	Lack of specific regulation	MUPs are a new activity that often on the national and international level lack specific policies to regulate activities and projects, leading to much uncertainty.	The lack of specific regulation for MUPs can create market inefficiencies, legal problems and failure to expand businesses. Lack of rules, especially in environmental and worker safety can lead to incidents. They can discourage business expansion. Lack of regulation can make obtaining financing more difficult due to uncertainties in the industry and business model. Finally there can be difficulty in obtaining permits if regulations are not clear.	Other	1 Slight injury	1 Slight damage	3 Local effect	3 Considerable impact	A	A	B	B	14
2	COVID-19	COVID-19 rules have created a lot of uncertainty about markets and people's mobility. In particular, interpersonal distance rules can affect tourism.	Tourism can be greatly affected by COVID-19 mitigation rules. Lack of tourists may cause businesses to lose revenue due to lost customers. In addition, restaurant shutdowns due to restrictions can cause big losses to the aquaculture company. This may lead to job losses or business failure.	Other	2 Minor injury	2 Minor damage	2 Minor effect	2 Limited impact	B	B	B	C	18
3	Lack of social acceptance	Aquaculture is not socially accepted by some citizens because of negative examples derived mainly from fish aquaculture.	If the company suffers from a bad reputation among locals it may struggle to establish itself in the market and sell its products. Moreover, this could translate into challenges in accessing financing. When the business also involves tourism this could reduce the number of visits and thus profits. There is also risk of delays in acquiring or rejections of permit applications.	Other	3 Major injury	2 Minor damage	1 Slight effect	2 Limited impact	B	B	B	A	14
4	Water quality	Water quality describes the condition of water, including chemical, physical, and biological characteristics. This parameter is crucial for aquaculture and other activities. Contamination of seawater by substances that make it unusable for various activities including fish farming and diving activity. Contamination could be due to oil leaks, other chemical wastes, or parasites.	Water quality is very important for aquaculture. Poor water quality near the site can put fish growth at risk. In addition, it could cause food safety issues potentially leading to the fish not being suitable for human consumption. This could represent a large loss of revenue for the company. A polluted site damages the surrounding ecosystem and is potentially hazardous to the health of workers and/or tourists.	Food and feed	4 Single fatality	3 Local damage	4 Major effect	3 Considerable impact	B	B	B	B	28
5	Weather condition	Weather conditions can be particularly severe at sea. The increasingly frequent extreme weather events (warming, storms, etc.) are dangerous for the people involved (workers and tourists) and to production facilities.	Severe weather conditions put divers at risk and can cause serious incidents. Also there is a risk of losing the fish stock entirely. In addition, following storms, some parts of the structure may become detached from the anchorage and disperse into the environment.	Safety to man and equipment	5 Multiple fatalities	4 Major damage	4 Major effect	3 Considerable impact	C	C	C	B	45
6	Lack of marine spatial planning (MSP)	MSP is a key tool for marine decision-making. In contrast to terrestrial spatial planning, often marine spatial planning is insufficiently developed or outdated and therefore of limited use for planning activities. It is beneficial to allocate space among competing economic activities	Lack of good spatial planning may increase conflicts between local businesses, leading to less collaboration and communication. It could increase marine traffic that if unorganized could cause serious accidents to people, equipment and the environment.	Other	2 Minor injury	3 Local damage	2 Minor effect	2 Limited impact	B	B	B	B	18
7	Earthquakes	Greece is located on a seismic zone of the earth making it an earthquake-prone area. In marine areas earthquakes can turn into strong waves.	The increase in wave motion could damage the infrastructure, injure people (workers and tourists), and disperse debris into the sea, creating great ecological damage.	Environmental and cumulative	3 Major injury	3 Local damage	3 Local effect	3 Considerable impact	B	B	B	A	21

8	Anchoring vessel issues	Vessels at anchor have the potential to cause a number of negative effects on the marine environment such as generating underwater noise, importing invasive species, damaging the seabed, discharging waste and effluents, and air pollution from engine exhaust. There is also the threat of fuel oil spillage.	Improper anchoring can cause damage and loss to the vessel, other vessels, aquaculture infrastructure, and the environment. Losses resulting from grounding and collision due to dragging or loss of the anchor can be significant and cause serious environmental problems. It can also endanger workers. In case of spills or other discharges, clean-up costs may be incurred.	Safety to man and equipment	1 Slight injury	3 Local damage	4 Major effect	3 Considerable impact	C	C	C	B	30
9	Connectivity issues	Connectivity with internet and other communication means such as mobile phones can be complicated to set up offshore but essential for operational and safety communications.	Lack of communication at sea can put both staff and tourists at risk. In addition, the lack of direct connectivity does not allow for timely action on any damage to the infrastructure, risking more serious damage that is costly to repair.	Safety to man and equipment	2 Minor injury	3 Local damage	2 Minor effect	2 Limited impact	B	B	A	A	14
10	Power supply	Equipment on the site needs a reliable and sufficient capacity power supply. This includes cameras, sensors, and lights. Activity at the site could damage the cables. The site relies upon power supply.	Intermittent power supply could create health and safety risks for workers and fish if alternative power supply is not available on site. Inadequate power supply could lead to critical systems failures for the aquaculture tanks.	Safety to man and equipment	3 Major injury	2 Minor damage	1 Slight effect	1 Slight impact	B	B	A	A	12
11	Cameras and sensors	The onshore team's understanding of site conditions within the cages relies upon functioning cameras and sensors on site. If poorly installed, of low quality, or not maintained/cleaned, malfunctioning could occur.	Camera/sensor failure could lead to a number of risks including poor understanding of site conditions leading to inappropriate response decisions by onshore team, injuries and fatalities, damage to assets, damage to marine ecosystems, damage to aquaculture fish, and slow response times. Consequences of malfunctions are higher when additional risks are in effect (ie during a storm). In addition, if not fixed well to the aquaculture cages, cameras and sensors could be lost to the environment.	Safety to man and equipment	4 Single fatality	4 Major damage	3 Local effect	2 Limited impact	B	C	C	B	33
12	Lack of expertise with business models and best practices	MUPs are considered a novelty because they involve different activities together, so there are not yet many business models to draw inspiration from. This can create uncertainty and increase business risk.	The uncertainty of not having comparable business models can lead to making inappropriate investment choices. The lack of experience of managers and staff could endanger the company's financial performance. This could be more complicated due to the small company size training staff based on limited finances.	Other	2 Minor injury	2 Minor damage	2 Minor effect	3 Considerable impact	B	B	B	B	18
13	Insurance cost and coverage	Insurance in MUP activities must be able to cover at the same time activities with different purposes and objectives (ie production methods, workers, equipment, etc) meaning the business elements that can be insured are often unclear. In this specific case, the insurance must cover the aquaculture activity and the risk of people diving. Some hazards are often not insured such as storms or earthquakes, this is dangerous for companies operating offshore given the likelihood of the risk.	Insurance is usually a risk mitigation activity. But in some cases, as in the case of MUPs, uncertainty about insurance liability makes investment in these activities difficult. Too high a price resulting from an over-cautious approach can discourage business formation. In addition, the inability to insure for some weather and natural phenomena makes activities at sea riskier for the operator who must self-insure, which may not be possible to do so adequately for a small business. Failure to achieve full coverage can have significant consequences, since tourists are involved and there could be serious injuries, which would also undermine the company's reputation and image. Not being fully insured does not increase the risk of each activity, but it does increase the consequences of an event for the operators.	Other	5 Multiple fatalities	5 Extensive damage	4 Major effect	3 Considerable impact	C	C	C	C	51

Greek
Date completed:
Post-mitigation

Completed by: Elisa

01/12/2022

ID	Hazard	Mitigation	Actions		What are the consequences (on 1 - small to 5 - major scale)?				What is the probability (A is small, D is highest)				Post-risk mitigation Risk Score Risk Score after Mitigation
			Action By	Action When	People	Assets	Environment	Reputation	People	Assets	Environment	Reputation	
1	Lack of specific regulation	It is important for the companies to have internal regulatory protocols at commencement on site that set high standards for the protection of the environment and people. A detailed business plan can help secure project funding/financing. Finally, establishing a good working relationship with the public sector through the exchange of data and information can help to ensure emerging regulations and standards meet company business requirements.	Project commercial managers and site managers	Business development and operations	1 Slight injury	1 Slight damage	1 Slight effect	1 Slight impact	A	A	A	A	4
2	COVID-19	Establish advertising and operations plans that keeps the attraction of the tourist activity high even during periods of restriction. In addition, a marketing programme could help minimise demand fluctuations during restrictions by offering discounts during periods of activity. Diversification of activities counteracts the loss of profits associated with tourism.	Business development managers and site managers	Project development and operations	2 Minor injury	1 Slight damage	1 Slight effect	1 Slight impact	B	A	A	B	8
3	Lack of social acceptance	Options to improve social acceptance include: - Disseminating knowledge on responsible farming and sustainable energy production. - Workshops with students and other stakeholders benefits and challenges to developing multi-use offshore - Utilizing a 3-pointed stakeholder engagement process: 1) a stakeholder analysis in which relevant stakeholders will be	Business managers	Business design and operation, marketing phase	1 Slight injury	1 Slight damage	1 Slight effect	1 Slight impact	A	A	A	A	4
4	Water quality	During the planning stages of the activity, a feasibility study should be conducted to define the area in which to farm. Provide clear and detailed information for the safety of staff and tourists. Conduct frequent water analysis of the site. Have a good safety regime and leakage control. Camaras and sensors can help prompt action in case of leaks even if not from the site's own infrastructure. Develop a cleanup plan and fund in case site pollution occurs.	Business development managers and site managers	Project development and operations	2 Minor injury	2 Minor damage	2 Minor effect	2 Limited impact	B	A	B	A	12
5	Weather condition	Extensive protocols should be developed to ensure safety including at the port, on vessels, and at the site. Equipment installed should be reviewed and designed to minimise environmental hazard and likelihood of detachment. Long term impacts of ocean salinity should be considered on all materials used. Regular checks should be made to ensure equipment has not detached and reasonable efforts made to recover all equipment. Health and safety training should be mandatory for all workers and visitors to the site. The training should be refreshed regularly including emergency drill practices. The weather forecast should be monitored continually with appropriate protocols developed for each eventuality. As part of developing the protocols, consultation with the coast guard should be made. Under severe conditions diving must be cancelled to avoid risking injuries. Insurance should be taken out to cover damage, working closely with insurance companies to identify an appropriate allocation of risk between the insurance company and the business. Disaster recovery plans should be developed to determine the best approach to stabilising and repairing the site in the event of severe damage.	All multi-use site managers	Project development and operations	2 Minor injury	2 Minor damage	2 Minor effect	2 Limited impact	B	B	B	A	14
6	Lack of marine spatial planning (MSP)	Establish good communication with local governments to achieve better spatial planning. Collaborate with other operators and businesses to have better spatial organization.	Business managers	Project development and operations	1 Slight injury	1 Slight damage	2 Minor effect	1 Slight impact	A	B	A	A	6
7	Earthquakes	The unpredictability of earthquakes makes them very difficult to mitigate. Provide good safety protocol for workers and tourists in the event of an earthquake. Appropriate insurance levels should be considered to cover damage, working closely with insurance companies to identify an appropriate allocation of risk between the insurance company and the business. Disaster recovery plans should be developed to determine the best approach to stabilising and repairing the site in the event of severe damage.	All multi-use site designers and managers	Design and operation of the site	3 Major injury	3 Local damage	3 Local effect	1 Slight impact	B	A	A	A	13

8	Anchoring vessel issues	Necessary to have a good anchoring plan to minimise risk. Properly train staff involved in this operation.	Project development team and site	Project development and operations	3 Major injury	2 Minor damage	3 Local effect	1 Slight impact	B	B	A	A	14
9	Connectivity issues	Research into new connectivity and data transmission alternatives. Consider alternative connectivity protocols and transmission systems such as LoRA, ZigBee, wifi, in order to transmit data from site devices to an in-between node that would be closer to a 4G network.	Project development team and site managers	Project development and operations	2 Minor injury	2 Minor damage	1 Slight effect	1 Slight impact	A	B	A	A	8
10	Power supply	To check that site power supply is adequate for the devices to work, project team need to check the consumption of the devices and compare to the power supply options available on site in design proposals. If inadequate, must consider alternative power options or lower power usage options. Research into new sources of electricity for the aquaculture infrastructure could be beneficial (e.g. solar panels)	Project development team and site managers	Project development and operations	2 Minor injury	3 Local damage	1 Slight effect	1 Slight impact	B	B	A	A	12
11	Cameras and sensors	To ensure secure installation of cameras and sensors onto the aquaculture infrastructure, make visits to the aquaculture site to plan and design proper installation including asking expert advice on the best way to install such devices to the existing infrastructure. Clean sensors according to equipment manufacturer guidance. Purchase high quality equipment with reliability levels appropriate for level of criticality of sensor.	All multi-use site designers and managers	Project development and implementation	1 Slight injury	1 Slight damage	1 Slight effect	1 Slight impact	A	B	B	A	6
12	Lack of expertise with business models and best practices	Collaboration and communication with other similar entities. Provision of protocols and documentation for detailed internal use that can provide good tracking of the innovation process (e.g. through trial and error). Investment in training and education could attract skilled workers.	All multi-use site designers, commercial managers and site managers	Project development and implementation	1 Slight injury	1 Slight damage	1 Slight effect	2 Limited impact	A	A	A	B	7
13	Insurance cost and coverage	To mitigate this issue, it is necessary to draft up internal security protocols. Tourists must be informed of all safety rules. They can be asked to sign a form to share individual responsibility while diving. The procedures need to be updated frequently, because new issues may arise over time, and it is important that these are included promptly. Drafting detailed protocols of safety rules for different activities and operators and collaboratively working with insurance companies could help the insurance company understand the risk profile better and trust that the companies can appropriately manage risks. This could allow for lower risk premiums and greater coverage of risks. Self insurance is an option for some less severe risks by building cash reserves and/or establishing flexible credit lines to be utilised in the event of the risk being realised.	Project managers and project commercial managers	Project development	2 Minor injury	2 Minor damage	2 Minor effect	2 Limited impact	B	B	B	B	16

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