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DELIVERABLE 1.1

CHALLENGES, RISKS AND BARRIERS FOR LARGE-SCALE COMMERCIAL ROLL OUT

Work Package 1
Framework and Facilitation of Systems Learning and
Upscaling Multi-Use

April 30th, 2020

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Abstract	This deliverable describes results of UNITED task 1.1. It provides an overview of barriers identified in earlier multi-use projects and informs the UNITED project on state-of-the-art research.
Keywords	Literature review, multi-use, barriers, Horizon 2020

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ACRONYMES

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

The use of European seas is changing, under the influence of multiple major societal challenges. Multi-use is seen as better way 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). UNITED will enhance the technology readiness level of the technology validated in relevant environment (TRL 5) to demonstration in an operational state (TRL 7+).

This deliverable is the result of work done under Work Package (WP) 1, Task 1.1. It identifies the barriers for large scale commercial roll out of multi-use platforms, through the study of the previous projects such as the H2020 call 'The Oceans of Tomorrow', which has provided promising designs, technological proposals and models for combining activities in terms of economic potential and environmental impact. To this end, an extensive systematic literature review was conducted to identify barriers reported in the scientific literature on multi-use. This was followed by a questionnaire, used to consult pilot owners involved in UNITED in order to elicit their insights in barriers to multi-use. The results from the literature review and questionnaire are compared to earlier provided documents by the pilot owners.

This review points to the wide variety in barriers, realising multi-use in practice is certainly not hampered by technological barriers only. Lastly, the consultation with the UNITED pilots leans that barriers need to be identified in a case-by-case manner, there are no general barriers to multi-use. This deliverable provides an overview of barriers identified in earlier multi-use projects, categorized along five pillars to achieve the first objective of UNITED WP1. The results presented in this deliverable can be of benefit in WP1 by providing insight and references to solutions already studied and reported on, to be used in Task 1.2 "Review of existing solutions or developed solutions" and providing input on economic barriers and solutions to inform Task 1.3 "Optimise business cases and requirements definitions". Furthermore, the review of literature can inform further development in the pilots, supporting UNITED consortium members in identifying relevant projects and publications to learn from.

1. INTRODUCTION

Background

The use of European seas is changing, under the influence of multiple major societal challenges. Concerns about climate change trigger 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 portfolio of maritime activities, including transportation, ports, sand extraction, fisheries and oil and gas extraction. The seas are also an important natural habitat, protected by legislation such as the Birds Directive (2009/147/EC) and Habitats Directive (92/43/EEC). All in all, these developments lead to a higher intensity of use of the sea. This can, and sometimes already does, lead to conflicting claims for space.

In this context, the concept of multi-use has gained popularity. Multi-use is seen as better way to make use of scarce sea space in conditions with favourable areas, and deliver efficiency gains that improve the economic performance of sectors. As illustrated by Schupp et al. (2019) and Dalton et al. (2019) the concept of multi-use is used to describe a variety of activities, from the physical shared use of infrastructure to staggered use. Both have developed a typology of multi-use. In this Deliverable, the typologies of Schupp et al. (2019) and Dalton et al. (2019) are combined, coming to three different types of multi-use:

- Multi-use Type A: Shared production platform: a situation where two different activities are closely connecting, with shared use of infrastructure. An example would the shared floating platforms for energy generation and aquaculture.[1]
- Multi-use Type B: Shared auxiliary platform and/or co-location. In this type, the two activities share an auxiliary platform and/or are co-located in the same space. An example would be the production of seaweeds in an offshore wind farm.
- Multi-use Type C: Staggered use (e.g. repurposing): in this type the two activities are not taking place at the same time, e.g. re-use of oil and gas platforms.

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).

The UNITED 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 the five pillars: its technical, regulatory, economic, social and environmental viability. It will demonstrate the benefits of the multi-use of marine space concept for multiple economic activities. Optimal multi-use concepts and co-location activities will be implemented in five pilots across European regional seas in close cooperation of local stakeholders and industrial actors.

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[1] See e.g. the Space@sea project, https://spaceatsea-project.eu/ (last accessed 04/04/2020)

Objective of this deliverable

This deliverable is the result of work done under Work Package (WP) 1, Task 1.1. It focusses on the challenges, risks and barriers for large scale commercial roll out of multi-use platforms, through the study of the previous projects such as the H2020 call 'The Oceans of Tomorrow', which has provided promising designs, technological proposals and models for combining activities in terms of economic potential and environmental impact. This can help the UNITED project partners in identifying relevant earlier projects and/or literature to learn how their barriers, challenges and risks were addressed by others.

In identifying challenges, risks and barriers, the following working definitions for these terms were used. Barriers: the overarching terms referring to *a circumstance or obstacle that prevents progress*. For a structured examination of those marked barriers, the analysis will focus on the five pillars: (1) technology-, (2) economics-, (3) environmental-, (4) societal-, (5) legal, policy and governance pillar. Challenges refer to *a call to prove or justify something*. It refers to a situation where a solution to a barrier is provided, or thought of, yet not proven or justified. Risks refer to *a situation involving exposure to danger*. When a risk is identified as a barrier, it suggest the chances that somebody or something is exposed to danger are unacceptably high. For reasons of clarity, this deliverable will mostly use the generic term barriers. In the concluding section we will come back to risks and challenges.

This report presents the barriers as identified in previous multi-use projects and reported in the scientific literature and is combined with the overview of barriers identified in literature and results from the questionnaire among the UNITED pilot owners (both in Annex). This outcome will be used as input to UNITED WP2, WP3, WP4, WP5 and WP6 to inform technology development and to give insight in the risk assessment that needs to be carried out for the optimized business cases based on above and facilitate the optimized business cases definition.

The report consists of the following chapters. In this chapter (Chapter 1), the UNITED project is briefly introduced. More information is available on the project website. Chapter 2 presents the methodological approach to the task, including a detailed description of methods used. Chapter 3 and Chapter 4 present the results from, subsequently, the literature review and the questionnaire. In Chapter 5, these results are discussed in the context of the so-called "pilot document" provided by the pilot owners. Chapter 6 draws conclusions and provides an outlook onto the future activities in UNITED.

2. METHODOLOGICAL APPROACH

Overview of the methods used

This task has followed a methodology based on three subsequent steps. In the first step, an extensive systematic literature review was conducted to identify barriers reported in the scientific literature on multi-use. In the second step, a questionnaire was used to consult pilot owners involved in UNITED in order to elicit their insights in barriers to multi-use. In step 3, the results from the literature review and questionnaire were compared to earlier provided documents by the pilot owners (so-called "pilot documents").

The three outcomes of this task are:

1. This deliverable
2. An Excel file with barriers identified and classified (Annex 2)
3. The replies to the questionnaires (Annex 2 to 8)

The relationships between the activities and the deliverables is visualized in Figure 1.

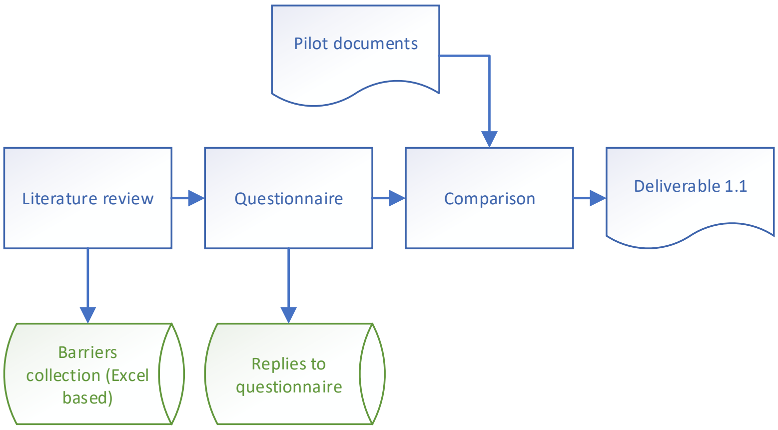

Figure 1: Workflow for preparing Deliverable 1.1

Due to the COVID-19 pandemic, first UNITED workshop did not take place before completion of this deliverable. The first UNITED webinar, replacing the workshops, was organised in June 202 (see Chapter 6).

Method for literature review

Literature review is a research methodology used to collate results from earlier studies, as written down in reports and publications. Within this method, there are a broad variety of approaches. The approach taken here is a systematic literature review, in which protocols for the collection, analysis of and reporting on literature are described in detail (Li, van den Brink and Woltjer 2016).

Literature identification and selection

To identify and retrieve the relevant publications on multi-use, the following activities were undertaken. The scientific publications from the multi-use projects MUSES, MARIBE, MERMAD and SOMOS were downloaded from the respective project websites or via Scopus. Furthermore, a SCOPUS literature search was conducted to find articles that were not included in the publication list of MUSES, MARIBE, MERMAD and SOMOS. The terms used for the literature search were:

- 'multi-use' AND 'platform'
- 'multi-use' AND 'sea' AND 'platform'

- 'multi-use' AND 'platform' AND 'barrier'
- 'multi-purpose' AND 'platform' AND 'barrier'
- 'multi-use' OR 'multi-purpose' AND 'sea' AND 'oceanic'
- 'multi-use' OR 'multi-purpose' AND 'sea' OR 'oceanic'

After the last search term resulted in 83 results of which not a single one was relevant or not already in the list of results, the literature search was stopped. The combination of these search terms let to a review of 279 articles, of which 41 were subsequently selected as being relevant for the literature review. Among these 41 articles were the ones previously selected from the MUSES, MARIBE, MERMAD and SOMOS projects. A complete list of all the publications can be found in Annex 1.

Method for taking stock of barriers

To take stock of the barriers risk and barriers, an Excel file was used. All selected articles were read and the reviewers populated the Excel file with the following characteristics per barrier, described in Table 1.

Table 1: Characteristics recorded in the literature review

Characteristic of article	Answer type
Pillar	• Technology • Economics • Environmental • Societal • Legal, policy and governance
Short description	Free text
Related to which type multi-use	• Multi-use Type A: Shared production platform • Multi-use Type B: Shared auxiliary platform and/or co-location • Multi-use Type C: Staggered use (e.g. repurposing) • Not specified
Remarks	Free text
Regional and/or sectoral focus (if provided)	Free text
Solutions/actions (if provided)	Free text
Reference	Free text
Project from which results stem (if provided)	Free text

In addition to this, the experiences from the ongoing WinWind project were included.[2] These are not reported in the scientific literature, hence two of the researchers involved in WinWind were asked to add the barriers they have encountered to the Excel file. The final result of the literature search is summarized in the following table 2.

Table 2: Number of publications included in the literature review, per year

Year	2011	2013	2014	2015	2016	2017	2018	2019	2020	**Total**
Number of publications	1	1	1	1	6	11	10	8	2	**41**

Method for questionnaire

As a second mean of collecting data on the prevalence of barriers in multi-use projects, a questionnaire was developed. The questionnaire development was led by Wageningen Economic Research and jointly developed with consortium partners. It was given to the participating multi-use projects of UNITED. The set of questions aimed to assess to what extent the project partners in UNITED experienced barriers that were found in the literature as problematic.

To create a reliable and accurate summary of the findings from our literature search, the barriers were split up and a pre-selection was made of all of them to include in the questionnaire. To determine which barriers were relevant for all pilots, two different researchers, both familiar with the pilots, selected a list of barriers that could be experienced by all or the majority of project partners. Then, each barrier was introduced with the statement: *"Please rate whether you agree or disagree with the following statements. The following elements of operating a multi-use platform (MUP) pose a considerable barrier to realize the project:"*. The rating took place with the use of a 5-point Likert scale, ranging from 1 ("Completely disagree") to 5 ("Completely agree"). As some barrier descriptions might still not have been applicable to all of the pilots, a 6th option ("Not applicable") was added.

The questionnaire was programmed with the Qualtrics survey management tool. Including all of the items from other work packages in UNITED, the overall sum of questions amassed to 73. The questionnaire was shared with the pilot owners in a video conference call, in which questions could be asked and answered. After a two-week processing period, the pilot owners submitted their answers. The answers were shared as PDFs and CSV files with all collaborators on the questionnaire. The figures and results in this report were created with R Studio, a tool for statistical computing and graphics.

Method for comparing with pilot documents

In the last step, the results from the literature review and the survey were compared with the pilot documents provided by the UNITED pilots. These documents were assessed to identify the barriers mentioned by the pilot owners and compared to the questionnaire results. First, the documents were retrieved from all project coordinators. The pilot document from North Sea Innovation Lab could not be accessed, hence the proposal document was used to obtain the necessary information. Secondly, the pilot documents were read thoroughly for the identification of any potential barriers foreseen by the pilots. The pilot documents were described briefly and the barriers from the documents were summarized. Thirdly, the insights from the questionnaire were assessed for each pilot individually, comparing these insights to the original pilot documents.

Comparing the pilot documents to the answers provided by the pilots in the questionnaire allows for useful insights into the main points of attention for each pilot individually. Chapter 5 therefore aims to provide each pilot with specific information on potential barriers and challenges and to assist in the successful realisation of each pilot.

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[2] https://www.wur.nl/en/article/Growing-lobster-and-crab-in-a-wind-farm.htm (last accessed 05/04/2020)

3. RESULTS FROM LITERATURE REVIEW

Quantitative analysis

The data recorded from the literature review (full overview in Annex 2) was assessed quantitatively in order to provide a comprehensive overview of the identified barriers, their prevalence per type of multi-use, and a division of most frequently mentioned barriers across sectors.

General findings

A general overview of the recorded data is shown in Figure 2. An analysis of the total number of barriers shows the distribution across the five pillars is relatively well-balanced. Of the total number of 311 identified barriers, those relating to legal, policy and governance are mentioned most frequently, followed by technical constraints, social and economic, and environmental challenges and barriers.

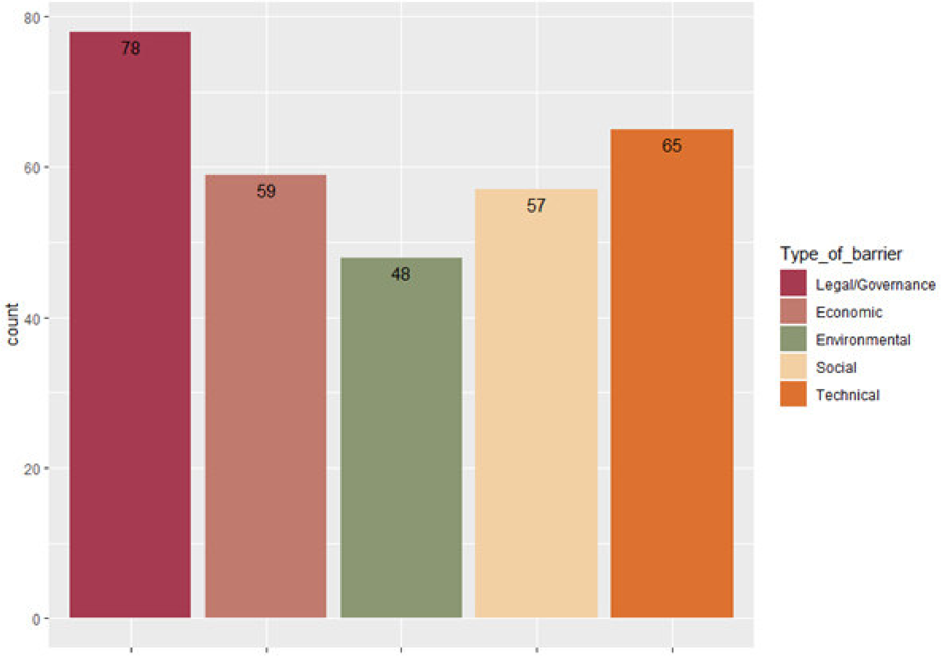


Figure 2: Type of barrier count

Although there is considerable awareness of environmental barriers to multi-use found in the reviewed literature, environmental barriers are mentioned less frequently than the others. Possible explanations for this include:

- Multi-use is believed to have a better environmental performance than single-use;
- Environmental barriers are transposed into the category legal, policy and governance barriers (for example when it comes to environmental regulations).

An overview of the number of barriers although more barriers are reported over time, this is partly explained to the increasing number of publications.

Table 3: Number of reported barriers over time

Year / Type of barrier	2011	2013	2014	2015	2016	2017	2018	2019	2020	Total
Legal / Governance / Administrative	0	0	1	2	16	10	11	24	14	78
Economic	0	0	3	3	10	11	12	13	7	59
Environmental	1	0	6	3	7	18	3	3	7	48
Social	1	1	4	1	11	5	13	15	6	57
Technical	2	0	1	3	17	12	7	17	6	65
Total barriers per year	4	1	15	12	61	56	46	72	40	307
Total publications per year	1	1	1	1	6	11	10	8	2	41

Table 4 provides an overview over the origin of the scientific publications and specifies whether they were funded by the EU or other institutions. Publications were defined as EU projects, when they were funded by the European Union in projects such as MARIBE or MERMAID, EU-member publications specifies that the publication was authored by scientists belonging to member states of the European Union that received funding from private or local government sources.

Table 4: Origin of scientific publications

Origin	EU project	EU-member publications	Non-EU publication
Number of publications	18	22	1

Table 5 shows the seas that were discussed in the different publications. When publications are noted as European, then they typically covered a wide variety of European seas, if not all of them. These publications often reported the results of several projects taking place in a wide variety of seas. For a better overview over these seas and the corresponding publications, consult Appendix 1.

Table 5: Seas covered in the publications

Seas covered	Several	Not specified	European	North Sea	Atlantic	Pacific	Baltic	Mediterranean
Number of publications	7	3	8	12	2	2	1	6

Division per type of multi-use

Figure 3 shows a division of barriers mentioned per type of multi-use as identified in Chapter 2. For multi-use type A, technical barriers are mentioned most frequently, likely due to type A multi-use demanding technologically challenging combinations in facilitating shared production across sectors. For multi-use type B, the lack of identified environmental barriers stands out. One possible explanation could be that type B multi-use combinations are partly developed to bring environmental benefits with more efficient use of space.

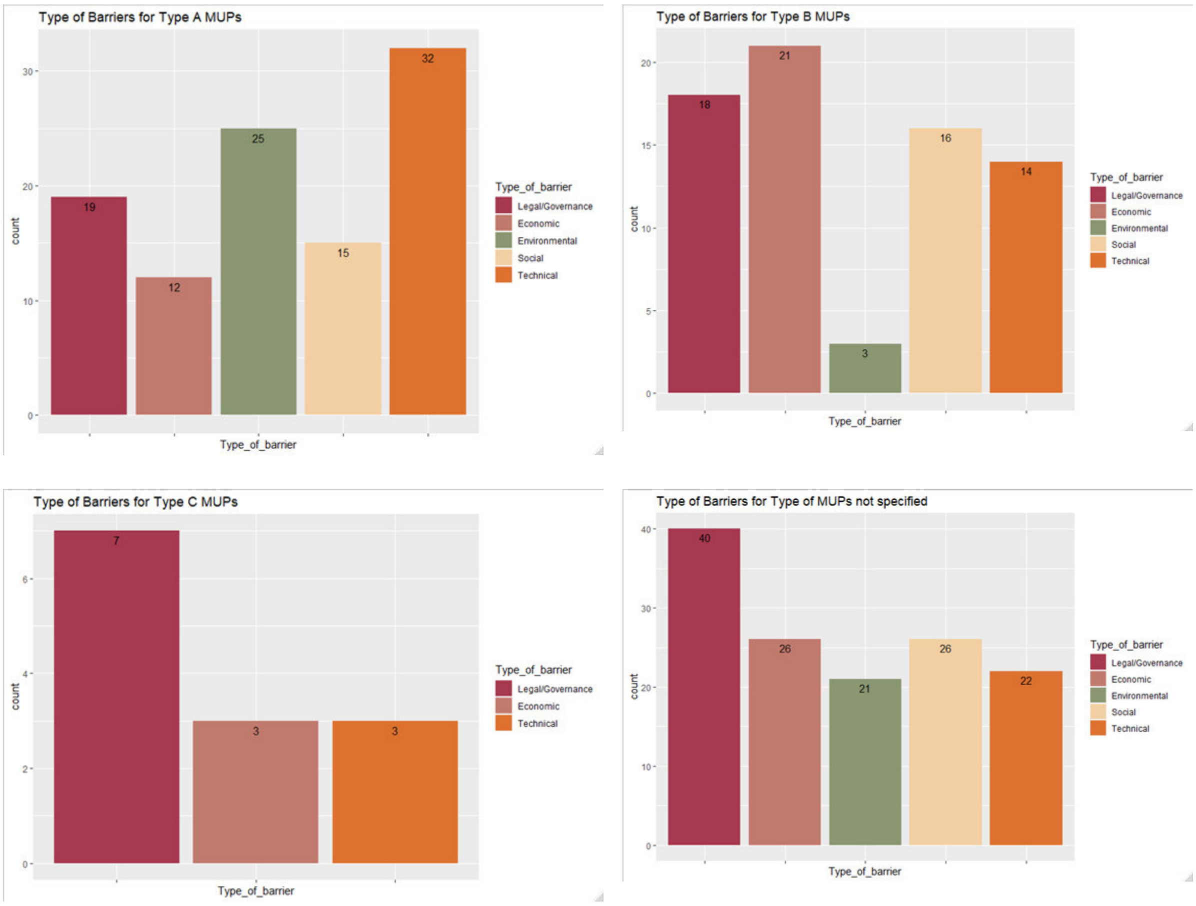


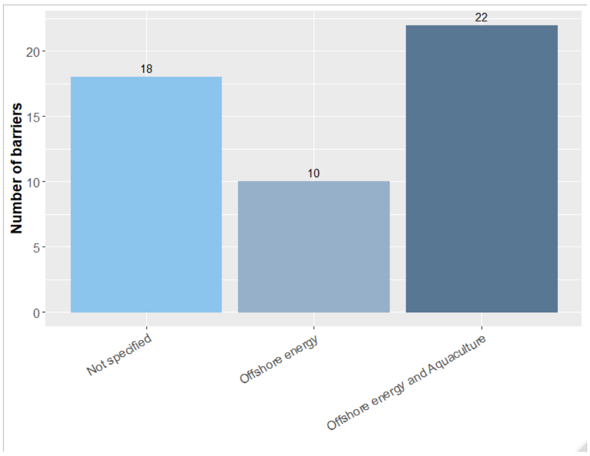
Figure 3: Occurrence of types of barrier per type of multi-use

For multi-use type C, the prevalence of legal, policy and governance barriers stands out. This can be explained by existing regulations that make staggered use challenging, such as issues of liability and the OSPAR convention. These regulatory constraints must be overcome before other barriers can be considered.

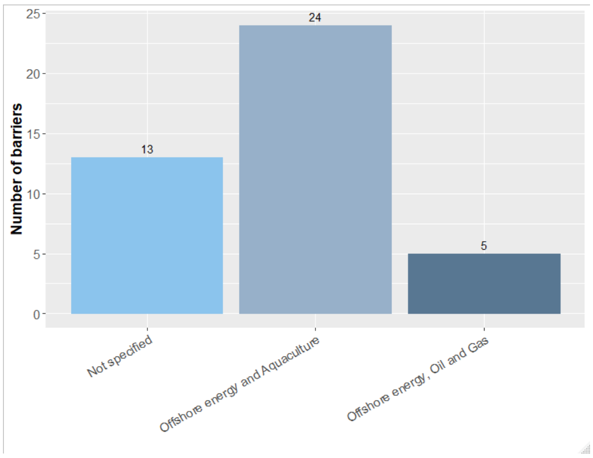
This division of multi-use types does not differentiate between two distinct multi-use development trajectories, (1) where one sector is already realised and the other one is added and (2) when the combination of both sectors is developed from scratch.

Division across sectors

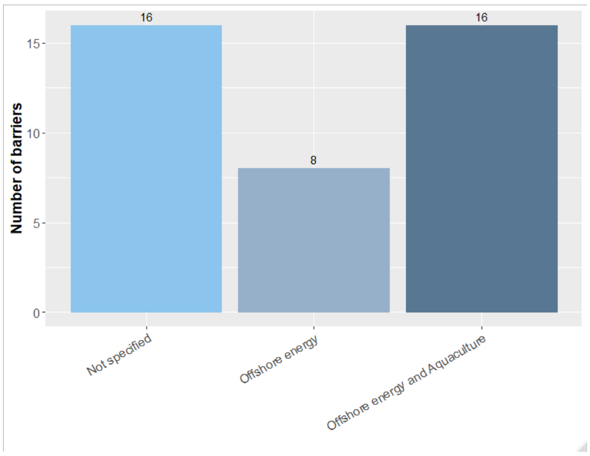
Figure 4 below visualises which sectors are most often related to the different barrier pillars – the three sectors most often mentioned are given. This figure shows that previous studies were focussed on the combination of offshore energy and aquaculture.



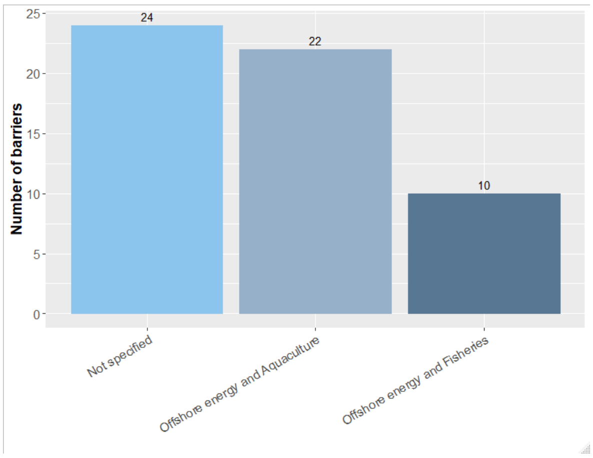
Technical barriers



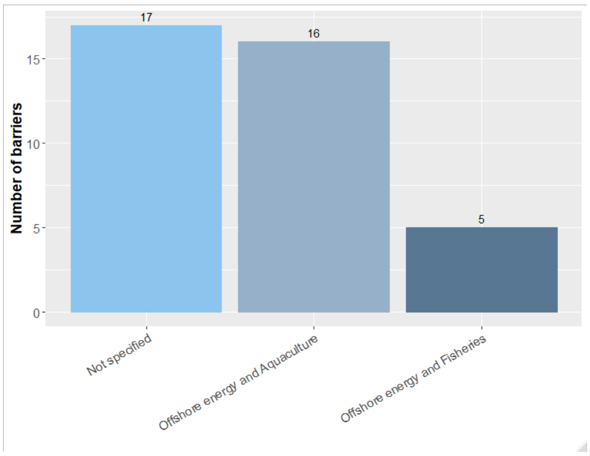
Economic barriers



Environmental barriers



Legal/governance/administrative barriers



Social barriers

Figure 4: Most important sectors per barrier

Qualitative analysis

The qualitative analysis provides insight into the types of barriers identified from the literature. The overview of barriers was analysed by the project team to identify main themes and trends. To support the analysis and visualize the findings, word clouds were assembled providing insight into the most frequently mentioned terms and words relating to the respective pillar. The figures were created using the R-package *wordcloud*. Words that occurred more than 3 times in the descriptions were added to the word cloud. For the exclusion of any fill words (i.e. and, the, a/an, and similar words), the *stopword* function of the R-package *tm* was used. Figure 5 shows an overview of the most frequently mentioned words and terms for all pillars combined.

Figure 5: Word cloud for all of the identified barriers

This overview shows that most of the barriers and challenges mentioned seem to be describing in relation to specific sectors, such as *aquaculture*, *offshore wind* and *energy*. Other terms that stand out are related to operational challenges, such as *maintenance* and *safety*, and economic challenges, such as *insurance* and *costs*. In what follows, the most frequently mentioned terms per pillar will be discussed in more detail.

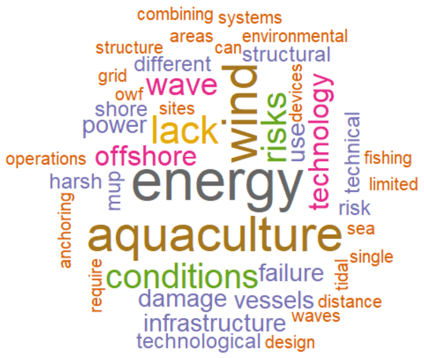


Figure 6: Technological barriers word cloud

When it comes to technical barriers, the first term that stands out among the others is *energy*. This mainly relates to *wave* and *tidal* energy demanding novel technological structures and *offshore* energy challenges, for example in energy storage, the design of systems that can handle harsh conditions at sea, and offshore wind energy transmission.

The *aquaculture* sector is mentioned frequently in relation to technological barriers, mostly relating to fixation/mooring issues, the compatibility of the sector with offshore wind, and the challenging weather and sea conditions.

Figure 7: Economic barriers word cloud

In relation to economic barriers, (high) *costs* appear to be the main concern, which includes concerns for the costs of *maintenance* and *insurance*.

The *aquaculture* and (*offshore*) *wind* sectors again appear, mainly related to the challenges of moving aquaculture offshore. Other notable concerns include *investment* and *investors*, both related to high costs but also to *uncertainties*, which currently limits investment of multi-use combinations.

Figure 8: Environmental barriers word cloud

Environmental barriers to multi-use revolve mainly around concerns for the impacts on *fish*, such as noise, disturbance, the effects on old and new species, aggregation around structures and over-exploitation of fishing grounds. *Birds* are also mentioned frequently in relation to environmental concerns, relating to the risk of collision and their attraction to fish waste.

There appears to be relatively low mention of waste pollution or emissions, and an increased focus on the impacts on the natural habitat of animals and the ecosystem.

Figure 9: Legal policy and governance barriers word cloud

For the legal, policy and governance barriers, the term *lack* stands out, referring mostly to 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 levels.

Insurance comes up as a legal concern as well as an economic one, relating to unclear insurance frameworks and *safety* issues.

Figure 10: Social barriers word cloud

In relation to social barriers, the *fishing* sector and (local) *fishermen* are mentioned frequently. This includes concerns about opposition by larger scale fisheries, the possible exclusion of fishermen and conflicts between multiuse activities and local fisheries.

Additionally, the *tourism* and *wind* sectors stand out, indicating challenges of social acceptance for these sectors.

The qualitative assessment strengthens the argument made before that there a different types of barriers. Recognizing that multi-use is technically challenging, we should also be aware of the importance of social and legal barriers. These features as prominently in the literature review. The qualitative analysis also highlights the earlier studies' sectoral focus on energy and aquaculture. The UNITED pilots that cover these sectors can learn from reported experiences.

4. RESULTS FROM QUESTIONNAIRE

Which barriers were most important?

The following tables give an overview of how the pilots rated the different barriers in the questionnaire. The full overview of the questions can be found in Annex 3.

If an answer is '-', this answer was either not filled out or the barrier was considered not applicable for the pilot (i.e. questions about potential problems of wind energy were not answered by pilots that did not include wind energy turbines).

In what follows, common themes will be introduced that can be found in the answers of the pilots.

Technical barriers

	Kastel-lorizo	*Fino3*	*NSIL*	*Middelgrun-den Wind*	*Belwind*
Lack of general technological knowledge available from the industry involved in MUPs in general (outside of the scope of UNITED).	2	4	3	3	4
Lack of general technological readiness level of all the parties involved with the MUP.	4	2	3	2	4
Lack of technological knowledge to allow MUP structure to withstand adverse weather conditions	4	3	3	2	1
Damage due to extreme adverse environmental catastrophic events (storms or underwater earthquakes)	5	4	5	1	5
Structural risk for MUP from accidental collision with (aquaculture) equipment	3	2	4	-	2
Vibration from wind turbines (when working with wind turbines)	3	1	-	1	1
Lack of infrastructure for energy provision for MUP	2	1	-	-	-
Risk of power failure	4	2	-	1	-
Risk of anchoring vessels damaging power supply cables	5	1	-	1	-
Lack of knowledge about specific anchoring techniques required	4	2	2	3	2
Risk of damage in case of mooring failure	2	4	2	-	2

The list of potential technical barriers shows a wide variety of concerns regarding technical barriers. Considering the different technical nature of the pilots as well as the different stages of multi-use realization of the pilots, the results of the technical barrier questions are not surprising. As different multi-use combinations have different technological needs at the stages of their development process, a strong common theme is not to be expected. Not one technical barrier was identified by all the pilots as being especially problematic.

Environmental barriers

	Kastellorizo	*Fino3*	*NSIL*	*Middelgrunden Wind*	*Belwind*
Lack of economic assessment tools to examining the economic viability of MUP.	4	2	3	1	4
Lack of certainty of effects of far offshore MUP on fish or oysters in aquacultures (with regard to economic effects).	-	-	3	-	5
Lack of attractiveness for private investors.	2	3	3	4	3
Lack of standardized procedures to co-use aspects related to the MUP (i.e. sharing cable equipment or ships)	5	4	3	3	2
High maintenance cost of aquaculture sites.	2	4	4	-	5
High cost of decommissioning of the MUP (potential costs after the end of the multi-use).	4	4	4	-	5
High insurance cost due to lack of experience in colocation/MUP projects	4	4	5	4	5
High insurance cost due to inherent risk associated with multiple use of the same platform.	4	4	5	4	5
High costs for grid connection.	3	3	5	-	-
Lack of expertise with business models and best practices.	5	3	4	4	4
Insufficient subsidies from the government.	5	3	5	5	2
High cost of maintenance.	4	4	4	3	5
High cost of operating staff.	2	2	4	4	5

The economic barriers show a more cohesive pattern than the technological barriers. Especially the points regarding insurance (i.e. Q7 and Q8) receive high score from all pilots. Similarly, the three questions describing barriers regarding a lack of expertise with business models (Q10) and best practices, insufficient subsidies from the government (Q11), and high maintenance costs (Q12), share high ratings with one or two exclusions.

As the economic barriers the pilots face are somewhat diverse, some shared pattern was expected. The fact that all pilots consider insurance to be a costly issue confirms prior expectations. As multi-use is still a considerably new concept, assessing the risk of different parties working together is difficult to implement and to adequately price. The perceived difficulties of finding adequate insurance reflects these uncertainties.

Environmental barriers

	Kastellorizo	*Fino3*	*NSIL*	*Middelgrunden Wind*	*Belwind*
Increased traffic of MUP support vessels resulting in damage to the ecosystem.	4	2	2	1	2
Increasing risk of pollution events (mainly excessive nutrient load and other substances) due to the installation of aquaculture cages.	5	-	3	-	4
Potential, real and perceived, conflicts among marine ecosystem flora and fauna due to artificial introduction of invasive species.	3	1	3	-	4
Risk of the cumulative effect of several aquaculture locations and the disturbance they can cause for the local ecosystem.	4	2	3	-	2
Underwater-noise disturbance of marine mammals such as wales.	-	1	2	-	1
Disturbance of the seabed sediments and seabed communities.	4	1	3	-	4
Collision risks to birds and bats above water.	5	1	1	-	-
Attraction of unwanted invasive species at the location of the MUP.	4	2	3	-	5

The environmental barriers show a very diverse pattern in their answers. This either indicates that the pilots consider their multi-use combinations to have different environmental effects (/barriers) or that there are different levels of environmental consequence awareness, the potential damaging environmental effects of multi-use are judged based on different levels of knowledge. Either way, the diverse pattern in the answers of the pilots suggests that some attention needs to be paid to environmental barriers and environmental effects of multi-use.

Social barriers

	Kastellorizo	*Fino3*	*NSIL*	*Middelgrunden Wind*	*Belwind*

Lack of social acceptance of the MUP by society in general.	3	3	2	4	2
Lack of acceptance of the MUP by the local affected community.	5	3	2	5	1
Lack of consensus about the MUP from multiple stakeholders in private and public sector.	5	4	3	5	2
Lack of trust between industry sectors directly involved in the MUP.	4	5	3	5	3
Lack of public awareness about implications of multi-use.	4	3	4	5	4
Low individual financial power and overall capacity to join MUP from local collaborators.	4	5	4	5	5
Conflicts of interest between different users of the sea (i.e. external tourist agencies, other energy producers, etc.).	4	5	4	5	5

The social barriers were on average considered to be potential problems for the pilots. Apart from the general acceptance of multi-use by the public (Q1) and by the local affected community (Q2), many of the other barriers were mostly considered to be problematic. Low individual financial power of potential local collaborators (Q6) as well as conflicts of interest between different users of the sea (Q7) were considered to be a barrier by all of the pilots. This indicates that these areas of potential social barriers need to be addressed in order to facilitate the role of social responsibility that multi-use combinations are seeking to accept.

Governance / Legal barriers

	Kastellorizo	*Fino3*	*NSIL*	*Middelgrunden Wind*	*Belwind*
Unclear and fragmented regulation for MUPs on national level.	5	4	4	5	1
Unclear and fragmented regulation for MUPs on European level.	5	4	4	5	3
Strict security regulation that discourage setting up a MUP.	5	4	4	5	2
The set of constrains related to safety distance to other users or distance from shore.	4	5	4	1	2
Separate environmental impact assessment processes (permitting) for each of the (hybrid) technologies and lack of guidance on cumulative impact assessment.	4	4	4	3	1

Lack of established licensing procedures for multi-use projects.	5	5	4	-	1
Lack of dialogue between public institutions and difficulties in identifying the administrative offices responsible for issuing permits.	4	5	4	5	1
Lack of cross-border cooperation in MUP projects.	3	5	4	1	3
Lack of established procedures for spatial planning of the sea with a focus on the interests of different stakeholders.	5	5	4	3	1
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).	2	5	4	1	5
Lack of established safety assessment methods for MUPs.	4	4	4	5	4

The barriers that deal with governance or legal issues were on average considered to be problematic for the pilots of the UNITED project. Apart from the Belwind pilot, most of the other pilots indicated that they agree or completely agree that the presented barriers pose a considerable obstacle for their multi-use combination. As the area of legal and governance barriers covers a wide range of potential problems, the individual barriers need to be considered in more detail and have to be addressed by UNITED.

The analysis of the questionnaire shows that a wide range of barriers is relevant for the pilots. All types of barriers are relevant for the pilots. It is difficult to identify commonalities between the pilots, the replies to the questionnaire do show a clear cohesive pattern.

5. COMPARISON WITH PILOT DOCUMENTS

Fino3

Description of the pilot

In Fino3, the multi-use combination of Offshore Wind Farms (OWF) and aquaculture (blue mussel/macroalgae) will be tested to demonstrate the feasibility of such undertakings in practice. The combination of OWF and aquaculture has mainly been driven by the need to increase the aquaculture production, a key component of the Common Fishery Policy, Blue Growth Strategy and national policies. Moreover, the multi-use of offshore sites is highly demanded in several policy documents. Therefore, the development and political demands are clearly in this direction.

Given the large fixed costs associated with development and operation of aquaculture in offshore areas, aquaculture developers consider the combination with OWF as an opportunity to make this move feasible and profitable. Cost saving can potentially be derived through shared operations and maintenance (O&M) between the two sectors. Financial benefits to the OWF sector through outsourcing the operational activities below will be possible to test and demonstrate not only in theory but also in practice at the location Fino3 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 sheltering effects of the offshore wind farm, joint operations and maintenance by several stakeholders, and the joint use of data transmitting systems and monitoring systems. In the pilot document, no explicit barriers were defined.

New insights after questionnaire

The answers from the Fino3 pilot indicate that many technological barriers are not considered that problematic. As the pilot is working on the basis of an already established platform in the ocean, several technical barrier categories that apply to other pilots might not hold here. Lack of general technical knowledge, damage due to extreme adverse environmental events, and the risk of damage in case of mooring failure are somewhat considered to be problematic barriers. Considering the economic barriers, the Fino3 pilot shares a similar set of concerns as the other pilots. While insurance, decommissioning, and high maintenance costs seem barriers, none of the barriers were rated with a 5. With regard to the environmental barriers, the Fino3 pilot is not concerned about them. This might be partly due to the secluded position of the pilot site further away from the coast than the other pilots in UNITED. For the governance and legal barriers, the answers from the Fino3 pilot were on average the highest, indicating that most barriers here are considered as problematic. Looking at the social barriers, the Fino3 pilot shares the same set of concerns regarding these obstacles as the other pilots.

Identified gaps and challenges

- Technological: weather conditions and the high energetic environment; automation of remote data recording; anchoring/mooring; site not appropriate for frequent visits, requiring minimal or automated maintenance of aquaculture.
- Economic: lack of standardized procedures; charter costs for ships; insufficient subsidies; insurance and maintenance costs; market price of goods low, scale up necessary.
- Environment: harsh environment; wave action and low concentration of spat.
- Governance and legal: unclear legal status for multi-use; lack of dialogue between stakeholders.
- Social: lack of trust between industry sectors; low individual financial power and overall capacity to join multi-use from local collaborators.

Identified Gaps and Difficulties

North Sea Innovation Lab

Description of the pilot

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 this pilot, NSIL will aim to reach four objectives:

1. Demonstration of offshore solar integration in offshore wind farms;
2. Demonstration of a safe operational plan for the commercial roll-out of integrated aquaculture in off-shore wind farms;
3. Demonstrate and quantify the wave dampening of floating solar energy;
4. Demonstrate Rotate Monitoring.

New insights after questionnaire

The NSIL indicated in the technical barrier section that most of the barriers presented there were not considered to be problematic for the multi-use combination. The only barrier that was considered to be an obstacle was the potential structural risk that could occur from accidental collision with aquaculture equipment. Regarding the economic barriers, the NSIL pilot provided similar answers as the other pilots (see chapter 4): insurance, maintenance cost and grid connection were considered to be potential barriers. The lack of infrastructure for energy for the multi-use activities was judged to be a barrier. NSIL was the only questionnaire participant that judged it as a potential obstacle.

Comparing the answers the NSIL has provided to the environmental barriers, it becomes apparent that many of the barriers are not seen as posing considerable obstacles to multi-use. For the barriers dealing with governance and legal issues, all of them are indicated to be somewhat of a barrier. For the social barriers, the NSIL pilot agrees that all the barriers presented pose problems, apart from the general acceptance of multi-use by the general and local public.

Identified gaps and challenges

- Technological: damage due to extreme adverse environmental catastrophic events.
- Economic: starting offshore multi-use activities is a challenge in general; high insurance and grid connection costs; insufficient subsidies from the government.
- Governance and legal: lack of procedures and regulation.

Belwind

Description of the pilot

This pilot will focus on integrating native flat oyster production in wind parks. The project will be carried out in two locations: offshore in the wind parks of Belwind and Northwestern 2, and nearshore in Westdiep. Today, 274 turbines are operational in the Belgian part of the North Sea. The present turbines are allocated in five wind farms, among which C-Power nv and Belwind nx. Within these two wind farms, an offshore mussel aquaculture pilot project Edulis is already running since September 2016. 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. The lines are currently used for test productions of flat oysters, blue mussels and seaweed. In this pilot, the nearshore site will be used for testing oyster growing equipment, nature-inclusive matrasses and for seaweed. Only when the systems prove to work nearshore, they will be tested in the offshore sites. This pilot has a primary and secondary objective:

1. To evaluate wind farms as a location for restoring native flat oyster reefs in combination with culturing flat oysters for human consumption;
2. To compare the growth of seaweed grown offshore and nearshore.

In the pilot document, one possible environmental barrier was identified. This barrier relates to the decommissioning of wind parks, which may conflict with the use of nature-inclusive scour protection which acts as a reef and enhances biodiversity.

New insights after questionnaire

The answers of the Belwind pilot were in some regards different from the answers provided by the other pilots. In several of the barrier sections, the Belwind pilot has indicated a different pattern than the pilots from the other countries. Regarding the technical barriers, Belwind indicated a diverse spread of potential barriers, some not being considered problematic at all, while others were seen as risky for multi-use. As with other pilots, the damage due to extreme environmental events (i.e. earthquakes or extreme storms), was considered as the highest potential barrier. Furthermore, the pilot feels competent with the technical knowledge it has acquired to make the multi-use combination resist adverse weather conditions.

Considering the economic barriers, the Belwind pilot was among the respondents that considered most barriers as being obstacles for their multi-use combination. The only part of the economic barriers that was not considered to be an obstacle for their project were lack of standardized procedures to co-use equipment or installations and the availability of government subsidies (or lack thereof). For the environmental barriers, Belwind acknowledged some barriers to be potential obstacles, while others were not seen as posing a risk. Underwater–noise disturbance was not seen as a problem at all, while the attraction of unwanted invasive species to the location of the multi-use combination was considered to be a potential barrier. Barriers that describe governance and legal issues were not considered to be as problematic by the Belwind pilot. In fact, Belwind had the lowest rating in this scale, indicating that most barriers do not pose an obstacle. The only barrier that was seen to be a problem was the uncertainty about the ability of one party to continue if the other party enters its decommissioning phase.

Looking at the social barriers, the answers provided by Belwind were similar to the ones provided by the other pilots. With their answers the pilot indicated that low individual financial power of local collaborators could prevent them from joining the multi-use combination, as well as conflicts of interest between different users of the sea are the only barriers that pose considerable obstacles. One item that the Belwind pilot did not consider at all a barrier was the acceptance of the multi-use combination by local affected community, suggesting a different relationship with the local community than the Kastellorizo or Middelgrunden Wind pilot.

Identified gaps and challenges

- Technological: damage due to extreme adverse weather conditions.
- Economic: insurance and maintenance costs.
- Environmental: attraction of unwanted invasive species at the multi-use location.
- Social: conflicts of interests between different users of the sea; low individual financial power and overall capacity to join multi-use from local collaborators.

Middelgrunden Wind

Description of the pilot

The Middelgrunden Wind pilot considers multi-use of tourism and OWF that results from shared sea space, joint on and offshore infrastructure and operational activities. These include OWF sightseeing boat tours, diving and leisure fishing as well as shared onshore facilities such as OWF related information centre and the Industrial visitor Center for Renewable Energy in Copenhagen (State of Green). Middelgrunden Wind is one of the rare OWFs (if not the only one) where tourism boats can approach the turbine closely and visitors can even climb the nacelle. The combination of tourism and OWF is increasingly gaining interest in Europe as shown in 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 a need of economic boost and through tourism development. This pilot is expected to increase the TRL level of the multi-use solution and to expand tourism activities related to OWF (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.

In the pilot document, several barriers were already identified. These include economic concerns (low financial power and capacity to initiate and sustain tourism opportunities, high insurance premiums due to safety risks and little information about the interaction between activities that could advise insurance premiums), societal concerns (lack of awareness and interest of local boat operators and artisanal fisheries), technical barriers (frequent manual stops of an OWF may result in risk of failure of small components) and legal barriers (who is to cover the insurance premium and who will be liable in case of accidents?).

New insights after questionnaire

The answers provided by Middelgrunden Wind to the questionnaire were informative, but sparse. Several of the barriers seem not to have been applicable. Looking at the technical barriers, none of the presented items were considered to be an obstacle to the multi-use combination. Notably, even the risk of damage due to extreme environmental events was seen as no problem at all, while all the other pilots had considered this a large potential risk for their work.

For the economic barriers, the Middelgrunden Wind pilot considered most barriers to be an issue for them, showing a similar pattern in answers than the other pilots. Interestingly, the Middelgrunden Wind pilot did not indicate that high maintenance costs and high decommissioning costs would be obstacles as these barriers were regarded as not applicable. In the environmental barrier section, only the item with regard to the increased traffic of support vessels and the subsequent damage to the environment was answered. The answer showed that the pilot did not consider this barrier to be an obstacle at all. Considering the governance and legal barriers, Middelgrunden Wind provided answers with a higher variety than in the other sections. Most items here were either considered to be a large obstacle, or not an obstacle at all.

Regarding the social barriers, the Middelgrunden Wind pilot had the highest ratings for all barriers, considering all the barriers as large obstacles. The only question that is partly considered an obstacle is the question that discusses the lack of social acceptance of the multi-use combination by the society in general. The overall awareness of the risk of social barriers might reflect the nature of the multi-use combination, which is focused on tourism and therefore needs to interact with people and the local community.

Identified gaps and challenges

- Economic: high costs of operating staff.
- Environmental: waste pollution from visitors.
- Governance and legal: lack of established safety assessments; lack of dialogue between institutions; unclear and fragmented regulation.

- Social: low individual financial power and overall capacity to join multi-use from local collaborators.

Kastellorizo

Description of the pilot

This pilot will aim to combine aquaculture and tourism activities in marine space. SKIRONIS AQUACULTURE SA is a company that operates on the field of production marketing and exploitation of fish farms with all kinds of fish, shellfish 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). The aquaculture total annual production of marine Mediterranean fish in that area is 230 tones. There is great touristic 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 absolute protection which prohibits any kind of construction. Licenses and legal issues should be investigated in order to proceed to any intervention in the marine space around that islet. 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).

New insights after questionnaire

The answers Kastellorizo provided to the questionnaire are comparable to the answers provided by the other pilots. For the technical barriers, most answers were similar to the ones provided by the other pilots. A notable exception is that the Kastellorizo pilot was the only one that considered the risk of damage to the power supply cables from anchoring vessels to be a major obstacle to the pilot. For all the other pilots, this was not considered as problematic. Similarly, Kastellorizo was the only pilot that judged the risk of power failure to be a major barrier.

Looking at the economic barriers, it is noticeable that it is the only pilot that did not consider maintenance cost to be an economic barrier. For the environmental barriers, Kastellorizo judged on average most of the items to be barriers to multi-use, suggesting a high level of environmental awareness. While other pilots did not consider the collision risk for birds and bats to be a problem, Kastellorizo judged it as major environmental obstacle. Similarly, the pilot from Kastellorizo showed awareness of the potential risk of pollution due to aquaculture cages and the disturbance they can cause to the local ecosystem. Considering the legal and governance barriers, as well as the social barriers, the answers from Kastellorizo were average and no answer was provided that differs too much from the majority of the other pilots. The only exception to this observation is that the Kastellorizo pilot considers the lack of acceptance of the multi-use combination by the local community more of a problem than the Fino3, NSIL, or Belwind pilot.

Identified gaps and challenges

- Technological: network connectivity; damage due to extreme weather conditions.
- Economic: lack of expertise with business models and best practices; insurance costs.

- Environmental: increased risk of pollution events; disturbance of seabed.
- Governance and legal: strict security regulations that discourage multi-use; lack of established procedures; unclear and fragmented regulation.

6. CONCLUSIONS AND RELEVANCE FOR UNITED

Conclusions

The results from the literature study and the questionnaire gives insight into the barriers that hinder the implementation of multi-use in the European Union. Previous project experience and the scientific literature represent a valuable of source of information to which the UNITED pilot owners can revert when tackling the barriers they encounter.

This review points to the wide variety in barriers, realising multi-use in practice is certainly not hampered by technological barriers only. The discourse of Technological Readiness Levels used (among others) to describe the progress in developing multi-use is in this respect misleading. A complete understanding of the state-of-the-art requires use of additional concepts such as Social Readiness Level, Financial Readiness Level and Legal Readiness Level.

Lastly, the consultation with the UNITED pilots leans that barriers need to be identified in a case-by-case manner, there are no general barriers to multi-use. As multi-use is, by nature, a combination of at least two different economic sectors, the number of possible combinations is high. Many barriers focus on the specific combination of two sectors and to not apply to other sectors or other combinations. Although many multi-use combinations focus on wind energy and aquaculture, even the barriers here are quite diverse when looking at different examples in the literature. These differences can be geographically explained - due to the ocean the multi-use combinations are located in - , the age of the structure used , or the distance to the shore, among other factors.

Relevance for UNITED

This deliverable provides an overview of barriers identified in earlier multi-use projects, categorized along five pillars to achieve the first objective of UNITED WP1. The results presented in this deliverable can be of benefit in in WP1 by:

- Giving insight into, and references to, barriers already studied and reported on, to be used in Task 1.2 "Review of existing solutions or developed solutions"
- Providing input on economic barriers and solutions to inform Task 1.3 "Optimise business cases and requirements definitions"

Furthermore, the review of literature can inform further development in the pilots, directing pilot owners to relevant project and publications to learn from. As such, the results are also input to Deliverable 7.1 (due in Month 8) and D7.1 (due in M16). Both describe the foreseen activities in the pilot in more detail. Table 4 below is an indicative linkage table, showing the main barriers identified by the five UNITED pilots and project and references in which these barriers are addressed. The barriers collection table presented in Annex 2 can be used by the UNITED consortium partners for further investigations.

The results and methods developed in this task remain the disposal of the consortium. If deemed necessary, they can be updated and used to review the barriers and score their relevance for the pilots during the UNITED project.

The results of Task 1.1 were presented at the first UNITED webinar took place on 3 June 2020. The webinar, which lasted 3 hours, introduced the project to a wider audience and initiated a broader discussion about the topic of multi-use. Over 90 attendees had an opportunity to learn about the ongoing project activities, its pilots, and involved partners. Some of the initial project results were verified via an interactive live poll session. The initial review of barriers to multi-use conducted in UNITED highlighted that not only Technological Readiness Level is important as an indicator for multi-use development progress, but also Social, Commercial & Legal Readiness Level. The live poll showed that local jobs and local seafood sources are some of the main expected benefits of the multi-use. The Q&A with speakers took place via the GoToWebinar chat. All the presentations and the Mentimeter report which was used to collect input to the other tasks in WP1, are available via https://www.h2020united.eu/publications

Table 4: Links between pilots, earlier projects and scientific literature

Pilot	Main barriers	Projects to learn from	Publications to learn from
Fino3	Risk of damage from adverse weather conditions	MUSES, TROPOS	Depellegrin et al. 2019; Papadroulakis et al. 2017
	Lack of trust between industry sectors	MARIBE	Van Den Burg et al. 2019; Stuiver et al. 2016
	Unclear legal status for multi-use	MARIBE	Stelzenmueller et al. 2016; Legorburu et al. 2018
North Sea Innovation Lab	Damage due to environmental catastrophic events (storms/earthquakes)		Buck & Langan 2017
	High insurance costs due to lack of experience in multi-use	MARIBE	Zanuttigh et al. 2016; Jansen et al., 2016; Stuiver et al. 2016
	High costs for grid connection	MUSES	Depellegrin et al. 2019
Belwind	High maintenance costs of aquaculture sites		Roeckmann 2017; Goseberg 2017
	Unwanted invasive species	MERMAID	Roeckmann 2017; Koundouri et al. 2017
	Conflicts of interests between different users of the sea	MERMAID	Koundouri et al. 2017; Kyvelou & Ierapetritis 2019 ; Van Hoof et al. 2020
Middelgrunden Wind	Unclear and fragmented regulation for multi-use	MUSES	Depellegrin et al. 2019; Bocci et al. 2019
	Lack of established safety assessment methods		Buck & Langan 2017; Onyango et al. 2020
	Lack of social acceptance of multi-use	MARIBE, MUSES	Van Den Burg et al. 2016; Depellegrin et al. 2019
Kastellorizo	Lack of expertise with business models and best practices	MARIBE	Legorburu et al. 2018
	Increased risk of pollution events	TROPOS, MERMAID	Zanuttigh et al. 2016; Koundouri et al. 2017
	Lack of established licensing procedures for multi-use	MUSES	Sangiuliano 2018; Schupp et al. 2019

ANNEX 1 – OVERVIEW OF LITERATURE REVIEWED

APA reference	Paper Name	Abstract	Origin of publication	Ocean
Abhinav, K. A., Collu, M., & Baquero Gómez, J. I. (2018, August). Multi-purpose ocean energy platforms for offshore aquaculture farms. In *3rd International Conference on Offshore Renewable Energy*.	Multi-purpose ocean energy platforms for offshore aquaculture farms	The Blue Growth strategy was laid out by the European Union (EU) in 2012 [1], with a view to realize sustainable development of the blue economy - based on the oceans, seas and coasts. Along the lines of the Blue Growth strategy, the present work investigates the performance of a multi-purpose platform (MPP) for use in an offshore aquaculture farm. The elements of offshore wind and fish feed storage are integrated in the same platform to support the energy demands of closely co-located aquaculture farms, at a location off the Scottish coast, with a water depth of 81 m. The work presented herein is part of the UK-China Investigation of the novel challenges of an integrated offshore multi-purpose platform (INNOMPP) project [2] (EPSRC Grant no. EP/R007497/1). Concepts involving MPPs in the range of multi-megawatts have been explored in previous studies funded by the EU – namely, the MARINA, ORECCA, TROPOS, H2OCEAN, and MERMAID projects [3-5]. While deriving from the above mentioned concepts, the present study attempts to identify the suitability of platforms with low power ratings for use in offshore fish farms. The long term goal is to make remote island communities self-sufficient with regards to their economic aspects (via aquaculture) and power needs. The performance of the MPP under coupled aerodynamic-hydrodynamic loading has been investigated within a non-linear time-domain framework. Initial results indicate the suitability of a feed barge as a support platform for a small rated wind turbine to cater to the energy needs of an offshore aquaculture farm	Europe (EU - Project)	European (Atlantic, Baltic Sea, Black Sea, Mediterranean Sea, North Sea)
Bas, B., Elginoz, N., Giannakis, E., Giannouli, A., Koundouri, P., Møhlenberg, F., ... & Xepapadeas, A. (2017). Socio-economic analysis of a selected multi-use offshore site in the Baltic Sea. In *The*	Socio-economic analysis of a selected multi-use offshore site in the Baltic Sea	Denmark has designated the area of the Kriegers Flak to install an offshore wind farm of 600 MW, which is planned to be fully operational in 2022. This chapter investigates the combination of wind turbines and offshore aquaculture. The fish farming is planned as two separate facilities located between the two groups of turbines and each fish farm section will consist of 12–14 round cages with a diameter of 45 m and a feeding barge delivering feed by means of compressed air through tubes to each cage. Although the Social Cost Benefit Analysis of the multi-use platform scenario was not completed due to lack of information, the scenario is expected to be sustainable considering the current policy and institutional framework, as well as the environmental and socio-economic effects.	Europe (Standard research publication)	North Sea

Ocean of Tomorrow (pp. 27-42). Springer, Cham.				
Bocci, M., Sangiuliano, S. J., Sarretta, A., Ansong, J. O., Buchanan, B., Kafas, A., ... & Schultz-Zehden, A. (2019). Multi-use of the sea: A wide array of opportunities from site-specific cases across Europe. *PloS one*, *14*(4).	Multi-use of the sea: A wide array of opportunities from site-specific cases across Europe	The concept of multi-use of the sea has gained popularity in recent years as a result of ocean space (coastal areas and regions with relatively small sea space in particular) becoming increasingly crowded due to the development of the maritime economy. Competing claims for space can be a source of conflict, however this may also lead to mutual benefits for different users when sustainable combinations are sought. Despite increasing European- wide efforts, on-the-ground knowledge and practice of multi-use are still limited. Therefore, with the aim of investigating opportunities for multi-use development in the European seas, 10 case studies were selected, involving different site-specific contexts. This study analyses the characteristics and development potential for ocean multi-use, integrating results from desk analysis and stakeholder perceptions from different sectors in each of the case study locations. Similarities and differences between various combinations of sea uses are also identified. The results show a high heterogeneity of multi-use opportunities between case studies, with a range of combinations identified. The investigated combinations of maritime uses share an overall balance between factors promoting (drivers) and hindering (barriers) multi-use development. Based on stakeholder opinions, expected benefits (added values) of multi-use implementation outweigh potential negative impacts. Management actions are also proposed to further exploit multi-use potential at a local, regional (subnational) and national levels.	Europe (EU - Project)	European (Mediterranean Sea, North Sea, Baltic Sea)
Buck, B. H., & Langan, R. (2017). Epilogue—Pathways Towards Sustainable Ocean Food Production. *Aquaculture Perspective of Multi-Use Sites in the Open Ocean*, 395.	Epilogue-pathways towards sustainable ocean food production	While there is a great deal of global interest in the development of combined uses of open ocean installations, for commercial scale multi-use platforms for food and energy production and other potential applications, the transition from concept to reality has yet to come to fruition. While much is known about the economics, environmental, political and societal effects of individual production sectors, there are many unknowns and challenges with regard to economics, engineering, liability and social aspects of multi-use. Mutually agreed upon principles, such as those articulated in the Bremerhaven Declaration, and EU directives and grant funding opportunities to advance research and development indicate that progress, although measured, is being made. The development of true commercial-scale multi-use offshore platforms will require investment in demonstration projects and multinational cooperation and collaboration across public and private sectors	Europe (Standard research publication)	Several
Calado, H., Papaioannou, E. A., Caña-Varona, M., Onyango, V.,	Multi-uses in the Eastern	Promoting co-existence and synergies amongst maritime uses is a key issue in maritime spatial management. Maritime economies are developing globally, leading to competition for marine resources and increasing environmental pressures. Multi-use (MU) is the joint	Europe (EU - Project)	Atlantic

Zaucha, J., Przedrzymirska, J., ... & Vergílio, M. (2019). Multi-uses in the Eastern Atlantic: Building bridges in maritime space. *Ocean & coastal management*, *174*, 131-143.	Atlantic: Building bridges in maritime space	use of marine resources in close geographic proximity. Focusing on the Eastern Atlantic sea basin, this article provides an overview of the MU context, existing and potential MUs, and the main drivers and barriers thereof. Based on desk research, literature review and stakeholder engagement, this study highlights differences between countries, regarding the implementation and advancement of sea strategies, and sector-specific and other Maritime Spatial Planning (MSP)-related policies. The legal, administrative and operational processes required to realise MUs are highly diverse and are related to the maturity of national maritime policies including MSP. A total of 25 MUs were identified and the three most relevant (Fisheries & Tourism & Environmental protection; Underwater cultural heritage & Tourism & Environmental protection, and; Offshore wind & Aquaculture) were analysed in-depth. The general conclusion refers to the need for multi-dimensional and multi-level policy actions overcoming technology constraints, and improving regulatory and policy frameworks. European strategies and actions might assist these efforts, however, the identified gaps are resolvable mainly at the national level within its specific context and through the engagement of innovative stakeholders. Recommendations for promoting MUs are presented. In summary, MUs are recognised as joint ventures, enabling synergy of interests and minimising conflicts. Findings suggest that early stakeholder engagement in the process of planning and implementing MU is necessary to achieve synergies, while respecting national planning cultures and existing MU experience leads to conflict solving solutions.		
Dalton, G., Bardócz, T., Blanch, M., Campbell, D., Johnson, K., Lawrence, G., ... & Ortega, S. T. (2019). Feasibility of investment in Blue Growth multiple-use of space and multi-use platform projects; results of a novel assessment approach and case studies. *Renewable and Sustainable Energy Reviews*, *107*, 338-359.	Feasibility of investment in Blue Growth multiple-use of space and multi-use platform projects; results of a novel assessment approach and case studies	Blue Growth is the creation of economic activity and jobs at sea, while multiple use of space makes efficient use of the available sea area by combining industries. Clearly there are many combinations and many value propositions. However, most technologies to date are considered blue sky concepts, with little robust techno-economic analysis demonstrating profitability. The paper begins by providing a comprehensive review of Blue Growth and multi-use in Blue Growth; both in policy as well as the wide range of current technologies, including ocean energy, offshore wind energy, offshore aquaculture and desalination. The Maribe H2020 project provides the vehicle for the research element of the paper. The major contribution is a new methodology for selecting, filtering, developing and ranking business propositions for multiple-use of space (MUS) and multi-use platforms (MUP). Application of the method for the first time identified three case studies where Blue Growth combination projects can be economically viable, with attractive internal rate of return (IRRs). Results presented for the case studies report standard investment metrics and show the relative contribution of each product (energy, food, water) to the system profitability, as well as socio-economic impact. Existing companies were fully engaged in the process. Co-creation between sector experts and industry led to both improved business value propositions and robust assessment of investment readiness. In contrast to the presumption that	Europe (EU - Project)	European (Atlantic, Baltic Sea, Black Sea, Mediterranean Sea, North Sea)

		large scale platforms are commercially attractive, the highest ranking case study companies required smaller capital expenditure (CAPEX) and operated in niche subsectors. In conclusion, the positive economic performance of the case studies should provide confidence for the EC as well as investors that MUS and MUP have viable economic futures leading towards commercialisation. The macro and micro assessment methods will be particularly useful in other Blue Economy contexts and in other multiple product contexts.		
Depellegrin, D., Venier, C., Kyriazi, Z., Vassilopoulou, V., Castellani, C., Ramieri, E., ... & Barbanti, A. (2019). Exploring Multi-Use potentials in the Euro-Mediterranean sea space. *Science of the Total Environment*, *653*, 612-629.	Exploring Multi-Use Potentials in the Euro-Mediterranean Sea Space. Science of the Total Environment	European seas are experiencing rapid development. The anthropogenic demand for marine resources and space exerts the need for novel concepts for sustainable resource exploitation and smart space allocation. Multi-Use (MU) is an emerging concept to overcome spatial claims and support Blue Growth, however its actual potentials and current status of implementation in different sea basins is to a large extent unexplored. An analytical framework using a mixed method approach is proposed for the identification and analysis of MU potentialities in eight EU countries of the Euro-Mediterranean sea basin. The paper addresses opportunities and challenges of ten existing and potential MU combinations driven by three maritime sectors: tourism, renewable energy and Oil & Gas industry. Opportunities and challenges for MU development were presented in terms of drivers, added values, barriers and impacts. Results show that highest potential for MU development are related to tourism-driven MU combinations (e.g. pescatourism), but also emerging MU potentials exist related to Floating Offshore Wind energy and aquaculture (Gulf of Lion) and the reuse of Oil & Gas decommissioned platforms (Northern-Central Adriatic Sea). Findings were discussed for their geospatial distribution and their policy, socio-economic, technical and environmental boundary conditions. Recommendations on actions to foster MU development in the Euro-Mediterranean sea space are provided	Europe (Standard research publication)	European (Atlantic, Baltic Sea, Black Sea, Mediterranean Sea, North Sea)
Elginoz, N., & Bas, B. (2017). Life Cycle Assessment of a multi-use offshore platform: Combining wind and wave energy production. *Ocean Engineering*, *145*, 430-443.	Life Cycle Assessment of a multi-use offshore platform: Combining wind and wave energy production	Due to increasing demand in the use of ocean space for energy and food production, multi-purpose use of marine areas is under concern. Here, a novel semi-submersible floating platform, which unites wave and wind energy converters, is investigated in terms of environmental sustainability. LCA is a methodology, to assess environmental burdens of a product/function including all the phases it experiences, which makes it a perfect tool to determine environmental burdens of renewable energy systems due to their considerably lower impacts during operation. In this study, LCA of an energy farm, constituted of multi-use offshore platforms was executed. Results showed manufacturing of the platform is the main source of pollution. In the manufacturing phase; fixed, moving and mooring parts are the main contributors and the WECs make a minor contribution. Material consumption is the main source for burdens during the life cycle of the system hence recycling ratios considered at the end of life scenarios affect the overall results. Implementation of multi-use	Europe (Standard research publication)	Mediterranean Sea

		floating concept to different locations gives various results changing with the capacity factor and the distances. The comparison between semi-submersible system and the spar platform ended up with comparable results both in terms of environmental burdens and material consumption.		
Goseberg, N., Chambers, M. D., Heasman, K., Fredriksson, D., Fredheim, A., & Schlurmann, T. (2017). Technological approaches to longline- and cage-based aquaculture in open ocean environments. In *Aquaculture Perspective of Multi-Use Sites in the Open Ocean* (pp. 71-95). Springer, Cham.	Technological approaches to longline- and cage-based aquaculture in open ocean environments	As the worldwide exploitation rate of capture fisheries continues, the development of sustainable aquaculture practices is increasing to meet the seafood needs of the growing world population. The demand for aquatic products was historically satisfied firstly by an effort to expand wild catch and secondly by increasing land-based and near-shore aquaculture. However, stagnation in wild catch as well as environmental and societal challenges of land-based and near-shore aquaculture have greatly promoted efforts to development farming offshore technologies for harsh, high energetic environments. This contribution thus highlights recent technological approaches based on three sample sites which reach out from sheltered near-shore aquaculture sites to sites with harsh wave/current conditions. It compares and evaluates existing technological approaches based on a broad literature review; on this basis, we then strongly advocate for presently available aquaculture technologies to merge with future offshore structures and platforms and to unveil its added value through synergetic multi-use concepts. The first example describes the recent development of longline farming in offshore waters of New Zealand. New Zealand has designated over 10,000 ha of permitted open ocean water space for shellfish farming. The farms range from 8 to 20 km out to sea and a depth of 35-80 m of water. Research has been ongoing for the last 10 years and the first commercial efforts are now developing in the Bay of Plenty. New methods are being developed which should increase efficiency and reduce maintenance with a particular focus on Greenshell mussel (Perna canaliculus) and the Pacific Oyster (Crassostrea gigas), Flat Oyster (Tiostrea chilensis) and various seaweeds. The second case study involves a long-term, open ocean aquaculture (OOA) research project conducted by the University of New Hampshire. During the course of approximately 10 years, the technological aspects of OOA farming were conducted with submersible cages and longlines, surface feeding systems and real time environmental telemetry. The grow-out potential of multiple marine species such as cod (Gadus morhua), haddock (Melanogrammus aeglefinus), halibut (Hippoglossus hippoglossus), blue mussel (Mytilus edulis), sea scallop (Placopecten magellanicus) and steelhead trout (Oncorhynchus mykiss) were investigated at a site 12 km from shore. The last study presents a multi-use aspect of aquaculture for an open ocean site with fish cages attached to existing offshore wind energy foundations. Technological components such as mounting forces and scour tendencies of two different cage structures (cylindrical and spherical) were investigated by means of hydraulic scale modeling. The cages were pre-designed on the basis of linear theory and existing	Europe (Standard research publication)	Mediterranean Sea

		standards and subsequently exposed to some realistic offshore wave conditions. The wind farm "Veja Mate" in German waters with 80 planned 5 MW turbines anchored to the ground by tripiles is taken as the basis for the tested wave conditions. Based on findings stemming from the three example approaches conclusions are drawn and future research demand is reported.		
Holm, P., Buck, B. H., & Langan, R. (2017). Introduction: New approaches to sustainable offshore food production and the development of offshore platforms. In *Aquaculture Perspective of Multi-Use Sites in the Open Ocean* (pp. 1-20). Springer, Cham.	Introduction: New approaches to sustainable offshore food production and the development of offshore platforms	As we exhaust traditional natural resources upon which we have relied for decades to support economic growth, alternatives that are compatible with a resource conservation ethic, are consistent with efforts to limit greenhouse emissions to combat global climate change, and that support principles of integrated coastal management must be identified. Examples of sectors that are prime candidates for reinvention are electrical generation and seafood production. Once a major force in global economies and a symbol of its culture and character, the fishing industry has experienced major setbacks in the past half-decade. Once bountiful fisheries were decimated by overfishing and destructive fisheries practices that resulted in tremendous biomass of discarded by-catch. Severe restrictions on landings and effort that have been implemented to allow stocks to recover have had tremendous impact on the economy of coastal communities. During the period of decline and stagnation in capture fisheries, global production from aquaculture grew dramatically, and now accounts for 50% of the world's edible seafood supply. With the convergence of environmental and aesthetic concerns, aquaculture, which was already competing for space with other more established and accepted uses, is having an increasingly difficult time expanding in nearshore waters. Given the constraints on expansion of current methods of production, it is clear that alternative approaches are needed in order for the marine aquaculture sector to make a meaningful contribution to global seafood supply. Farming in offshore marine waters has been identified as one potential option for increasing seafood production and has been a focus of international attention for more than a decade. Though there are technical challenges for farming in the frequently hostile open ocean environment, there is sufficient rationale for pursuing the development of offshore farming. Favorable features of open ocean waters include ample space for expansion, tremendous carrying and assimilative capacity, reduced conflict with many user groups, lower exposure to human sources of pollution, the potential to reduce some of the negative environmental impacts of coastal fish farming (Ryan 2004; Buck 2004; Helsley and Kim 2005; Ward et al. 2006; Langan 2007), and optimal environmental conditions for a wide variety of marine species (Ostrowski and Helsley 2003; Ryan 2004; Howell et al. 2006; Benetti et al. 2006; Langan and Horton 2003). Those features, coupled with advances in farming technology (Fredheim and Langan 2009) would seem to present an excellent opportunity for growth, however, development in offshore waters has been measured. This has been due in large part to the spill over from	Europe (Standard research publication)	Several

		the opposition to nearshore marine farming and the lack of a regulatory framework for permitting, siting and managing industry development. Without legal access to favorable sites and a "social license" to operate without undue regulatory hardship, it will be difficult for open ocean aquaculture to realize its true potential. Some parallels can be drawn between ocean aquaculture and electricity generation. Continued reliance on traditional methods of production, which for electricity means fossil fuels, is environmentally and economically unsustainable. There is appropriate technology available to both sectors, and most would agree that securing our energy and seafood futures are in the collective national interest. The most advanced and proven renewable sector for ocean power generation is wind turbines, and with substantial offshore wind resources in the, one would think there would be tremendous potential for development of this sector and public support for development. The casual observer might view the ocean as a vast and barren place, with lots of space to put wind turbines and fish farms. However, if we start to map out existing human uses such as shipping lanes, pipelines, cables, LNG terminals, and fishing grounds, and add to that ecological resource areas that require some degree of on such as whale and turtle migration routes, migratory bird flyways, spawning grounds, and sensitive habitats such as corals, the ocean begins to look like a crowed place. Therefore, when trying to locate new ocean uses, it may be worthwhile to explore possibilities for co-location of facilities, in this case wind turbines and fish and shellfish farms. While some might argue that trying to co-locate two activities that are individually controversial would be a permitting nightmare, general agreement can probably be reached that there are benefits to be gained by reducing the overall footprint of human uses in the ocean. Meeting the challenges of multi-use facilities in the open ocean will require careful analysis and planning; however, the opportunity to co-locate sustainable seafood and renewable energy production facilities is intriguing, the concept is consistent with the goals of Marine Spatial Planning and ecosystem based management, and therefore worthy of pursuit.		
Jansen, H. M., Van Den Burg, S., Bolman, B., Jak, R. G., Kamermans, P., Poelman, M., & Stuiver, M. (2016). The feasibility of offshore aquaculture and its potential for multi-use in the North	The feasibility of offshore aquaculture and its potential for multi-use in the North Sea	Following the Blue Growth ambition of the European Commission, the interest in the potential of offshore is growing. This paper aimed to contribute to the discussion on the feasibility of offshore aquaculture development and its potential for multi-use with other maritime activities. A review of national and international projects forms the basis of the paper, where the Dutch North Sea is used as a case-study area. Analysis of technical, economic and ecological boundaries indicated that the potential of fish culture is limited, that seaweed cultivation is likely to gain potential when challenges related to processing will be overcome and that mussel culture has the highest potential in the near future. The North Sea is an area where many stakeholders claim space, which might set boundaries to the number of sites available for mussel culture. Competing claims are a potential source	Europe (Standard research publication)	North Sea

Sea. *Aquaculture international*, *24*(3), 735-756.		of conflict but may also lead to mutual benefits when smart combinations are sought, e.g. with wind parks, fisheries and nature conservation; especially, the possibility of combining mussel culture in or around wind parks is worthwhile to be further explored. A spatial distribution model adapted for the Dutch North Sea conditions demonstrated that offshore mussel production in wind farms can be profitable. Yet, the commercial interest for offshore development of mussel culture is still limited. Actions required to stimulate further development of the offshore mussel industry are presented for the government, the private sector, research institutes and civil society organizations.		
Kamermans, P., Walles, B., Kraan, M., Van Duren, L. A., Kleissen, F., Van der Have, T. M., ... & Poelman, M. (2018). Offshore wind farms as potential locations for flat Oyster (Ostrea edulis) restoration in the Dutch North Sea. *Sustainability*, *10*(11), 3942.	Offshore wind farms as potential locations for flat oyster (Ostrea edulis) restoration in the Dutch North Sea	The "Dutch Energy Agreement" motivates governments and industries to invest in renewable energy sources, of which offshore wind energy is one of the solutions to meet the agreed target of 16% of the total energy budget from renewable resources by 2023. An option for the multi-use of wind farms is nature-inclusive building, in which the design and construction of wind farms make use of the potential for co-design with oyster bed restoration. This can support the government's ambitions, for the Dutch North Sea, to achieve biodiversity goals, restore ecosystem functions, and enhance ecosystem services, including future seafood production. For the recovery of flat oyster (Ostrea edulis) beds, knowledge is required about the conditions under which active restoration of this species in the North Sea can be successfully implemented. This paper gives a framework and presents results to determine suitability of wind farms for flat oyster restoration, and provides recommendations for pilot studies. Our analysis showed that a number of wind farms in the Dutch section of the North Sea are suitable locations for development of flat oyster beds. Combining oyster restoration and oyster culture, as a protein source, is a viable option worth investigating.	Europe (Standard research publication) - Dutch government	North Sea
Klinger, D. H., Eikeset, A. M., Davíðsdóttir, B., Winter, A. M., & Watson, J. R. (2018). The mechanics of blue growth: management of oceanic natural resource use with multiple, interacting sectors. *Marine Policy*, *87*, 356-362.	The mechanics of blue growth: management of oceanic natural resource use with multiple, interacting sectors	Integrated management of multiple economic sectors is a central tenet of blue growth and socially optimal use of ocean-based natural resources, but the mechanisms of implementation remain poorly understood. In this review, we explore the challenges and opportunities of multi-sector management. We describe the roles of key existing sectors (fisheries, transportation, and offshore hydrocarbon) and emerging sectors (aquaculture, tourism, and seabed mining) and the likely synergistic and antagonistic inter-sector interactions. We then review methods to help characterize and quantify interactions and decision-support tools to help managers balance and optimize around interactions.	Europe (Standard research publication) - Green-MAR by Nordforsk	Several

Koundouri, P., Chen, W., Dávila, O. G., Giannouli, A., Brito, J. H., Kotoroni, E., ... & Souliotis, I. (2017). A socio-economic framework for integrating multi-use offshore platforms in sustainable blue growth management: theory and applications. In *Handbook on the Economics and Management of Sustainable Oceans*. Edward Elgar Publishing.	A socio-economic framework for integrating multi-use offshore platforms in sustainable blue growth management: Theory and applications	none	Europe (EU - Project)	Pacific (Taiwan)
Kyvelou, S. S. I., & Ierapetritis, D. G. (2019). How to make blue growth operational? A local and regional stakeholders perspective in Greece. *WMU Journal of Maritime Affairs*, *18*(2), 249-280.	How to make blue growth operational? A local and regional stakeholders perspective in Greece	The so-called blue growth is gaining importance in European policy making since it is expanding its relevance beyond traditional economic sectors to new and rapidly developing ones that present significant potential of innovation. This paper seeks to identify the most important factors that can be driving forces of blue growth, taking the example of Greece that being currently in a post-memorandum era, is obliged, in order to meet its engagements, to accelerate with economic growth in general, by untapping also local and regional blue growth potentials and by using MSP to facilitate the growth of its maritime economy. With the aim to put forward concrete policy proposals to boost and make operational blue growth in Greece in a multi-actor perspective, a field survey was designed and conducted with participating representatives of 24 "development companies" operating at local and regional level, all over the country. The method used was the one of environmental scanning (SWOT analysis, etc.). The survey highlighted the strengths and weaknesses as well as the opportunities, the risks and the many challenges that outline prospects and practical aspects of blue growth in the Greek regional space. The results and key findings of the primary research are discussed, highlighting the most important areas of strategy for promoting blue growth at a local level by the development companies including balancing he protection of the marine environment (ecosystem-based management) and economic growth, safeguarding maritime jobs, promoting entrepreneurial discovery through the Re-	Europe (Standard research publication)	Mediterranean Sea

		gional Strategy for Smart Specialisation, enforcement of maritime law, promoting biotechnology research and the creation of maritime clusters. Finally, policy proposals are presented to support blue entrepreneurship, which may be one of the cutting edges of the country's new development model.		
Lacroix, D., & Pioch, S. (2011). The multi-use in wind farm projects: more conflicts or a win-win opportunity?. *Aquatic Living Resources*, *24*(2), 129-135.	The multi-use in wind farm projects: More conflicts or a win-win opportunity?	The pressures on the use of the seashore are steadily rising, not only in developed countries but worldwide. Anthropogenic activity has long impacted the marine continental shelf down to a depth of approximately -200 m. New activities are now affecting this coastal space such as renewable energies, recreational uses and aquaculture in addition to the traditional ones of navigation or fishing. This evolution raises new sources of conflict amongst users which can require state involvement in order to manage the different stakeholders and pressure groups. However, the coastal space still offers a large potential for development for two reasons. Firstly, the physical three dimensional potential of this space enables the whole water column to be used, principally to increase the fishing productivity as in Japan. Secondly, innovative synergies can be created between socio-technical and ecological uses (a "fourth dimension") such as the eco-design of wind turbine foundations in order to create fish habitat or sea grass settlement. This new vision in "4D" for the design and the management of coastal infrastructure can potentially reduce the risk of conflict as different uses of the coastal space would not necessarily exclude one another. Indeed, several forms of synergy could be developed such as fisheries with aquaculture or biological sustainability with social acceptability. Until now, limited attempts at such an approach have been done. We suggest this is likely due to the absence of a common eco-engineering vision and the lack of experience amongst biologists and engineers in the co-construction of projects. This eco-engineering, or "green" vision, also takes into account the complexity and resilience of the ecosystem in the long term, if underwater engineered infrastructures are also "eco"-designed to increase ecological gain This new conception, for development within the coastal area, provides for an increased bio-oriented complexity to engineered structure and therefore a better resistance of the ecosystem in the long term to anthropogenic pressures and a reduction in multi-user conflicts.	Europe (Standard research publication)	Several
Legorburu, I., Johnson, K. R., & Kerr, S. A. (2018). Multi-use maritime platforms-North Sea oil and offshore wind: Opportunity and risk. *Ocean*	Multi-Use Maritime Platforms - North Sea Oil and Offshore Wind: Opportunity and Risk	Multi Use Platform (MUP) concepts integrate different maritime economic activities within the same space. In line with the EU's Blue Growth Strategy, this new type of business model provides a series of potential advantages: efficient use of marine space, sharing of risks and costs, sharing resources, reduced environmental impacts, and enhanced socio-economic benefits. Delivering this vision will require tools that identify viable multiuse combinations allowing for the optimal use of sea space. The analysis performed here shows how the combined use of statistical analyses and Geographical Information Systems (GIS) might achieve this task in the context of oil & gas and offshore wind in the North Sea. Results provide a	Europe (EU - Project)	North Sea

& Coastal Management, *160*, 75-85.		delimitation of the study area according to the spatial distribution of oil resources and the best technological configuration required by the wind industry. The analysis opens the door for the identification of additional factors that might influence the development of this new business model; for example differences between the Norwegian and UK's energy markets, climate policies or oil production patterns have to be highlighted. After reviewing these aspects, it can be concluded that current Norwegian policy and market features provide a promising starting point for the development of this specific MUP concept		
Lu, S. Y., Jason, C. S., Wesnigk, J., Delory, E., Quevedo, E., Hernández, J., ... & Anastasiadis, P. (2014, April). Environmental aspects of designing multi-purpose offshore platforms in the scope of the FP7 TROPOS Project. In *OCEANS 2014-TAIPEI* (pp. 1-8). IEEE.	Environmental aspects of designing multi-purpose offshore platforms in the scope of the FP7 TROPOS Project	The objective of the FP7 funded TROPOS project is to design a modular multi-use platform for use in deep waters, with a focus on the Mediterranean, tropical and sub-tropical regions. In this paper, the related environmental aspects are considered, where both legal and technical issues are addressed. The multiple purpose platforms can enlarge the benefit from different functions, and reduce the environmental impacts through synergies among single impact as well. This proposed study demonstrates the impact assessment through multiple, integrated technologies.	Europe (EU - Project)	Mediterranean Sea
Mikkola, E., Heinonen, J., Kankainen, M., Hekkala, T., & Kurkela, J. (2018). Multi-Platform Concepts for Combining Offshore Wind Energy and Fish Farming in Freezing Sea Areas: Case Study in the Gulf of Bothnia. In *ASME 2018 37th International Conference on Ocean, Offshore and Arctic Engineering*. American Society of Mechanical	Multi-platform concepts for combining offshore wind energy and fish farming in freezing sea areas: Case study in the Gulf of Bothnia	Climate change together with increasing demand for space pose a challenge to energy and food production at sea areas. Co-location of offshore renewable en ergy produ ction, aqua culture and oth er blue economy activities can answer the need for more susta inable marine space utilization while reducing and dividing costs of the different activities. This paper presents a case study of a multi-use platform that combines wind energy and fish farming in the Gulf of Bothnia, where the sea freezes every winter. A marine spatial planning (MSP) tool is used to find suitable locations for the multi-use platform with respect to economic potential of energy and nutrient production, structural solutions and environmental impact. The tool is used to visualize site selection criteria based on geographic information system (GIS) data such as seabed data, wind and wave data and ice data as well as protected marine areas. Production potential scenarios for the multi-use platform at different scales are calcu la ted. Synergies of combining offshore wind energy and fish farming are discussed	Europe (Standard research publication) - Academy of Finland	Baltic Sea

Engineers Digital Collection.				
Onyango, V., Papaioannou, E., Schupp, M. F., Zaucha, J., Przedzymirska, J., Lukic, I., ... & van de Velde, I. (2020). Is Demonstrating the Concept of Multi-Use Too Soon for the North Sea? Barriers and Opportunities from a Stakeholder Perspective. *Coastal Management*, 1-19.	Is Demonstrating the Concept of Multi-Use Too Soon for the North Sea? Barriers and Opportunities from a Stakeholder Perspective.	Multi-use (MU) has been promoted as a viable approach to the effective planning and mitigation of user-conflicts in the marine realm. Despite several research and pilot projects demonstrating the approach's feasibility and benefits, commercially viable MU applications remain patchy and few. Further, MU is neither systematically applied nor purposively planned for even in the imminent event of incompatible and conflicting use of marine space. This paper seeks to identify barriers and opportunities for mainstreaming MU based on desktop study and iterative stakeholder consultation. The findings reveal that the MU concept was frequently framed as 'co-location' or 'co-existence' and aimed toward mitigating conflict among users. Practice was ahead of theory with little attention to synergistic and efficiency aspects. Barriers for MU application include shortcomings in legislation, sectoral thinking, and burdensome administrative procedures. The main opportunity lies in creating a conducive policy environment where MU risks and transaction costs become low and competitive, respectively. Solutions at the sea basin and national level, upon which further MU application can be anchored, are proposed.	Europe (EU - Project)	North Sea
Papandroulakis, N., Thomsen, C., Mintenbeck, K., Mayorga, P., & Hernández-Brito, J. J. (2017). The EU-Project "TROPOS". In *Aquaculture Perspective of Multi-Use Sites in the Open Ocean* (pp. 355-374). Springer, Cham.	The EU-project "TROPOS"	The global population is growing and the demand for food and energy is steadily increasing. Coastal space all over the world becomes increasingly limited and near-shore resources are often already heavily exploited. The use of offshore regions may provide new opportunities, but also involves major challenges such as the development of designs and technologies suitable for offshore condition. The floating TROPOS 'Green & Blue' modular multi-use platform concept introduced in this chapter is especially designed for offshore conditions and provides solutions for the problems and obstacles involved in "moving offshore". The Green & Blue platform concept integrates fish and algae aquaculture with a wind farm. The floating multi-use approach allows for platform operation in deep waters and the promotion of synergies such as joint logistics, shared infrastructure and services, thereby making the use of offshore resources viable and profitable.	Europe (EU - Project)	Several
Przedrzymirska, J., Zaucha, J., Depellgrin, D., Fairgrieve, R., Kafas, A., Calado, H. M. G. P., ... & Papaioannou, E. (2018). Multi-use of the sea: From research to practice.	Multi-use of the sea: From research to practice	The increasing demand for ocean resources exerts an increasing pressure on the use of ocean space across all European Sea Basins. This underlines issues of compatibility (or conflicts) between different maritime uses as well as between economic activities and environmental protection. The idea of multi-use (MU), as a guiding concept for efficient allocation of compatible activities in the same marine space, can increase spatial efficiency and at the same time provide socio-economic and environmental benefits. However, its transition from a concept to real-world development is facing several barriers. Based on analysis	Europe (EU - Project)	Several

In *SHS Web of Conferences* (Vol. 58, p. 01025). EDP Sciences.		of five European sea basins done under the Horizon 2020 MUSES project (Multi-Use in European Seas), this paper aims to clarify the concept of MU by discussing: 1) the definition in the literature and practice so far, and; 2) how existing regulatory and planning regimes are supporting and challenging the development of several MUs (considered as the most promising). The analytical methodology developed for the MUSES project relied on data collected via desk research and semi structured interviews with key stakeholders (e.g. industry, regulators), over the period of seven months. The semi-quantitative analysis of data conducted, identified the commonalities and differences among countries in respect to each of the analyzed MUs. The paper points out priorities for the MU development in different sea basins and recommends initial steps to overcome existing barriers, whilst maximizing local benefits. This paper is a starting point towards a broader scientific debate on: (i) what could be the role of management policies (like for instance maritime spatial planning - MSP) in supporting and fostering MU concept development, (ii) what are technical and technological challenges for technically advanced MUs, (iii) how added values of MUs concept (e.g. benefits for local economies, positive impacts on environment) could be enhanced.		
Quevedo, E., Cartón, M., Delory, E., Castro, A., Hernández, J., Llinás, O., ... & Jeffrey, H. (2013, June). Multi-use offshore platform configurations in the scope of the FP7 TROPOS Project. In *2013 MTS/IEEE OCEANS-Bergen* (pp. 1-7). IEEE.	Multi-use offshore platform configurations in the scope of the FP7 TROPOS Projec	The FP7 funded TROPOS project approach is to develop a modular multi-use platform for use in deep waters, with a focus on the Mediterranean, tropical and sub-tropical regions. In this paper, three different platforms configurations, - which have been designed to show the synergies and compatibilities among the platform uses of Transport, Energy, Aquaculture and Leisure - are presented.	Europe (EU - Project)	Not specified
Röckmann, C., Lagerveld, S., & Stavenuiter, J. (2017). Operation and maintenance costs of offshore wind farms and potential multi-use platforms in the Dutch North Sea.	Operation and maintenance costs of offshore wind farms and potential multi-use platforms in the	Aquaculture within offshore wind farms has been identified as one of the many possibilities of smart use of marine space, leading to opportunities for innovative entrepreneurship. 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 mechanical force, corrosion, and biofouling. The expected lifetime of an offshore structure is to a great extent determined by the risk of failures. This chapter elaborates on logistical challenges that the offshore industry faces. Operation and maintenance (O&M) activities typically represent a big part of the total costs (e.g. 25-30% of the total lifecycle costs for	Europe (Standard research publication)	North Sea

In *Aquaculture Perspective of Multi-Use Sites in the Open Ocean* (pp. 97-113). Springer, Cham.	Dutch North Sea	offshore wind farms). The offshore wind energy sector is considered an industry with promising features for the public and private sector. Large wind farms farther off the coast pose high expectations because of higher average wind speeds and hence greater wind energy yield (in terms of megawatts per capital). These conditions entail additional challenges in logistics, though. One of the main hurdles that hinders use of offshore wind energy is the high cost for O&M. The offshore wind industry will have to solve these problems in order to achieve substantial cost reduction - alone or jointly with other (potential) users. It is precisely the logistical problems around O&M where most likely synergy benefits of multi-use platforms (MUPs) can be achieved. The offshore wind energy industry is eagerly looking for technical innovations. Until now they mostly sought the solutions in their own circles. If the combination of offshore wind energy and offshore aquaculture proves to be feasible and profitable in practice, there may be an additional possibility to reduce the O&M costs by synergy effects of the combined operations. Logistic waiting times, for example, can result in substantial revenue losses, whereas timely spare-parts supply or sufficient repair capacity (technicians) to shorten the logistic delay times are beneficial. A recent study suggests that a cost reduction of 10% is feasible, if the offshore wind and offshore aquaculture sectors are combined in order to coordinate and share O&M together. The presented asset management control model proves useful in testing the innovative, interdisciplinary multi-use concepts, simulating return rates under different assumptions, thus making the approach more concrete and robust.		
Rozemeijer, M. J. C., & van de Wolfshaar, K. E. (2019). *Desktop study on autecology and productivity of European lobster (Homarus gammarus, L) in offshore wind farms* (No. C109/18). Wageningen Marine Research.	Desktop study on autecology and productivity of European lobster (Homarus gammarus, L) in offshore wind farms (No. C109/18)	This desk study describes the biology of the European lobster H. gammarus. Using the obtained data a model was developed to describe the growth of the European lobster under assumed conditions on the anti-scouring of monopiles in Dutch OWFs. One of the main questions to answer was, if, theoretically, local productivity supports the continuous harvesting of lobsters with passive fishery methods.	Europe (Standard research publication)	North Sea
Sangiuliano, S. J. (2018). Analysing the potentials and effects of multi-use between	Analysing the potentials and effects of multi-use between tidal energy	As the population of cities continues to proliferate, society places a greater strain on the productivity of geographical features and their resources. In recent years, this trend has increased for the planet's seas. In order to further maximize the utility of marine space, the concept of co-location between economic sectors operating in the sea, and coexistence of such sectors with the ecosystem, has provided traction for the concept of multi-use (MU).	Europe (EU - Project)	North Sea

tidal energy development and environmental protection and monitoring: A case study of the inner sound of the Pentland Firth. *Marine Policy*, *96*, 120-132.	development and environmental protection and monitoring: A case study of the inner sound of the Pentland Firth.	In response, the European Union Horizon 2020 programme funded the Multi-Use in European Seas (MUSES) project which aims to provide innovative technical and policy solutions to facilitate MU in the five European sea basins. Within the broader analytical framework of MUSES, 10 case studies were developed to determine the potentials and effects of MU for various sectors. This paper examines MU between tidal energy development and environmental protection, as well as tidal energy development and environmental monitoring. A desk analysis provided for known drivers, added values, barriers, and impacts of MU. Results from the desk analysis were validated by key stakeholders, resulting in policy and technical recommendations informing the MUSES Action Plan. The analysis demonstrates that technological advancements to monitoring equipment are required to further studies of environmental interactions with tidal energy arrays, and determine the viability of co-locating developments in environmentally sensitive areas. However, greater capacity deployments of tidal energy are required so that robust monitoring data sets can accumulate over time, geographical scope, and ecological make-up. Such capacity development is currently hindered by ineffective government fiscal measures.		
Schultz-Zehden, A., Weig, B., & Lukic, I. (2019). Maritime Spatial Planning and the EU's Blue Growth Policy: Past, present and future perspectives. In Maritime Spatial Planning (pp. 121-149). Palgrave Macmillan, Cham.	Maritime Spatial Planning and the EU's Blue Growth Policy: Past, present and future perspectives	This chapter discusses the role of Maritime spatial planning (MSP) and its relationship to Blue Growth. After presenting differences among European sea-basins with regard to blue sector development, it underlines the need for a differentiated definition and policy support for Blue Growth. We argue that MSP should be adapted towards the different Blue Growth support needs of countries, regions and maritime sectors throughout Europe. The success of MSP as a tool to support Blue Growth depends on how strongly MSP is intertwined with other measures of the Integrated Maritime Policy and territorial development measures. MSP should be seen more strongly in strategic future development planning, for example, highlighting potential development areas which may stimulate economic growth in territorial areas lagging behind others.	Europe (Standard research publication)	European (Atlantic, Baltic Sea, Black Sea, Mediterranean Sea, North Sea)
Schupp, M. F., Bocci, M., Depellegrin, D., Kafas, A., Kyriazi, Z., Lukic, I., ... & Buck, B. H. (2019). Towards a common understanding of ocean multi-use. *Frontiers in Marine Science*, *6*, 165.	Towards a common understanding of ocean multi-use	The "open ocean" has become a highly contested space as coastal populations and maritime uses soared in abundance and intensity over the last decades. Changing marine utilization patterns represent a considerable challenge to society and governments. Maritime spatial planning has emerged as one tool to manage conflicts between users and achieve societal goals for the use of marine space; however, single-sector management approaches are too often still the norm. The last decades have seen the rise of a new ocean use concept: the joint "multi-use" of ocean space. This paper aims to explain and refine the concept of ocean multi-use of space by reviewing the development and state of the art of multi-use in Europe and presenting a clear definition and a comprehensive typology for existing multi-	Europe (EU - Project)	Several

		use combinations. It builds on the connectivity of uses and users in spatial, temporal, provisional, and functional dimensions as the underlying key characteristic of multi-use dimensions. Combinations of these dimensions yield four distinct types of multi-use with little overlap between them. The diversity of types demonstrates that there is no one-size-fits-all management approach, but rather that adaptive management plans are needed, focusing on achieving the highest societal benefit while minimizing conflicts. This work will help to sharpen, refine and advance the public and academic discourse over marine spatial planning by offering a common framework to planners, researchers and users alike, when discussing multi-use and its management implications.		
Sie, Y. T., Château, P. A., Chang, Y. C., & Lu, S. Y. (2018). Stakeholders Opinions on Multi-Use Deep Water Offshore Platform in Hsiao-Liu-Chiu, Taiwan. *International journal of environmental research and public health*, *15*(2), 281.	Stakeholders opinions on multi-use deep water offshore platform in Hsiao-Liu-Chiu, Taiwan	This paper describes a group model building activity designed to elicit the potential effects a projected multi-use deep water offshore platform may have on its local environment, including ecological and socio-economic issues. As such a platform is proposed for construction around the island of Hsiao-Liu-Chiu, Taiwan, we organized several meetings with the local stakeholders and structured the debates using group modeling methods to promote consensus. During the process, the participants iteratively built and revised a causal-loop diagram that summarizes their opinions. Overall, local stakeholders concluded that a multi-use deep water offshore marine platform might have beneficial effects for Hsiao-Liu-Chiu because more tourists and fish could be attracted by the structure, but they also raised some potential problems regarding the law in Taiwan and the design of the offshore platform, especially its resistance to extreme weather. We report the method used and the main results and insights gained during the process.	Standard research publication - Cooperation between EU and Taiwan	Pacific (Taiwan)
Stefanakou, A., Dagkinis, I., Lilas, T., Maglara, A., & Vatistas, A. (2016, July). Development of a floating wind-desalination multi-use platform (MUP) in the context of optimal use of maritime space. In *Offshore energy and storage symposium (OSES) and industry connector event*.	Development of a floating wind-desalination multi-use platform (MUP) in the context of optimal use of maritime space. In Offshore energy and storage symposium (OSES) and industry connector event.	Water scarcity is a major problem in many islands. The aim of this paper is to further enhance a pilot technology, which utilizes wind and solar energy to desalinate sea water in order to develop a proof-of-concept design for a fully integrated multi-component and multi-use platform in order to exploit ocean resources in a sustainable way for the production of drinking water and/or electricity under various configurations. The ability of the system to adopt multiple configurations means that it can be tailor made to the specific requirements in different areas. The main idea of the project was to find an economic and ecological solution for the producing drinking water and/or electricity with energy provided by a wind generator and a photovoltaic system, for the water stressed islands of the Aegean by integrating a desalination unit with wind power and photovoltaic panel in the same floating structure. Also, as well as the floating structure is made of steel pipes, it can safely be used as compressed air storage tanks for pressures up to 80 bar. Alternative design combinations of offshore wind turbine together with photovoltaics, desalination unit, compressed air storage and grid connection are presented in order to meet different requirements.	Europe (Standard research publication)	Not specified

Stelzenmüller, V., Diekmann, R., Bastardie, F., Schulze, T., Berkenhagen, J., Kloppmann, M., ... & Kraus, G. (2016). Co-location of passive gear fisheries in offshore wind farms in the German EEZ of the North Sea: A first socio-economic scoping. *Journal of Environmental Management*, *183*, 794-805.	Co-location of passive gear fisheries in offshore wind farms in the German EEZ of the North Sea: A first socio-economic scoping.	Worldwide the renewable energy sector is expanding at sea to address increasing demands. Recently the race for space in heavily used areas such as the North Sea triggered the proposal of co-locating other activities such as aquaculture or fisheries with passive gears in offshore wind farms (OWFs). Our interdisciplinary approach combined a quantification of spatial overlap of activities by using Vessel Monitoring System and logbook data with a stakeholder consultation to conclude and verify on the actual feasibility of co-location. In the German Exclusive Economic Zone (EEZ) of the North Sea up to 90% of Danish and 40% of German annual gillnet fleet landings of plaice overlapped with areas where OWFs are developed. Our results indicated further that the international gillnet fishery could lose up to 50% in landings within the North Sea German EEZ when OWF areas are closed entirely for fisheries. No spatial overlap was found for UK potters targeting brown crab in the German EEZ. We further identified a number of key issues and obstacles that to date hinder an actual implementation of co-location as a measure in the marine spatial planning process: defining the legal base; implementation of safety regulations; delineation of minimum requirements for fishing vessels such as capacities, quotas, technical equipment; implementation of a licensing process; and scoping for financial subsidies to set up business. The stakeholder consultation verified the scientific findings and highlighted that all those points need to be addressed in a planning process. In the German EEZ we have shown that the socioeconomic importance of spatial overlap varies within planning boundaries. Therefore we recommend an interdisciplinary bottom-up approach when scoping for suitable areas of co-location. Hence, an informed marine spatial planning process requires comprehensive and spatial explicit socio-economic viability studies factoring in also ecological effects of OWFs on target species	Europe (Standard research publication) - German government	North Sea
Stuiver, M., Soma, K., Koundouri, P., Van den Burg, S., Gerritsen, A., Harkamp, T., ... & Hommes, S. (2016). The Governance of multi-use platforms at sea for energy production and aquaculture: challenges for policy makers in European seas. *Sustainability*, *8*(4), 333.	The governance of multi-use platforms at sea for energy production and aquaculture: Challenges for policy makers in European Seas	European seas are encountering an upsurge in competing marine activities and infrastructures. Traditional exploitation such as fisheries, tourism, transportation, and oil production are accompanied by new sustainable economic activities such as offshore windfarms, aquaculture, and tidal and wave energy. One proposed solution to overcome possible competing claims at sea lies in combining these economic activities as part of Multi-Use Platforms at Sea (MUPS). MUPS can be understood as areas at sea, designated for a combination of activities, either completely integrated in a platform or in shared marine space. MUPS can potentially benefit from each other in terms of infrastructure, maintenance, etc. Developing MUPS in the marine environment demands adequate governance. In this article, we investigate four European sites to find out how governance arrangements may facilitate or complicate MUPs. In particular, we apply a framework specifying policy, economic, social, technical, environmental, and legal (PESTEL) factors to explore governance arrangements in four case study sites in different sea basins around Europe (the Mediterranean Sea, the	Europe (EU - Project)	European (Atlantic, Baltic Sea, Black Sea, Mediterranean Sea, North Sea)

		Atlantic Ocean, the North Sea, and the Baltic Sea). The article concludes with policy recommendations on a governance regime for facilitating the development of MUPS in the future		
Tonk, L., & Rozemeijer, M. J. C. (2019). *Ecology of the brown crab (Cancer pagurus): and production potential for passive fisheries in Dutch offshore wind farms* (No. C064/19A). Wageningen Marine Research.	Ecology of the brown crab (Cancer pagurus): and production potential for passive fisheries in Dutch offshore wind farms	It is currently unknown whether low impact brown crab fishery in offshore wind farms in the North Sea is feasible from an ecological point of view. This desk study provides an overview of current knowledge on brown crab ecology and a base document in order to create insight in harvest potential of brown crab (Cancer pagurus) within Dutch offshore wind farms. Brown crab is of substantial commercial importance with an average 50,000 tonnes in landings yearly in Europe. The UK has the largest brown crab fishing industry (approx. 34,000 tonnes) whereas the Netherlands play a much smaller part (approx. 550 tonnes). Stock assessment of brown crab in the central and southern North Sea show that populations of females are increasing and thereby approaching the recommended level for females. Populations of males are low and remain around the minimum recommended level for males. However, the age at which brown crabs become fertile is likely to vary regionally. This has implications for management through appropriate Minimum Conservation Reference Size (MCRS) restrictions (ranging between 130-140 mm) that are set to conserve the reproductive potential of brown crabs. Local estimates of size at first maturity will aid to preserve the production potential.	Europe (Standard research publication) - Dutch government	North Sea
Van den Burg, S. W. K., Aguilar-Manjarrez, J., Jenness, J., & Torrie, M. (2019). Assessment of the geographical potential for co-use of marine space, based on operational boundaries for Blue Growth sectors. *Marine Policy*, *100*, 43-57.	Assessment of the geographical potential for co-use of marine space, based on operational boundaries for Blue Growth sectors	The worlds' oceans and seas have tremendous potential to contribute to the provision of food, feed, energy and natural resources. The emerging concepts of "Blue Growth" and "Blue Economy" have put the development of new marine industries on the political agenda. As marine industries expand, spatial interconnections and industry boundaries are being drawn and the potential for the combined use of marine space is being explored. The aim of this paper is to provide a single source document that summarizes the probable boundaries of marine growth industries, namely aquaculture; offshore wind energy with fixed foundations; floating offshore wind energy; tidal and wave energy; marine biotechnology, seabed mining; and tourism and recreation, based on depth and distance from the shore. This is an important first step in developing a single source document for marine industry boundaries that will help marine spatial planners and researchers develop innovative industry combinations to foster growth in the marine sector. This paper explores marine industry overlaps in four basins: European Atlantic, Baltic/North Sea, Mediterranean/Black Sea and the Caribbean/ Gulf of Mexico. By describing the geographical characteristics of different sea basins, this paper helps to focus marine governance strategies for stimulating combinations of marine industries towards the most promising areas. The methodology developed in this paper was also used to generate 72 country-specific maps and corresponding tables to support marine spatial planning processes at a national level.	Europe (EU - Project)	European (Atlantic, Baltic Sea, Black Sea, Mediterranean Sea, North Sea)

Van den Burg, S. W. K., Kamermans, P., Blanch, M., Pletsas, D., Poelman, M., Soma, K., & Dalton, G. (2017). Business case for mussel aquaculture in offshore wind farms in the North Sea. *Marine Policy*, *85*, 1-7.	Business case for mussel aquaculture in offshore wind farms in the North Sea.	The European Blue Growth strategy aims to expand the new maritime sectors of aquaculture, energy, biotechnology, coastal tourism and mineral mining. Growth of these sectors will increases pressure on the seas, particularly on those areas that are densely used by traditional sectors such as fisheries and transport. This has triggered interest in developing multiuse of space and multiuse platforms at sea. This paper assesses the feasibility of offshore mussel production project in wind farms by design and ex-ante evaluation of a mussel aquaculture system in the North Sea. A system for mussel cultivation in the Dutch Borssele offshore wind farm was designed, producing both mussel seed and consumption-sized mussels with semi-submerged longlines. Based on the economic model and the risk assessment, this paper concludes that mussel aquaculture is an appealing commercial model for increased returns in offshore wind farms. The economic models shows that the internal rate of return and net present value are positive and based on the sensitivity analysis, it can be concluded that these results are robust.	Europe (EU - Project)	North Sea
Van den Burg, S., Stuiver, M., Norrman, J., Garção, R., Söderqvist, T., Röckmann, C., ... & De Bel, M. (2016). Participatory design of multi-use platforms at sea. *Sustainability*, *8*(2), 127.	Participatory design of multi-use platforms at sea	European oceans are subject to rapid development. New activities such as aquaculture and ocean energy have gained importance. This triggers interest in "multi-use platforms at sea" (MUPS), i.e., areas at sea in which different activities are combined. MUPS are complex features with regards to technology, governance, and financial, socioeconomic, and environmental aspects. To identify realistic and sustainable solutions and designs for MUPS, the MERMAID project applied a participatory design process (PDP) involving a range of stakeholders representing companies, authorities, researchers, and NGOs. This paper evaluates if and how the participatory design process contributed to the design of multi-use platforms. It is based on interviews with the managers of the case study sites and a questionnaire administered to all stakeholders participating in the PDP workshops. Analyzing the four case studies, we conclude that the participatory design process has had a valuable contribution to the development of the four different designs of MUPS, even though the preconditions for carrying out a participatory design process differed between sites. In all four cases, the process has been beneficial in generating new and shared knowledge. It brought new design issues to the table and increased knowledge and understanding among the different stakeholders.	Europe (EU - Project)	European (Atlantic, Baltic Sea, Black Sea, Mediterranean Sea, North Sea)
van Hoof, L., van den Burg, S. W. K., Banach, J. L., Röckmann, C., & Goossen, M. (2020). Can multi-use of the sea be safe? A frame-	Can multi-use of the sea be safe? A framework for risk assessment of multi-use at sea	By 2050 the world population is expected to reach 10 billion people. This population needs food, water and energy. Increasingly, opportunities are sought out at sea to accommodate these needs. As there is already competition for space, especially in the near-shore, opportunities for multi-use, including the combination of, for example, food and energy production in a single location, are sought. One issue that needs to be addressed to allow for multi-use at sea is safety. Existing frameworks for (marine) risk assessment tend to be rather sector specific and, although existing models and frameworks for risk analysis provide useful	Europe (Standard research publication)	Not specified

work for risk assessment of multi-use at sea. *Ocean & Coastal Management*, *184*, 105030.		elements for an integrated analysis, none of the approaches fully caters for the need of having a framework based on a cyclical process of stakeholder input in all steps of the process of risk identification, risk management and risk evaluation and communication, identifying actions to be taken and providing tools useful in each of the steps, while integrating the three perspectives of maritime safety, food (and feed) safety, and environmental impact assessment and the different perspectives of the actors involved. This study developed a common framework for the risk assessment of multi-use at sea, consisting of six steps (Exploring, Understanding, Appraising, Deciding, Implementing and Evaluating & Communication). The framework encompasses and integrates an analysis of food and feed safety aspects, the safety of people and equipment, and environmental safety aspects. For each step, actions are defined, tools that can be of help to stakeholders are presented, and stakeholder participation measures are described. The framework is iterative and dynamic in its nature; with constant communication and evaluation of progress, decisions can be taken to either take a step forward or back. The framework is developed to assist operators and producers, policymakers, and other stakeholders in assessing and managing risks of multi-use at sea	- Lloyd's Register Foundation	
Weiss, C. V., Ondiviela, B., Guinda, X., del Jesus, F., (2016). Co-location opportunities for renewable energies and aquaculture facilities in the Canary Archipelago. *Ocean & Coastal Management*	Co-location opportunities for renewable energies and aquaculture facilities in the Canary Archipelago. Ocean & Coastal Management	Integrated Offshore Management is a future challenge for the development of sustainable growth of marine economies. The progressive increase in worldwide demands for marine-based renewable energies combined with higher market demands for aquaculture-based food requires better knowledge on marine spatial planning tools that allow optimizing the use of this space for different purposes. That is the case of energy production and aquaculture activities, in which synergistic and competitive interactions must be thoroughly analyzed at an appropriate scale. The present study proposes a specific methodology that integrates several selection criteria responding simultaneously to the needs and limitations of marine aquaculture and renewable energy production, aiming to identify opportunities for the co-location of these activities. The methodology was implemented over 25 km of the coastal fringe of four islands of the Canary Archipelago, applying a multi-criteria approach based on independent probabilistic suitability and mapping analysis (time series of 20–30 years) for: (i) wind and wave energy production potential; (ii) structural requirements for aquaculture cages and energy devices; (iii) limits for operation and maintenance activities; (iv) feasibility to transport energy to the grid; and (v) biological requirements for eight species of fish. A stepwise procedure was carried out, including: 1) suitability for wave, wind and aquaculture activities, with spatial resolution of 0.01° (0–1 probability scale); and 2) integrated co-location mapping, considering suitability for each activity. Opportunities for the co-location of wind and aquaculture farms were identified in the southeastern portion	Europe (Standard research publication)	Atlantic

		of the islands, while in Tenerife and Fuerteventura wave-wind devices co-location opportunities were identified. Thus, opportunities for marine aquaculture and renewable energy were demonstrated in the present case study applying a preliminary assessment of the potential exploitation of these resources.		
Westerberg, V., Jacobsen, J. B., & Lifran, R. (2013). The case for offshore wind farms, artificial reefs and sustainable tourism in the French mediterranean. *Tourism Management*, *34*, 172-183.	The case for offshore wind farms, artificial reefs and sustainable tourism in the French mediterranean	As the French government strives to achieve their offshore renewable energy target, the impact of offshore wind farms on coastal tourism in the Languedoc Rousillon is now being questioned. To assess this issue, a choice experiment was undertaken to elicit tourist preferences for wind turbines at different distances from the shore. We also examined whether potential visual nuisances may be compensated by wind farm associated reef-recreation or by adopting a coherent environmental policy. The findings indicate that age, nationality, vacation activities and their destination loyalty influence attitudes towards compensatory policies. Two policy recommendations are suggested. First, everything else being equal, wind farms should be located no closer than 12 km from the shore. Second, and alternatively, a wind farm can be located from 5 km and outwards without a loss in tourism revenues if accompanied by a coherent environmental policy and wind farm associated recreational activities	Europe (Standard research publication)	Mediterranean Sea
Wever, L., Krause, G., & Buck, B. H. (2015). Lessons from stakeholder dialogues on marine aquaculture in offshore wind farms: Perceived potentials, constraints and research gaps. *Marine Policy*, *51*, 251-259.	Lessons from stakeholder dialogues on marine aquaculture in offshore wind farms: Perceived potentials, constraints and research gaps	Drawing on a case study in Germany, this contribution explores the practical application of offshore aquaculture within offshore wind farms in view of the different stakeholders involved. Using a transdisciplinary research approach, an understanding of the rationalities and interests among the different involved stakeholder groups was explored. Offshore wind energy is high on the political agenda in Germany. The vast spatial requirements however inherit potential user conflicts with competing, and under current legislation excluded users such as fishermen. Solutions for combining sustainable uses of the same ocean space have thus seen increasing interest within the research community in Germany and in Europe over the past years. This paper was inspired by and presents the outcomes of a stakeholder analysis and in particular a stakeholder workshop. Central focus was placed on academics and private as well as public stakeholders engaged in current research efforts of combining offshore wind farms and aquaculture in the German North Sea. The paper identifies the overall acceptance of such a multi-use scenario in society, opportunities and constraints as perceived by the stakeholders, and key research gaps. The results confirm the assumption that there is a clear need, and also willingness on behalf of the policy makers and the research community, to find sustainable, resource- and space-efficient solutions for combined ocean use.	Europe (Standard research publication) - German government	North Sea

Zanuttigh, B., Angelelli, E., Kortenhaus, A., Koca, K., Krontira, Y., & Koundouri, P. (2016). A methodology for multi-criteria design of multi-use offshore platforms for marine renewable energy harvesting. *Renewable Energy*, *85*, 1271-1289.	A methodology for multi-criteria design of multi-use offshore platforms for marine renewable energy harvesting	Multi-use offshore platforms (MUPs) combining renewable energy from the sea, aquaculture and transportation facilities can be considered as a challenging way to boost blue growth and make renewable energy (especially wave energy) environmentally and socio-economically sustainable. MUPs allow sharing the financial and other market/non-market costs of installation and management, locally using the produced energy for different functionalities and optimizing marine spatial planning. The design of these solutions is a complex interdisciplinary challenge, involving scientists and technical experts with different backgrounds.This paper presents a new methodology for the design of a MUP based on technical, environmental, social and economic criteria. The methodology consists of four steps: a pre-screening phase, to assess the feasibility of different maritime uses at the site; a preliminary design of the alternative schemes based on the identified maritime uses; a ranking phase, where the performance of the MUPs is scored by means of expert judgment of the selected criteria; a preliminary design of the selected MUP selected.An example application of this procedure to a site offshore the Western Sardinia coast, Mediterranean Sea, Italy, is provided. In this site the deployment of a MUP consisting of wave energy converters, offshore wind turbines and aquaculture is specifically investigated.	Europe (EU - Project)	Mediterranean Sea

ANNEX 2 – RESULTS LITERATURE REVIEW

Needs to be included here

Type of barrier (economic, societal, technology, environmental, legal, policy and governance)	Description	Relevance for types of	Relevance for types of	Relevance for types of	Relevance for types of	sectors covered	sectors covered	sectors covered	sectors covered	sectors covered					sectors covered	Solutions/Actions	Example / Case Study	Reference	Related project
		Type A	Type B	Type C	Not specified	sectors covered	Offshore energy	Aquaculture	tourism	desalination	oil and gas	environmental protec-	fisheries	other	not specified				Related project
Economic	Lack of robust techno-economic analysis examining the economic viability of MUS/MUP combinations				1		x	x		x						New methodology for selecting, filtering, developing and ranking business propositions	MARIBE project, in particular (1) wave energy + seaweed aquaculture, (2) wave energy + fin-fish aquaculture, (3) desalination + floating wind	Dalton et al (2019)	MARIBE

Economic	Lack of confidence from investors				1		x	x		x						New methodology for selecting, filtering, developing and ranking business propositions	MARIBE project, in particular (1) wave energy + seaweed aquaculture, (2) wave energy + finfish aquaculture, (3) desalination + floating wind	Dalton et al (2019)	MARIBE
Legal, policy and governance	Lack of insight into potential of multi-use: difficult for msp				1		x	x								It is important to recognize the potential of combined use within sea basins by understanding operational boundaries and geographical characteristics. . --> define operationL boundaries, GIS mapping (=method applied in the paper)	fixed offshore wind and aquaculture	van den burg (2019)	MARIBE
Legal, policy and governance	Institutional arrangements for cross-sectoral activities are missing and need to be developed		1		1										x			van den burg (2019)	MARIBE
Societal	A lack of trust between sectors is reportedly an issue of concern, leading to a call for innovative social networks				1										x	Recognizing the potential for certain combinations, policymakers can gear up efforts to bring stakeholders together in innovative social networks, addressing non-operational barriers to		van den burg (2019)	MARIBE

	that can help to create trust [67].															multi-use --> social innovation (Soma et al 2018)			
Legal, policy and governance	Legislation is often seen as a barrier to multi-use. Policies that enable or even require the multiple use of sea space can encourage the development of multiple use approaches.				1											regulation/ subsidies		van den burg (2019)	MARIBE
Economic	Still, institutional and legislative restraints as well as economic aspects have been judged important unresolved issues of multiuse of wind farms and mussel aquaculture [25].		1				x	x									offshore wind and (mussel) aquaculture	van den burg, kamermans et al (2017)	MARIBE
Economic	A detailed business case for this multiuse combination is however lacking. A financial and risk assessment for such concept is needed to inform		1				x	x								develop business case + risk assessment	offshore wind and (mussel) aquaculture	van den burg, kamermans et al (2017)	MARIBE

	decision-makers on whether an attractive profit could be realisable from mussel cultivation in offshore wind farms.																		
Economic	Fulfilling the potential of Blue Growth requires the upscaling of innovative practices to full commercial scale as well as growth to mature economic sectors. This requires more than knowledge and networks, it also requires financial impulses by investors. Attracting private investors is therefore of paramount importance to implementation of the new Blue Growth strategy.		1												x			van den Burg, Stuiver et al 2017	MARIBE
Economic	High costs for grid connection		1				x	x									Floating offshore wind and aquaculture	Depellegrin et al., 2019	MUSES
Societal	Social acceptability of the OW for tourism sector and fishermen		1				x	x									Floating offshore wind and aquaculture	Depellegrin et al., 2019	MUSES

Societal	Safety and security concerns of workers		1				x	x									Floating offshore wind and aquaculture	Depellegrin et al., 2019	MUSES
Economic	High maintenance costs of aquaculture sites		1				x	x									Floating offshore wind and aquaculture	Depellegrin et al., 2019	MUSES
Legal, policy and governance	Competing uses in aquaculture sector hampers development of aquaculture development		1				x	x									Offshore wind and aquaculture	Depellegrin et al., 2019	MUSES
Legal, policy and governance	Unclear and fragmented regulation on national level		1				x	x									Offshore wind and aquaculture	Depellegrin et al., 2019	MUSES
Technology	Self-sustainability of aquaculture can be already reached with solar energy	1					x	x									Wave energy and aquaculture	Depellegrin et al., 2019	MUSES
Technology	Damage risks from adverse weather conditions	1					x	x									Wave energy and aquaculture	Depellegrin et al., 2019	MUSES
Technology	Feeding practices need to be correctly monitored	1					x	x								Telemetric system for environmental parameter monitoring and feeding, ideally supported by alternative energy resources, e.g. solar panels	Wave energy and aquaculture	Depellegrin et al., 2019	MUSES
Societal	Consensus from multiple stakeholders in private and public sector	1					x			x						Facilitate early engagement on stakeholders in MSP, sectorial plans and MU benefits	Desalination and offshore wind	Depellegrin et al., 2019	MUSES

Economic	High maintenance costs of the strcuture compared to land	1					x			x							Desalination and offshore wind	Depellegrin et al., 2019	MUSES
Economic	Security of tenure for the aquaculture sector after decommissioning of OW sites		1				x	x								Facilitate stakeholder engagement and communication	offshore wind and (mussel) aquaculture	Calado et al., 2019	MUSES
Environmental	Increased traffic for aquaculture vessels resulting into health and security risks		1				x	x									offshore wind and (mussel) aquaculture	Calado et al., 2019	MUSES
Technology	Lack of proof of concept that can demonstrate the techno-economic feasibility of the MUP		1				x	x								Knowledge transfer, subsidies	offshore wind and (mussel) aquaculture	Calado et al., 2019	MUSES
Economic	Small sized OW farms do not allow profitable aquaculture		1				x	x								Facilitate stakeholder engagement and communication	offshore wind and (mussel) aquaculture	Calado et al., 2019	MUSES
Societal	Social acceptability of the OW for society and fishermen		1				x	x								Dissiminate knowledge on responsible farming and sustainable energy production	offshore wind and (mussel) aquaculture	Calado et al., 2019	MUSES
Legal, policy and governance	Delayed collocation of aquaculture when OW is already in place		1				x	x									offshore wind and (mussel) aquaculture	Calado et al., 2019	MUSES

Environmental	Unknown cumulative effects from MUPs		1				x	x								Subsidies to address cumulative environmental and socio-economic effects from MUPs	offshore wind and (mussel) aquaculture	Depellegrin et al., 2019	MUSES
Societal	Unknown cumulative effects from MUPs		1				x	x								Subsidies to address cumulative environmental and socio-economic effects from MUPs	offshore wind and (mussel) aquaculture	Depellegrin et al., 2019	MUSES
Societal	Lack of communication among sectors		1				x	x								Facilitate early engagement on stakeholders in MSP, sectorial plans and MU benefits	offshore wind and aquaculture	Bocci et al., 2019	MUSES
Societal	Scarce public awareness about positive implications of multi-use		1				x	x								Facilitate early engagement on stakeholders in MSP, sectorial plans and MU benefits	offshore wind and aquaculture	Bocci et al., 2019	MUSES
Technology	Lack of infrastructure for shore side electricity generation	1					x							x			Renewable energy (wind, wave, tidal) and port facilities	Bocci et al., 2019	MUSES
Legal, policy and governance	Strict security regulation when carrying tourists on the platform			1				x	x		x						O&G and tourism and aquaculture	Depellegrin et al., 2019	MUSES
Technology	Special anchoring technology required to approach O&G platform (e.g. by sailing boats, transport and maintenance vessels)			1			x	x	x		x					Development of anchoring technology suitable for adverse environmental conditions	O&G and tourism and aquaculture; O&G platform and offshore wind	Depellegrin et al., 2019	MUSES

Legal, policy and governance	EU Offshore Safety Directive (2013/30/EU)			1				x	x		x					create ad hoc national legal frameworks that provide private or public entities opportunity for re-use of the infrastructure	O&G and tourism and aquaculture	Depellegrin et al., 2019	MUSES
Technology	Only eight-legged (or more) platforms suitable for this MUP			1				x	x		x					Develop smart multi-criteria analysis instruments to identify environmental, technical and socio-economic re-use solutions for O&G infrastructures	O&G and tourism and aquaculture	Depellegrin et al., 2019	MUSES
Economic	Absence of buisness model and best practice			1				x	x		x					Pilot demonstrator on re-use of O&G platform	O&G and tourism and aquaculture	Depellegrin et al., 2019	MUSES
Technology	High vibration from turbine can cause damage to infrastructure			1			x				x						O&G platform and offshore wind	Depellegrin et al., 2019	MUSES
Economic	High maintenance costs of the structure after decommissioning			1			x	x	x		x					Need to involve O&G sector in the re-use project/consortium	O&G and tourism and aquaculture; O&G platform and offshore wind	Depellegrin et al., 2019	MUSES
Societal	Consensus from multiple stakeholders in private and public sector		1				x	x								Develop stakeholder engagement approaches toa address staheholders' opinion on MUPs developement	Offshore wind and aquaculture; Offshore wind and tourism; Offshore wind and Fisheries	Przedrzymirska et al., 2018	MUSES

Legal, policy and governance	Unclear deployment procedures of most mature MUPs on sea basin level		1				x	x	x							Provide assitance mechanisms in accordance to the maturity level of the MUP	Offshore wind and aquaculture; Offshore wind and tourism; Offshore wind and Fisheries	Przedrzymirska et al., 2018	MUSES
Technology	Power failure risks from local energy storage/use technology	1	1				x	x									Renewable energy (wind, wave) and aquaculture	Zanuttigh et al., 2016	Other
Environmental	Increasing risk of pollution events (mainly excessive nutrient load abd other substances) due to the installation of aquaculture cages				1		x	x									Renewable energy (wind, wave) and aquaculture	Zanuttigh et al., 2016	Other
Economic	Financial risks related to the level of commercialization of the wind and wave energy technology		1				x	x									Renewable energy (wind, wave) and aquaculture	Zanuttigh et al., 2016	Other
Legal, policy and governance	MUPs optimze sea space use, but involve a set of constrains related to safety distance to other uses or distance form shore				1		x	x									Renewable energy (wind, wave) and aquaculture	Zanuttigh et al., 2016	Other
Technology	Long implementation period of a full MUP (wind, wave and aquaculture)		1				x	x									Renewable energy (wind, wave) and aquaculture	Zanuttigh et al., 2016	Other

	due to the early stage development of wave energy generation devices compared to wind technology																		
Economic	High insurance costs due lack of experience in co-location projects		1				x	x									Renewable energy (wind, wave) and aquaculture	Zanuttigh et al., 2016	Other
Technology	Increased risk for damage and accidents for wind and floating wave energy devices in case of mooring failure		1		1		x	x									Renewable energy (wind, wave) and aquaculture	Zanuttigh et al., 2016	Other
Technology	MUPs are modular and therefore require different mooring technology for wind energy (fixed device), wave and aquaculture (floating devices)		1				x	x									Renewable energy (wind, wave) and aquaculture	Zanuttigh et al., 2016	Other
Economic	High maintenance costs can emerge from extraordinary interventions to wind and wave energy devices		1				x	x									Renewable energy (wind, wave) and aquaculture	Zanuttigh et al., 2016	Other

Economic	Insufficient subsidies / appropriate funding mechanisms for tidal energy developments in relation to other technologies such as offshore wind energy	1					x					x				Subsidy is made available, perhaps in the form of a FIT, so that financial investors will be attracted and tidal projects will reach bankability sooner. National authorities develop a subsidy mechanism which allows for pre-commercial tidal energy to be competitive with more commercial forms of electricity generation.	Pentland Firth (Scotland) - Tidal energy / Environmental Protection	Sangiuliano, 2018	MUSES
Environmental	Partially known effects from TCT on fish, mammals and birds		1				x					x				Combination between TCT and monitoring devices may help in better understanding and qunatifying environmental effects. The benefits of effective monitoring co-location provides tremendous economic, societal, environmental, regulatory, technical, and industry value. An increased knowledge base on key environmental factors is vital to the exploration of MU between tidal development and environmental protection. Standardized data collection and analysis methods. Ensuring that	Pentland Firth (Scotland) - Tidal energy / Environmental Protection / Environmental Monitoring	Sangiuliano, 2018	MUSES

																developers effectively disseminate environmental data either by establishing this as a binding requirement, or allowing for developers to charge for data release in order to financially incentivize cooperation.			
Technology	Lack of technological maturity of tidal energy may deter investors and thus limit technological progression	1					x					x					Pentland Firth (Scotland) - Tidal energy / Environmental Protection	Sangiuliano, 2018	MUSES
Technology	Lack of infrastructure to accommodate tidal energy	1	1				x					x					Pentland Firth (Scotland) - Tidal energy / Environmental Protection	Sangiuliano, 2018	MUSES

Legal, policy and governance	Staggered MU may initiate complex licensing procedures						x					x					Pentland Firth (Scotland) - Tidal energy / Environmental Monitoring	Sangiuliano, 2018	MUSES
Societal	Social acceptability due to impacts on landscapes and seascapes of TCTs and/or associated infrastructure such as on/offshore substations	1					x					x					Pentland Firth (Scotland) - Tidal energy / Environmental Protection	Sangiuliano, 2018	MUSES
Economic	Possible economic impacts on local communities	1					x					x				Establishment of a community benefit fund	Pentland Firth (Scotland) - Tidal energy / Environmental Protection	Sangiuliano, 2018	MUSES
Societal	Existing uses provides for claims of encroachment and litigation	1					x					x				EC and national authorities restructure SEA, EIA, and MSP Directives/Regulations to consider synergies and negative impacts specific to MU with tidal energy, EPAs, and other uses/users of marine space as MU is not explicitly included in these assessments and processes.	Pentland Firth (Scotland) - Tidal energy / Environmental Protection	Sangiuliano, 2018	MUSES
Societal	MUP developments to be in conflict with both the local fishing community, which is a				1										x		MUPs in general	Kyvelou and Ierapetritis, 2019	Other

	traditionally significant stakeholder in the marine realm, and the commercial and tourism maritime routes																		
Societal	Potential, real and perceived, conflicts among sea uses				1										x	Implement MU MSP, looking for spatial efficiency. Early stakeholder engagement in the process of planning and MU implementation.	MUs in general	Kyvelou and Ierapetritis, 2019	Other
Economic	Potential, real and perceived, conflicts among sea uses				1										x	Implement MU MSP, looking for spatial efficiency. Early stakeholder engagement in the process of planning and MU implementation.	MUs in general	Kyvelou and Ierapetritis, 2019	Other
Environmental	Potential, real and perceived, conflicts among sea uses				1										x	Implement MU MSP, looking for spatial efficiency. Early stakeholder engagement in the process of planning and MU implementation.	MUs in general	Kyvelou and Ierapetritis, 2019	Other
Legal, policy and governance	Licensing procedures are often complicated for boat tours within the OWF zone and		1				x		x								OWF and tourism	Schultz-Zehden et al., 2018	MUSES

	entail high insurance premiums due to safety risks.																		
Economic	Licensing procedures are often complicated for boat tours within the OWF zone and entail high insurance premiums due to safety risks.		1				x		x								OWF and tourism	Schultz-Zehden et al., 2018	MUSES
Societal	Lack of awareness and interest of local boat operators and artisanal fishers (angling) about the opportunity, as well as low individual financial power and overall capacity from local tourism businesses to initiate and sustain such tourism opportunities		1				x		x								OWF and tourism	Schultz-Zehden et al., 2018	MUSES
Societal	Public (citizens, tourists) perception of OWF		1				x		x							Coherent environmental policy & wind farm associated recreational activities	OWF and tourism	Westerberg et al., 2013	Other
Technology	Technology readiness level, especially with regards to harsh environmental conditions in offshore	1					x	x								Support development of pilot projects and proofs of concept (functioning fullscale pilot	OWF and aquaculture	Schultz-Zehden et al., 2018	MUSES

	areas, and compatibility of technologies used for different types of aquaculture and OWF															with Technology Readiness Level (TRL 8))			
Societal	Power imbalance between the two sectors	1					x	x								Support involvement of established businesses to address low investment capacity of small-scale aquaculture sector	OWF and aquaculture	Schultz-Zehden et al., 2018	MUSES
Legal, policy and governance	Unassessed risk, unclear permitting processes and insurance implications	1					x	x								Develop a facilitation policy to drive this MU at a strategic and project level	OWF and aquaculture	Schultz-Zehden et al., 2018	MUSES
Societal	Power imbalance between the two sectors		1				x						x			Adopt clear regulatory guidelines and policy that promotes coexistence and mutual benefit. Support transition to a new and innovative fleet which is compatible with increasing numbers of wind farms and reduced space for fishery.	OWF and fisheries	Schultz-Zehden et al., 2018	MUSES
Societal	Level of development, perceptions and regulations in the different countries on environmental impacts and safety risks of fishing within OWF		1				x						x			Establish effective cooperation mechanisms between representatives for the two sectors (e.g. topical working groups, MSP stakeholder forums or sectoral planning channels). Pilots in the real	OWF and fisheries	Schultz-Zehden et al., 2018	MUSES

																environment, as well as the exchange of lessons learned from existing cases.			
Legal, policy and governance	Separate environmental impact assessment processes (permitting) for each of the (hybrid) technologies and lack of guidance on cumulative impact assessment				1		x									Enable exchange of information between different developers on environmental impacts, in an open process that can advise future EIA requirements	OWF and MRE generation	Schultz-Zehden et al., 2018	MUSES
Legal, policy and governance	Regulatory and incentive regimes with regards to MRE, which do not currently support combined renewable energy technologies				1		x									Design and support planning and financial incentive schemes	OWF and MRE generation	Schultz-Zehden et al., 2018	MUSES
Economic	Lack of financial incentives and sureties for development of new technologies and combinations	1	1												x	Provide financial incentives and sureties for development of new technologies and combinations	highly connected use combinations including MUPs	Schupp et al., 2019	MUSES

Legal, policy and governance	Lack of established licensing procedures for multi-use projects	1	1												x	Develop and deploy joint licensing procedures for multi-use development throughout entire life cycles	highly connected use combinations including MUPs	Schupp et al., 2019	MUSES
Legal, policy and governance	Lack of decision support systems for planners weighing multi-use projects	1	1												x	Identify and address gaps in current knowledge about safety, benefits and drawbacks and create decision support systems	highly connected use combinations including MUPs	Schupp et al., 2019	MUSES
Technology	Lack of market scale (or close to) pilot projects demonstrating technical and economic feasability to investors	1	1												x	Develop pilot sites to showcase and advance new technology in the field	highly connected use combinations including MUPs	Schupp et al., 2019	MUSES
Legal, policy and governance	Uncertainties around development priorities for one or more of the involved sectors	1	1	1			x	x								Formalization of public policies	AQ & OWF in canary archipelago	Weiss et al., 2018	Other
Economic	Lack of attractiveness for private investments due to economic factors	1	1				x	x									OWF & Wave energy canary archipelago	Weiss et al., 2018	Other
Technology	Structural risks to OWF structures from accidental collision with aquaculture equipment (entanglement).	1	1				x	x								Physical design of OWF structures should take such risks into account while AQ structures need to include adequate mooring/anchors	OWF & mussel aquaculture	Jansen et al., 2016	MARIBE

															to prevent breaking free of long lines			
Technology	Anchoring of O&M Vessels for AQ operations could damage power cables	1	1				x	x								OWF & mussel aquaculture	Jansen et al., 2016	MARIBE
Economic	Potentially increased insurance costs for combined multi-use operations as presence of other uses makes the disruption of one or both of the uses more likely	1	1				x	x								OWF & mussel aquaculture in the Netherlands	Jansen et al., 2016	MARIBE
Legal, policy and governance	Government position on multi-use scenarios is currently still unclear	1	1	1	1		x	x							Clarify government position on multi-use to give a development impuls and	OWF & mussel aquaculture in the Netherlands	Jansen et al., 2016	MARIBE
Economic	Investment is currently stymied by regulatory and operational uncertainties, including permitting, structural engineering, remote management tools and monitoring systems				1		x	x							it is crucial to show a level of development and success using pilot facilities	OWF & mussel aquaculture in the Netherlands	Jansen et al., 2016	MARIBE

Technology	Practical obstacles for fishermen and offshore wind developers		1												x			Stuiver et al., 2016	MARIBE
Legal, policy and governance	No public auhorities have decided to realize MUPS to date				1										x	involvement in R&D actions	Mediterranean site	Stuiver et al., 2016	MARIBE
Legal, policy and governance	Policies and regulations withhold companies from investing in MUPS				1										x	involvement in R&D actions	Mediterranean site	Stuiver et al., 2016	MARIBE
Legal, policy and governance	Legal and policy obstacles include bureaucratic complications (authorizations, licenses, infrastructural development, etc.). [34]. Among the bureaucratic complications, a lack of dialogue between public institutions and difficulties in identifying the administrative offices responsible for issuing permits has been addressed by stakeholders. In particular, it is unhelpful that each sector has				1										x		Mediterranean site	Stuiver et al., 2016	MARIBE

	its own legal instructions that become relevant when implementing MUPS.																		
Societal	legal and policy obstacles include bureaucratic complications (authorizations, licenses, infrastructural development, etc.). [34]. Among the bureaucratic complications, a lack of dialogue between public institutions and difficulties in identifying the administrative offices responsible for issuing permits has been addressed by stakeholders. In particular, it is unhelpful that each sector has its own legal instructions that become relevant when implementing MUPS.				1										x		Mediterranean site	Stuiver et al., 2016	MARIBE

Environmental	Legal and policy obstacles include bureaucratic complications (authorizations, licenses, infrastructural development, etc.). [34]. Among the bureaucratic complications, a lack of dialogue between public institutions and difficulties in identifying the administrative offices responsible for issuing permits has been addressed by stakeholders. In particular, it is unhelpful that each sector has its own legal instructions that become relevant when implementing MUPS.				1	MUPS including aquaculture		x									Mediterranean site	Stuiver et al., 2016	MARIBE
Legal, policy and governance	Lack of cross-border cooperation in MSP				1										x		Atlantic site	Stuiver et al., 2016	MARIBE
Legal, policy and governance	Current permitting procedure is complex, insufficient				1										x		Atlantic site	Stuiver et al., 2016	MARIBE

	coordination between different polic levels																		
Societal	Conflics of interest between different users of the sea				1										x	site selection is important	Atlantic site	Stuiver et al., 2016	MARIBE
Technology	Waves and water depth at the sites				1										x		Atlantic site	Stuiver et al., 2016	MARIBE
Environmental	Environmental impact of offshore energy				1	offshore energy	x										Atlantic site	Stuiver et al., 2016	MARIBE
Technology	Lack of clearity related to grid capacity				1	including offshore energy	x										Atlantic site	Stuiver et al., 2016	MARIBE

Societal	Policy and legal obstacles, co-use of wind farms not allowed (At the time of writing, SvdB)				1	including offshore energy	x										North Sea	Stuiver et al., 2016	MARIBE
Economic	Concern about financial feasibility of combining sectors				1	offshore wind and aquaculture	x	x									North Sea	Stuiver et al., 2016	MARIBE

Legal, policy and governance	No designated sites for MUPS				1										x		North Sea	Stuiver et al., 2016	MARIBE
Economic	Risks can have a negative impact on insurance premiums				1										x	risk assessment,pilots	North Sea	Stuiver et al., 2016	MARIBE
Societal	Lack of trust between actors				1										x	cooperation, "poldering", involving stakeholders, pilots	North Sea	Stuiver et al., 2016	MARIBE
Technology	reliable anchoring and sufficiently robust construction to withstand harsh conditions in the North Sea				1	involving hard structures									x		North Sea	Stuiver et al., 2016	MARIBE
Environmental	concerns about the environmental impacts				1										x	environmental impact assesssments	North Sea	Stuiver et al., 2016	MARIBE
Legal, policy and governance	spatial planning of the sea with a focus on the the interests in different stakeholders has just started				1												Baltic site	Stuiver et al., 2016	MARIBE

Legal, policy and governance	regulation for offshore wind and aquaculture do not 'match				1	offshore wind and aquaculture	x	x									Baltic site	Stuiver et al., 2016	MARIBE
Technology	potential internal risk of internal damage				1	offshore wind and aquaculture	x	x								install technical monitoring capacity and conduct risk assessment	Baltic site	Stuiver et al., 2016	MARIBE

Environmental	environmental impact of structure				1	offshore wind and aquaculture	x	x								create artificial rifs to support local nature	Baltic site	Stuiver et al., 2016	MARIBE
Societal	resistance to further expansion of the aquaculture industry, given their emissions to the environment				1	offshore wind and aquaculture	x	x									Baltic site	Stuiver et al., 2016	MARIBE

Environmental	impact on marine lanscape				1										x	involvement of stakeholders in the planning procedures	Baltic site	Stuiver et al., 2016	MARIBE
Societal	low acceptance of MUPS				1										x	participatory approach to design can benefit		van den Burg et al., 2016	MARIBE
Technology	technical barriers				1										x	identification through participatory approach	Atlantic site	van den Burg et al., 2016	MARIBE
Economic	too many uncertainties				1										x			van den Burg et al., 2016	MARIBE
Technology	risk of MUPS are higher than risks of single use				1										x			van den Burg et al., 2016	MARIBE
Economic	Integration of two sectors will undoubtedly require a return on the investment for both parties. The lifetime of the combination turns out to be a crucial factor for success in this type of business		1			oil and gas platforms + offshore wind (fl	x				x					prospects of an extended life phase, characterised by narrowing profit margins, is likely to increase interest in multi-use combinations	North Sea	Legoerburu et al 2018	MARIBE

						oating)													
Economic	costs of HVDC cable from offshore wind to shore can vary greatly		1			oil and gas platforms + offshore wind (floating)	x				x						North Sea	Legoerburu et al 2018	MARIBE

Economic	If it is to be succesful, the business model based inthe combination between offshore oil and offshore wind industries has to be competitive in the market		1			oil and gas platforms + offshore wind (floating)	x				x					the interplay between oil and electricity prices and (future) production costs is leading. The availaiblity of resources (oil and wind) may be insufficient in itself to create activity.	North Sea	Legoerburu et al 2018	MARIBE
Societal	Combining the offshore oil an offshore wind sectors requires a high degree of agreement and coordination		1			oil and gas platfor	x				x						North Sea	Legoerburu et al 2018	MARIBE

						ms + offshore wind (floating)													
Legal, policy and governance	questions arise about the ability of one activity to continue if the other enters its decommission phase (e.g legal status of the activities or the share of decommissioning costs)		1			oil and gas platforms + offshore win n	x				x						North Sea	Legoerburu et al 2018	MARIBE

						d (floating)													
Economic	As separate oil and electricity companies the problems of sharing risk, logistics, costs and revenue are greatly magnified but nonetheless quite possible to resolve given the incentive to do so		1			oil and gas platforms + offshore wind (floating)	x				x						North Sea	Legoerburu et al 2018	MARIBE

Economic	The integration between both industries will require a high degree of coordiantion, substantial investment and significant economic and technical risk-taking.		1			oil and gasplatforms + offshore wind (floating)	x				x					business models will have to be designed on a case-by-case basis	North Sea	Legoerburu et al 2018	MARIBE
Economic	The director general of the Liu-Chiu fishermen's association strongly disapproved of the construction of the platform because of the negative impact it would have on local fisheries,	1													x		Taiwan	Sie - 2018	TROPOS for Taiwan

	and declined to participate further in the study																		
Societal	Stakeholders indicated that the position of the platform would impair daily transportation between Liu-Chiu and the main island of Taiwan, as well as local fisheries	1													x	Changing location of planned platform	Taiwan	Sie - 2018	TROPOS for Taiwan
Technology	the stakeholders feared that the platformstructure might not be typhoon resistant; in the event that wreckage is carried to the coast of Liu-Chiu, the coral ecosystem there would be damaged.	1													x	no action taken	Taiwan	Sie - 2018	TROPOS for Taiwan
Environmental	indicated that discussing only the fish populations in the area oversimplified the ecological community of Liu-Chiu and that corals should be included as an ecological subsystem	1													x	corals were considered	Taiwan	Sie - 2018	TROPOS for Taiwan

Technology	ice loads introduce a significant uncertainty for structural design / other imperfect location decisions with regard to the MUP	1													x	Optimizing the finding of optimal locations with adequate tools	Gulf of Bothnia	Mikkola - 2018	
Economic	Operation and maintenance activities typically represent a big part of the total costs, which are some of the main hurdles that hinder use of offshore wind energy	1					x	x								In short: If the offshore wind and aquaculture sectors join forces, O&M activities can be coordinated and shared together and thus costs saved	Renewable energy (wind, wave) and aquaculture	Roeckmann - 2017	
Environmental	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	1					x	x								Eco-facilitation, the enhancement of biological diversity and production (e.g. by offering increased food availability and shelter, thereby attracting flora and fauna)	Renewable energy (wind, wave) and aquaculture	Roeckmann - 2017	
Technology	The possibility of larger wave heights will require new systems for safe	1					x	x								new ships with motion stabilizers are required to guaranty safe transfers of personnel and	Renewable energy (wind, wave) and aquaculture	Roeckmann - 2017	

	O&M personnel transfer															material (such as Ampelmann)			
Economic	Neither standardized practices nor procedures to procure cables or share cabling equipment, ships, and all other elements necessary for a safe and speedy repair.				1		x	x									Renewable energy (wind, wave) and aquaculture	Roeckmann - 2017	
Economic	50% of the charged maintenance labour are non-productive time because of waiting for e.g. specific certified personnel, transport opportunities, etc.				1		x	x								It is assumed that by combining wind energy and mussel production these 'lost hours' can be reduced to **at least 25% of the charged maintenance labour**	Renewable energy (wind, wave) and aquaculture	Roeckmann - 2017	
Legal, policy and governance	More participants in the O&M process will lead to a more complex organization and more uncertainty and financial risk for the asset owner.				1		x	x								Development of model	Renewable energy (wind, wave) and aquaculture	Roeckmann - 2017	

Technology	The high energy (winds and waves) of such exposed locations, however, present significant technical challenges in the design, testing and construction of aquaculture systems that are capable of surviving in these areas.				1			x								aquaculture activities should not be situated waters with current velocities above 1 m/s unless volume-reducing effects can be safely restricted by technological means.	Multi-use platform New Zealand	Goseberg - 2017	
Environmental	in combination with technical barriers can pose problems for the MUP				1			x								need to be considered and solved	Multi-use platform New Zealand	Goseberg - 2017	
Legal, policy and governance	in combination with technical barriers can pose problems for the MUP				1			x								need to be considered and solved	Multi-use platform New Zealand	Goseberg - 2017	
Societal	in combination with technical barriers can pose problems for the MUP				1			x								need to be considered and solved	Multi-use platform New Zealand	Goseberg - 2017	
Economic	in combination with technical barriers can pose problems for the MUP				1			x								need to be considered and solved	Multi-use platform New Zealand	Goseberg - 2017	
Economic	the high maintenance costs, exposed nature of the site, and slow growth of marine				1			x									Multi-use platform New Zealand	Goseberg - 2017	

	fish species (cod, haddock and halibut) created operational and economic challenges																		
Legal, policy and governance	There are some considerations regarding production and seasonality that must be taken into account.				1			x								it is important to have multiple species in production simultaneously, unless a species that can be harvested year round is utilized	Multi-use platform New Zealand	Goseberg - 2017	
Technology	the feasibility of combining the different energy converters in a multi-use platform should also be examined	1													x			Koundouri - 2017	
Technology	Technical risks could include, for example, structural failure (regarding modular or single structure, geotechnical failure and moorings), power take off and pollution	1													x			Koundouri - 2017	
Legal, policy and governance	Consideration of compatability of different legal frameworks	1													x			Koundouri - 2017	

Legal, policy and governance	Exploration of the feasibility of commercial crab and lobster exploitation in offshore wind parks					North Sea offshore wind parks, crab and lobster fishery	x						x			Pilot demonstration on feasibility commercial C&L exploitation		Tonk et al., 2019 Rozemeijer et al., 2019	WIN WIND
Environmental	Increasing aggregation of fish around devices: leads to fish concentrated around windmills				1	Offshore	x											Lacroix & Pioch, 2011	

	without adequate refuge, risk of increased fishing and over-exploitation					wind farms													
Technology	Improvements to the structure are limited to a simple addition to the structure for a single specific use				1	Offshore wind farms	x									Several aims should be targeted by an eco-design of the device, from the outset and conception of the project		Lacroix & Pioch, 2011	
Societal	Challenge is to humanize the coastal region of the sea in the same way as human societies try to do on land, slowly learning how to integrate rules of sustainability and equity for the sake of future generations				1	Offshore wind farms	x											Lacroix & Pioch, 2011	
Technology	Absence of a common eco-engineering vision and lack of experience				1	Offshor	x											Lacroix & Pioch, 2011	

	among biologists and engineers in the co-construction of projects					e wind farms													
Economic	For land-based or nearshore aquaculture, processing units are close and flow of product is continuous. For offshore farms, connection with land is neither easy nor daily	1				MUPs in general, aquaculture, floating		x								On-site processing unit is a requisite (as seen in the TROPOS MUP approach)		Papandroulakis et al., 2017	TROPOS
Technology	Fixation of aquaculture facilities difficult task because of harsh weather and	1				Aquacultu		x								Floating structure (as seen in the TROPOS MUP approach)		Papandroulakis et al., 2017	TROPOS

	wave conditions and deep waters.					re, floating													
Technology	Co-development and shared use of infrastructure	1				MUPs in general, floating									x			Papandroulakis et al., 2017	TROPOS
Technology	Selection of sites and technologies appropriate for environmental conditions	1				MUPs in general, floating									x			Papandroulakis et al., 2017	TROPOS

Technology	Synergies in operational planning	1				MUPs in general, floating									x			Papandroulakis et al., 2017	TROPOS
Technology	Suitability for oyster settlement: turbine constructions often induce edge scour along the edges;				1	Oyster bed restoration (MU), North Sea								x		Utilize protective layers over cable crossings		Kamermans et al. 2018	

Legal, policy and governance	Major discussion on the requirements to decommission any anthropogenic structures in the North Sea, which conflicts with long-term nature development strategies				1	Oyster bed restoration (MU), North Sea								x				Kamermans et al. 2018	
Technology	Structural failure, power take off and polution	1				MUPs general									x			Koundouri et al. 2017	TROPOS, MERMAID
Economic	Captial, operations and maintenance costs related to the installation depth, materials, power	1				MUPs gen									x			Koundouri et al. 2017	TROPOS, MERMAID

	extraction and storage, moorings and transportation					eral													
Environmental	Loss of area and disturbance of biota and seabeds	1				MUPs general									x	Apply appropriate mitigation strategies and monitoring		Koundouri et al. 2017	TROPOS, MERMAID
Environmental	Risk to jeopardize native habitats and species, including fish, mammals and birds	1				MUPs general									x	Apply appropriate mitigation strategies and monitoring		Koundouri et al. 2017	TROPOS, MERMAID
Environmental	Visual and noise impacts	1				MUPs general									x	Apply appropriate mitigation strategies and monitoring		Koundouri et al. 2017	TROPOS, MERMAID
Environmental	Use of marine space (other than used by marine communities)	1				MUPs gen									x	Apply appropriate mitigation strategies and monitoring		Koundouri et al. 2017	TROPOS, MERMAID

						eral													
Environmental	Water or fish pollution because of toxic materials	1				MUPs general									x	Apply appropriate mitigation strategies and monitoring		Koundouri et al. 2017	TROPOS, MERMAID
Environmental	Coast modifications	1				MUPs general									x	Apply appropriate mitigation strategies and monitoring		Koundouri et al. 2017	TROPOS, MERMAID
Legal, policy and governance	MU combinations with tourism may face concessions of permits, licence limits and complex bureaucratic processes	1				MUPs, tourism			x								Portugal, Italy	Bocci et al. 2019	MUSES
Legal, policy and governance	Lack of common regulations at national levels for aquaculture-related tourism activities	1				MUPs, tourism,		x									Portugal, Italy	Bocci et al. 2019	MUSES

						aquaculture													
Legal, policy and governance	Restrictive rules concerning the number of people hosted aboard aquaculture vessels and/or hygiene and security constraints	1				MUPs, aquaculture		x									Portugal, Italy	Bocci et al. 2019	MUSES
Societal	Limitations to cooperation and dialogue among sectors	1				MUPs with aquaculture		x										Bocci et al. 2019	MUSES
Societal	Scarce public awareness of positive implications of MU	1				MUPs with												Bocci et al. 2019	MUSES

						aquaculture													
Societal	Limited knowledge of cumulative environmental impacts of the combination	1				MUPs with aquaculture			x									Bocci et al. 2019	MUSES
Societal	Resistance from underwater cultural heritage authorities and environmental NGOs due to fear of looting/damage of artefacts and damage of natural ecosystems	1				MUPs with tourism			x									Bocci et al. 2019	MUSES
Legal, policy and governance	Complex licensing procedure (including need for holding a second license to practice MU)	1				MUPs with to			x								Portugal	Bocci et al. 2019	MUSES

						urism													
Legal, policy and governance	Lack of coordination/communication among authorities dealing with UCH and tourism	1				MUPs with tourism			x								Italy	Bocci et al. 2019	MUSES
Legal, policy and governance	Issues relating to consultation process between two sectors (timing, frequency, lack of support, governance structure, representation and power imbalances)	1				Offshore wind and fisheries	x						x				East Scotland	Bocci et al. 2019	MUSES
Legal, policy and governance	Need for consensus for multiple administrative and private interests	1				Offshore en	x			x							Greece	Bocci et al. 2019	MUSES

						ergy and desalination platforms													
Technology	Difficulties in offshore wind energy transmission and storage in ports	1				MUs, offshore wind	x										West Scotland	Bocci et al. 2019	MUSES
Technology	Lack of available infrastructure for Shore Side Electricity in ports	1				MUs, offshor	x										West Scotland	Bocci et al. 2019	MUSES

						e wind													
Technology	Impractical to convert some types of vessels like tankers and cargo to new powering systems	1				MUs, offshore wind	x										West Scotland	Bocci et al. 2019	MUSES
Technology	Incompatibility of osshore wind energy components with fishing operations and vice versa	1				MUs, offshore wind	x										East Scotland	Bocci et al. 2019	MUSES
Technology	Fishing vessels and gears not compatible with altered sea conditions dure to presence of offshore wind farms	1				MUs, offshore wi	x										East Scotland	Bocci et al. 2019	MUSES

						nd, fisheries													
Technology	Hard and soft MU uses need to combine different approaches/traditions of the use of the sea	1				MUs (hard and soft)									x			Bocci et al. 2019	MUSES
Technology	Distance from shore of renewables	1				MUs, offshore wind									x			Bocci et al. 2019	MUSES
Legal, policy and governance	Insurance companies may not favour multi-use at sea because of safety concerns	1				MUPs									x		Egmond, The Netherlands	Van Hoof et al. 2020	

Legal, policy and governance	Regulatory frameworks may prohibit multi-use	1				MUPs								x			Egmond, The Netherlands	Van Hoof et al. 2020	
Environmental	Vessel may collide with one of the wind pylons, resulting in spilling of oil in water which may contaminate seaweed	1				MUPs with seaweed, offshore wind	x	x									Egmond, The Netherlands	Van Hoof et al. 2020	
Environmental	Combination of pylons and seaweed may lead to fish aggregation, increased growth of crustacean on the pylons may attract birds, which may collide with the rotors of wind farm	1				MUPs with seaweed, offsh	x	x									Egmond, The Netherlands	Van Hoof et al. 2020	

						ore wind													
Societal	Ship-ship conflicts within area between two operators	1				MUPs with seaweed, offshore wind	x	x									Egmond, The Netherlands	Van Hoof et al. 2020	
Environmental	Fixed parts of wind turbine, moving parts of wind turbine and mooring system responsible for environmental burdens because of high amounts of material usage	1				MUPs with wind and w	x									Applied recycling ratios for used resource materials important in context of obtained total environmental impacts		Elginoz & Bas 2017	MERMAID

						ave energy													
Environmental	Environmental impacts resulting from distance from shore (sea transportation) and length of high voltage cables (copper consumption) B202	1				MUPs with wind and wave energy	x											Elginoz & Bas 2017	MERMAID
Technology	Storm conditions could induce major stress on aquaculture installations	1				MUPs with aquacul		x								Significant part of the installation should be located beneath the surface and/or in direct contact with the MUP		Buck & Langan 2017	

						ture													
Environmental	Potential risks originating from co-use concept not known, especially cumulative effects from wind energy turbines or oil rigs in combi with aquaculture	1				MUPs with aquaculture		x										Buck & Langan 2017	
Environmental	Impact on ecosystem diverse when decommissioning offshore structures after expected lifetime; restoration of habitats may lead to severe impact of organisms associated with reef structure	1				MUPs with aquaculture		x								Not onlt the impact of structures on marine habitats alone, but also in combination depending on respective use should be taken into account		Buck & Langan 2017	
Societal	Ownership issue: such a venture might take various forms of ownership and management	1				MU offshore									x	Several possibilities: (a) sole owner; (b) negotiated contract; (c) legislated contract		Buck & Langan 2017	

Legal, policy and governance	For all current offshore users, political allocation of ocean space is licensed for specific purposes only, not MU	1				MU offshore									x	New version of assignments of ocean space in the future to avoid issues of ownership and private property		Buck & Langan 2017	
Legal, policy and governance	Shared insurance or every stakeholder has its own insurance	1				MU offshore									x			Buck & Langan 2017	
Legal, policy and governance	Different environmental, safety and regulatory regimes apply to different sectors and different national jurisdictions	1				MUPs									x			Buck & Langan 2017	
Societal	Lack of common understanding of the nature of operations within different sectors and of the feasibility of combining these in a way that provides mutual benefit	1				MUPs									x			Buck & Langan 2017	
Economic	Installing a larger aquaculture MU installation is very cost-intensive, as it needs to be scaled	1				MU with a		x										Buck & Langan 2017	

	up significantly from pilot scale					quaculture													
Legal, policy and governance	Dynamic nature of ocean complicates cross-sector management (melting sea ice, sea level rise, altered ecosystems etc.)				1	Multi-sector management									x			Klinger et al. 2018	Other (GreenMAR)
Legal, policy and governance	Lack of information on how sectors interact with each other and how changes in one sector affect actions of others				1	Multi-sector management									x			Klinger et al. 2018	Other (GreenMAR)

Environmental	Offshore wind-farms and wave energy cause several environmental impacts, such as disturbance and harm to ecosystems, noise and vibrations, fish aggregation etc.				1	Offshore wind and wave energy	x											Klinger et al. 2018	Other (GreenMAR)
Environmental	Tourism can cause habitat loss, habitat damage, wildlife depletion and wildlife disturbance				1	MU with tourism			x									Klinger et al. 2018	Other (GreenMAR)
Societal	Tourism operations may see access to aesthetic resources diminished because of hydrocarbon structurs, whereas hydrocarbon operation may be unimpacted				1	MU with tourism			x									Klinger et al. 2018	Other (GreenMAR)

Societal	If seabed mining is located on prime fishing zones, fishermen may be excluded from access to the area				1	MU with seabed mining and fisheries							x	x				Klinger et al. 2018	Other (GreenMAR)
Economic	Economic sectors in shipping lanes may cause additional risk of collision and added safety costs				1	MU with transportation								x				Klinger et al. 2018	Other (GreenMAR)

Societal	Risk of oil spills negatively impacts fisheries and aquaculture products				1	Multi-sector management									x			Klinger et al. 2018	Other (GreenMAR)
Societal	Unfriendly relations between fishermen and aquaculture farms may cause vandalism or other types of interference				1	Multi-sector management									x			Klinger et al. 2018	Other (GreenMAR)
Societal	Location of platform may conflict with harbours with commercial and touristic maritime routes, fisheries or	1				MUPs, offshor	x										Venice	Koundouri et al. 2017	MERMAID

	oil and gas platforms					e wind													
Environmental	Location of platform may conflict with natural habitsts and restricted areas	1				MUPs, offshore wind	x										Venice	Koundouri et al. 2017	MERMAID
Technology	Long distance to shore of offshore wind is a challenge for connection to the grid	1				MUPs, offshore wind	x										Venice	Koundouri et al. 2017	MERMAID
Environmental	Environmental impacts of the cables on the soft bottom of sea	1				MUPs, offsh	x										Venice	Koundouri et al. 2017	MERMAID

						ore wind													
Environmental	Artificial structures favour non-indigenous species, which may lead to their abundance or increased number of for example jellyfish	1				MUPs, offshore wind	x									Settlement of non-indigenous species can be limited by using materials or coatings that prevent colonisation	Venice	Koundouri et al. 2017	MERMAID
Environmental	Harsh environmental conditions: high temperature variation, strong currents - habitable for only very limited number of species, low growth rate, higher risk of infection	1			1	MU offshore wind, aquaculture	x	x									Germany	Wever et al. 2015	Other (OOMU)

Environmental	Interactions between caged fish and wild fish				1	MU offshore wind, aquaculture	x	x									Germany	Wever et al. 2015	Other (OOMU)
Environmental	Potential impacts on marine environment (nutrient input, noise impacts)				1	MU offshore wind, aquaculture	x	x									Germany	Wever et al. 2015	Other (OOMU)

Technology	Fouling				1	MU offshore wind, aquaculture	x	x									Germany	Wever et al. 2015	Other (OOMU)
Societal	Conflicting views on favourable uses or non-uses				1	MU offshore wind, aquaculture	x	x									Germany	Wever et al. 2015	Other (OOMU)

Economic	High investment cost, therefore not attractive for individual fishermen; possibly only marginal income effects				1	MU offshore wind, aquaculture	x	x									Germany	Wever et al. 2015	Other (OOMU)
Technology	Limited knowledge of aquaculture farming (in Germany)				1	MU offshore wind, aquaculture	x	x									Germany	Wever et al. 2015	Other (OOMU)

Legal, policy and governance	Legal uncertainties, e.g. property rights, legal definitions of 'offshore' or 'harmful effects', applicability of laws and regulations				1	MU offshore wind, aquaculture	x	x									Germany	Wever et al. 2015	Other (OOMU)
Legal, policy and governance	Uncertainty with respect to liability and insurance issues, legal tenure arrangements				1	MU offshore wind, aquaculture	x	x									Germany	Wever et al. 2015	Other (OOMU)

Economic	High risk/uncertainty with respect to price developments				1	MU offshore wind, aquaculture	x	x									Germany	Wever et al. 2015	Other (OOMU)
Economic	High costs of investment				1	MU offshore wind, aquaculture	x	x									Germany	Wever et al. 2015	Other (OOMU)

Technology	Range of species very limited with respect to aquaculture due to biological requirements				1	MU offshore wind, aquaculture	x	x									Germany	Wever et al. 2015	Other (OOMU)
Economic	MU type A relies on deploying investment heavy new technology or infrastructure in new and challenging environments	1				MU type A									x			Schupp et al. 2019	MUSES
Societal	Incompatibility between competing martime uses may result in claims for exclusive access to space		1			MU co-existence/co-lo									x			Schupp et al. 2019	MUSES

						cation													
Legal, policy and governance	Responsibility and liability issues with MU repurposing scenario			1		MU repurposing									x			Schupp et al. 2019	MUSES
Legal, policy and governance	National and international legal constraints addressing the opportunities for repurposing			1		MU repurposing									x			Schupp et al. 2019	MUSES
Legal, policy and governance	Commercial large scale fisheries and recreational or artisanal fisheries have highly different impacts on surrounding uses and the environment and require different regulatory considerations with regards to the risks			1		MU repurposing							x			Make a clear distinction between commercial large scale fisheries and recreational or artisanal fisheries		Schupp et al. 2019	MUSES

	they pose for other uses and users																		
Economic	Uncertainties create a low degree of financial security for investors of repurposing			1		MU repurposing									x			Schupp et al. 2019	MUSES
Legal, policy and governance	Integration of fisheries challenging: fisheries management traditionally followed a sectoral approach, making it difficult for fishermen to enter whole system management frameworks		1			MU, co-location offshore wind and fisher	x						x					Stelzenmueller et al. 2016	Other (NOAH)

						ies													
Societal	Risk that relations to other human activities beyond sector-specific requirements are not explicitly considered, which may result in loss of space for fisheries		1			MU, co-location of offshore wind and fisheries	x						x					Stelzenmueller et al. 2016	Other (NOAH)
Societal	Fishermen might change fishing practices within wind farm boundaries because of fear of losing fishing		1			MU, co-loca	x						x				Germany	Stelzenmueller et al. 2016	Other (NOAH)

	gear and wariness of vessel break-down with risk of turbine collision					tion offshore wind and fisheries													
Societal	Wind farm maintenance may cause disruption by closing areas to fishing and increasing steaming distances to fishing grounds		1			MU, co-location offshore wind	x						x				Germany	Stelzenmueller et al. 2016	Other (NOAH)

						and fisheries													
Technology	For fisheries in offshore wind farms: risk of setting up business with vessels fulfilling all requirements		1			MU, co-location of offshore wind and fisheries	x						x				Germany	Stelzenmueller et al. 2016	Other (NOAH)

Technology	Technology and fishing practices are already established elsewhere		1			MU, co-location offshore wind and fisheries	x						x				Germany	Stelzenmueller et al. 2016	Other (NOAH)
Environmental	Increased risk of bycatch of harbor porpoises		1			MU, co-location offs	x						x			Equipping the fleet with pingers may significantly reduce bycatch of porpoises	Germany	Stelzenmueller et al. 2016	Other (NOAH)

						hore wind and fisheries													
Legal, policy and governance	Definition of a legal base		1			MU, co-location offshore wind and fish	x						x				Germany	Stelzenmueller et al. 2016	Other (NOAH)

						eries													
Legal, policy and governance	Implementation of safety regulations		1			MU, co-location of offshore wind and fisheries	x						x				Germany	Stelzenmueller et al. 2016	Other (NOAH)
Legal, policy and governance	Delineation of minimum requirements for fishing vessels to conduct a gillnet or pot fishery in offshore		1			MU, co-loca	x						x				Germany	Stelzenmueller et al. 2016	Other (NOAH)

	wind farm areas (capacities, quotas, technical equipment)					tion offshore wind and fisheries													
Legal, policy and governance	Implementation of a licensing process		1			MU, co-location offshore wind	x						x				Germany	Stelzenmueller et al. 2016	Other (NOAH)

						and fisheries													
Economic	Scoping for financial subsidies to set up business to fulfill requirements to fish inside OWF areas		1			MU, co-location offshore wind and fisheries	x						x				Germany	Stelzenmueller et al. 2016	Other (NOAH)

Technology	Distance constraints: transmission of power produced by wind, tidal or wave energy, both in terms of cost and energy losses through transportation				1	MU offshore wind, wave and tidal energy	x											Van den Burg et al. 2019	MARIBE
Legal, policy and governance	Institutional arrangements for cross-sectoral activities are missing and need to be developed				1	MU in general									x			Van den Burg et al. 2019	MARIBE
Legal, policy and governance	Stuiver et al. 2016: a clear policy framework to guide multi-use, inclu-				1	MU in ge									x			Van den Burg et al. 2019	MARIBE

	ding a clear licensing procedure, is currently lacking					neral													
Legal, policy and governance	Lack of trust between sectors				1	MU in general									x			Van den Burg et al. 2019	MARIBE
Legal, policy and governance	Risks and uncertainties limit the full development of aquaculture and offshore wind combinations		1			MU offshore wind and aquaculture	x	x								Formalization of public policies and sustainable, balanced solutions for these activities	Canary Islands	Weiss et al. 2016	Other (TEN-SHORES)
Economic	Lack of attractiveness for private investments due to economic factors,		1			MU win	x										Canary Islands	Weiss et al. 2016	Other (TEN-SHORES)

	hinder development					d and wave farms													
Technology	Waves impose environmental stress on fish in aquaculture cages		1			MU wave energy and aquaculture	x	x									Canary Islands	Weiss et al. 2016	Other (TEN-SHORES)
Technology	Availability of resources in areas without an electrical grid		1			MU winde	x	x								Installation of electrical substations	Canary Islands	Weiss et al. 2016	Other (TEN-SHORES)

						nergy wave energy													
Societal	Near-shore presence of MUP could cause serious conflicts with other sea activities (marinas, leisure, fishing, etc.)				1	MUP water and electricity production	x			x						Moor MUP futher offshore to avoid conflict		Stefanakou et al. 2016	
Societal	Wind turbines could be perceived				1	MUP with	x									Positioning of MUP will have to take into account optimal distance		Stefanakou et al. 2016	

	negatively and often referred to as visual pollution					wind energy										from shore as well as alignment			
Technology	Lack of adequate energy resources for the aquaculture (as wind turbines produce MW, but aquacultures require only kW)	1						x								Provide an extra power source (a small barge with a small 2-bladed wind turbine) for the aquaculture		Abhinav, 2018	
Environmental	opposed to aquaculture because of the emission	1				Baltic sea, Wind farm and aquacul	x	x									Multi-use Offshore Site in the Baltic Sea (Kriegers Flak)	Bas et al., 2017	

						ture													
Environmental	It is impossible for farms to increase the production without an increase of nitrogen load.	1				Baltic sea, Wind farm and aquaculture	x	x								On the longer term farms could possibly compensate for such increase	Multi-use Offshore Site in the Baltic Sea (Kriegers Flak)	Bas et al., 2017	
Environmental	the size of the facility, waste production, the vulnerability of the surrounding environment	1				Baltic sea, Wind far	x	x								Needs to be considered in Environmental Impact analysis	Multi-use Offshore Site in the Baltic Sea (Kriegers Flak)	Bas et al., 2017	

					m and aquaculture														
Societal	most vulnerable groups to MUPs are: energy suppliers, fishermen, energy consumers, persons involved in tourism activities; persons involved in transport and storage activities	1			Baltic sea, Windfarm and aquaculture	x	x								need to be considered when planning MUP	Multi-use Offshore Site in the Baltic Sea (Kriegers Flak)	Bas et al., 2017		

Economic	lack of access to capital				1	Multi-use in general									x	With further proof of concept this issue will be addressed.		Holm et al., 2017	
Legal, policy and governance	unclear identification of ownership				1	Multi-use in general									x	Needs to be addressed by legislators		Holm et al., 2017	
Technology	unresolved technological issues				1	Multi-use in general									x	Future development of technology will address this issue (partly because more MUP use will address these issues)		Holm et al., 2017	

Legal, policy and governance	lack of a regulatory structure				1	Multi-use in general									x	Needs to be addressed by legislators		Holm et al., 2017	
Legal, policy and governance	lack of information on how sectors interact with each other	1				TROPOS multi-use									x	Needs to be considered and eventually addressed through aprtnership or change of MUP approach	TROPOS examples	Lu, 2014	TROPOS
Environmental	Effect on environment through physical effects of the moorings	1				TROPOS multi-use									x	Needs to be considered and eventually addressed through aprtnership or change of MUP approach	TROPOS examples	Lu, 2014	TROPOS

Environmental	Effect on environment through emissions during construction	1				TROPOS multi-use									x	Needs to be considered and eventually addressed through aprtnership or change of MUP approach	TROPOS examples	Lu, 2014	TROPOS
Environmental	Effect on environment through servicing logistics	1				TROPOS multi-use									x	Needs to be considered and eventually addressed through aprtnership or change of MUP approach	TROPOS examples	Lu, 2014	TROPOS
Environmental	Effect on environment through operations or repair and maintenance	1				TROPOS multi-use									x	Needs to be considered and eventually addressed through aprtnership or change of MUP approach	TROPOS examples	Lu, 2014	TROPOS

Technology	possible damage from operating machinery during construction	1				TROPOS multi-use									x	Needs to be considered and eventually addressed through aprtnership or change of MUP approach	TROPOS examples	Lu, 2014	TROPOS
Societal	Ignoring environmental impact when developing renewable energy usually causes local resident conflict	1				TROPOS multi-use									x	Needs to be considered and eventually addressed through aprtnership or change of MUP approach	TROPOS examples	Lu, 2014	TROPOS
Economic	market monopolizing by corporation				1	TROPOS multi-use									x	Needs to be considered and eventually addressed through aprtnership or change of MUP approach	TROPOS examples	Lu, 2014	TROPOS

Economic	increase traffic complexity				1	TROPOS multi-use									x	Needs to be considered and eventually addressed through aprtnership or change of MUP approach	TROPOS examples	Lu, 2014	TROPOS
Societal	the culture and industrial changes in coastal communities				1	TROPOS multi-use									x	Needs to be considered and eventually addressed through aprtnership or change of MUP approach	TROPOS examples	Lu, 2014	TROPOS
Economic	increase transportation cost				1	TROPOS multi-use									x	Needs to be considered and eventually addressed through aprtnership or change of MUP approach	TROPOS examples	Lu, 2014	TROPOS

Societal	affect natural landscape and people's rejection of these changes				1	TROPOS multi-use									x	Needs to be considered and eventually addressed through aprtnership or change of MUP approach	TROPOS examples	Lu, 2014	TROPOS
Environmental	pollution/emissions affect public health				1	TROPOS multi-use									x	Needs to be considered and eventually addressed through aprtnership or change of MUP approach	TROPOS examples	Lu, 2014	TROPOS
Environmental	changes of coastal topographic				1	TROPOS multi-use									x	Needs to be considered and eventually addressed through aprtnership or change of MUP approach	TROPOS examples	Lu, 2014	TROPOS

Societal	over-exploitation				1	TROPOS multi-use									x	Needs to be considered and eventually addressed through aprtnership or change of MUP approach	TROPOS examples	Lu, 2014	TROPOS
Legal, policy and governance	Lack of an adequate regulatory framework				1	OWF with aquaculture	x	x									North Sea	Onyango et al. 2020	
Legal, policy and governance	Unclear insurance policy framework				1	OWF with aquaculture	x	x									North Sea	Onyango et al. 2020	

Legal, policy and governance	Policy makers and regulators' limited experience with MU				1	OWF with aquaculture	x	x									North Sea	Onyango et al. 2020	
Legal, policy and governance	Health and safety concerns				1	OWF with aquaculture	x	x									North Sea	Onyango et al. 2020	
Legal, policy and governance	Lack of tradition of cooperation between sectors				1	OWF with aquacul	x	x									North Sea	Onyango et al. 2020	

						ture													
Legal, policy and governance	Inconsistent policy-making within countries				1	OWF with aquaculture	x	x									North Sea	Onyango et al. 2020	
Societal	Low interest from industry, benefits unclear				1	OWF with aquaculture	x	x									North Sea	Onyango et al. 2020	
Societal	No incentives				1	OWF with aquac	x	x									North Sea	Onyango et al. 2020	

						ulture													
Legal, policy and governance	Bans, e.g. breeding mussels on commercial scale not allowed (BE); presumption against finfish aquaculture in east coast of Scotland				1	OWF with aquaculture	x	x									North Sea	Onyango et al. 2020	
Legal, policy and governance	Lack of political encouragement, legal and planning incentives				1	OWF with aquaculture	x	x									North Sea	Onyango et al. 2020	
Economic	Lack of larger pilots, funding for scaling up				1	OWF with aqu	x	x									North Sea	Onyango et al. 2020	

						aculture													
Economic	High labour costs for open sea aqua-culture				1	OWF with aquaculture	x	x									North Sea	Onyango et al. 2020	
Economic	MU finance risks				1	OWF with aquaculture	x	x									North Sea	Onyango et al. 2020	
Societal	Opposition to aquaculture (DE)				1	OWF with aq	x	x									North Sea	Onyango et al. 2020	

						uaculture													
Technology	Design and technological risks				1	OWF with aquaculture	x	x									North Sea	Onyango et al. 2020	
Economic	Moving aquaculture offshore has added costs				1	OWF with aquaculture	x	x									North Sea	Onyango et al. 2020	
Economic	Difficult to make sufficient economies of scale (BE)				1	OWF with a	x	x									North Sea	Onyango et al. 2020	

						quaculture													
Technology	Risks and difficulties in combining MU combinations (NL)				1	OWF with aquaculture	x	x									North Sea	Onyango et al. 2020	
Technology	Suitable sites for MU				1	OWF with aquaculture	x	x									North Sea	Onyango et al. 2020	
Societal	Tensions and conflicts between users				1	OWF with	x	x									North Sea	Onyango et al. 2020	

						aquaculture													
Technology	Increased traffic and navigation risks				1	OWF with aquaculture	x	x									North Sea	Onyango et al. 2020	
Economic	Livelihood diversification of certain users (fishers) requires considerable investment				1	OWF with aquaculture	x	x									North Sea	Onyango et al. 2020	
Environmental	Risk of eutrophication, disease, escapees into the wild (aquaculture)				1	OWF wi	x	x									North Sea	Onyango et al. 2020	

						th aquaculture													
Environmental	Fishing inside OWFs reduces de-facto protected areas around installations (increasing pressure on benthic ecosystem				1	OWF with aquaculture	x	x									North Sea	Onyango et al. 2020	
Environmental	Birds attracted by fish waste (bird collisions)				1	OWF with aquaculture	x	x									North Sea	Onyango et al. 2020	
Legal, policy and governance	No permitting system, EIA for MU				1	OWF	x		x								North Sea	Onyango et al. 2020	

						with tourism													
Societal	Local communities, eg. fishers might object to OWFs				1	OWF with tourism	x		x								North Sea	Onyango et al. 2020	
Technology	Harsh physical conditions in exposed OWFs				1	OWF with tourism	x		x								North Sea	Onyango et al. 2020	
Legal, policy and governance	Integrating health and safety concepts is complex				1	OWF with fisheries	x						x				North Sea	Onyango et al. 2020	

Legal, policy and governance	Permit issues: eg. only maintenance vessels for OWF allowed within 500m (BE) and fishery/sailing not permitted within OWFs (BE,NL)				1	OWF with fisheries	x						x				North Sea	Onyango et al. 2020	
Technology	Combining OWF and fisheries structures and operations				1	OWF with fisheries	x						x				North Sea	Onyango et al. 2020	
Economic	Inadequate data on costs and performance				1	OWF with fisheries	x						x				North Sea	Onyango et al. 2020	
Legal, policy and governance	Risk of damages to infrastructure and insurance cover				1	OWF with	x						x				North Sea	Onyango et al. 2020	

						fisheries													
Environmental	Increased shipping noise, fishing pressure, on benthic ecosystem (DE)				1	OWF with fisheries	x						x				North Sea	Onyango et al. 2020	
Environmental	Fishing vessels dump fish waste, attract birds, expose birds to risks				1	OWF with fisheries	x						x				North Sea	Onyango et al. 2020	
						x	181	127	21	6	14	8	25	6	88				

ANNEX 3 - QUESTIONNAIRE

Introduction

Dear Sir or Madam, dear UNITED participant,

Welcome to this internal questionnaire for the European Union Horizon 2020 - UNITED project.

The here generated insights will directly benefit you in the further planning of your pilot as well as allow you to generalize potential insights that you have in the current setting you operate into slightly different scenarios.

The use of this information will be going towards publications and other deliveries that in one way or the other will be publicly disseminated. However, we will keep your identity confidential and we will treat all information anonymously when communicated to people outside of the Horizon 2020 - UNITED project.

The questionnaire will require some of your time. In an effort to take up as little of your time as possible, the answers you provide here will inform 4 different work packages - WP 1, WP 2, WP 3, and WP 5.

In case, you have any questions or something remains unclear, you can send an email to:
Marvin Kunz at marvin.kunz@wur.nl

Preliminary identifiable information

The following questions are necessary to help us understand your other answers better.

In which pilot (country) are you participating in?

- ○ Belgium
- ○ Denmark
- ○ Germany
- ○ Netherlands
- ○ Greece

What is your position within the pilot?
(If you do not have a position, shortly describe your main responsibilities)

How many partners do you currently work with in realizing the MUP?

	0	2	4	6	8	10	12	14	16	18	20
Number of partners	0	2	4	6	8	10	12	14	16	18	20

Technology

The set of questions on this page addresses possible barriers that you might encounter and is used to inform the work of WP 1.1.

Technological barriers

Please rate whether you agree or disagree with the following statements.

The following technical elements of operating a multi-use platform (MUP) pose a considerable barrier to realize the project:

	Completely disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Completely agree	Not applicable
Lack of general technological knowledge available from the industry involved in MUPs in general (outside of the scope of UNITED).	○	○	○	○	○	○
Lack of general technological readiness level of all the parties involved with the MUP.	○	○	○	○	○	○
Lack of technological knowledge to allow MUP structure to withstand adverse weather conditions	○	○	○	○	○	○
Damage due to extreme adverse environmental catastrophic events (storms or underwater earthquakes)	○	○	○	○	○	○
Structural risk for MUP from accidental collision with (aquaculture) equipment	○	○	○	○	○	○
Vibration from wind turbines (when working with wind turbines)	○	○	○	○	○	○
Lack of infrastructure for energy provision for MUP	○	○	○	○	○	○
Risk of power failure	○	○	○	○	○	○
Risk of anchoring vessels damaging power supply cables	○	○	○	○	○	○
Lack of knowledge about specific anchoring techniques required	○	○	○	○	○	○
Risk of damage in case of mooring failure	○	○	○	○	○	○

Which technical barrier do you consider as most problematic for the realization of your pilot?

Which important technical barriers that hinder you from realizing your pilot have we missed?

WP 2

While the previous section asked questions about broader technical barriers, now, we want to know from you more details about the technological situation of your pilot.

This part of the questionnaire will include 2 pages with open questions and they are used to inform the work of WP 2.

Which technological issues did/do you encounter in the design/implementation/operation of the multi-use experiments in your pilot?

How did you overcome these issues?
(Or in case they still pose a problem, how do you plan on overcoming them?)

Which type of information/tool/equipment could have helped to avoid or reduce the impact of this issue on the experiment?

Which processes/parameters have you been monitoring since the start of your pilot?

Which technological issues/challenges do you see for the future upscaling of your experiment?

Which type of information/tool/equipment would help you to make upscaling of your multi-use activities possible?

Would operational and/or forecasted data be helpful, such as certain physical or biological sea conditions? If yes, which parameters?

○ No

○ Yes, ☐

What type of research would you need to make upscaling of your multi-use activities possible?

☐

Which processes/parameters are you going to monitor, in addition to or instead what you have been monitoring so far?

☐

Which (technological) KPI's are you using to measure the success of your multi-use experiment?

☐

Economic barriers

The set of questions on this page addresses possible barriers that you might encounter and is used to inform the work of WP 1.1.

Economic barriers

Please rate whether you agree or disagree with the following statements.

The following economic elements of operating a Multi-use platform (MUP) pose a considerable barrier to realize the project:

	Completely disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Completely agree	Not applicable
Lack of economic assessment tools to examining the economic viability of MUP.	○	○	○	○	○	○
Lack of certainty of effects of far offshore MUP on fish or oysters in aquacultures (with regard to economic effects).	○	○	○	○	○	○
Lack of attractiveness for private investors.	○	○	○	○	○	○
Lack of standardized procedures to co-use aspects related to the MUP (i.e. sharing cable equipment or ships)	○	○	○	○	○	○
High maintenance cost of aquaculture sites.	○	○	○	○	○	○
High cost of decommissioning of the MUP (potential costs after the end of the multi-use).	○	○	○	○	○	○
High insurance cost due to lack of of experience in co-location/MUP projects.	○	○	○	○	○	○

	Completely disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Completely agree	Not applicable
High insurance cost due to inherent risk associated with multiple use of the same platform.	○	○	○	○	○	○
High costs for grid connection.	○	○	○	○	○	○
Lack of expertise with business models and best practices.	○	○	○	○	○	○
Insufficient subsidies from the government.	○	○	○	○	○	○
High cost of maintenance.	○	○	○	○	○	○
High cost of operating staff.	○	○	○	○	○	○

Which economic barrier do you consider as most problematic for the realization of your pilot?

Which important economic barriers that hinder you from realizing your pilot have we missed?

WP 3

On the following 4 pages you will answer questions for WP 3.1.
These questions look in detail at the economic situation of your pilot and will be used to give as a better understanding of the economic pillar for MUPs.

The following questions are looking at the economic factors concering your pilot in more detail.

Please note, that when a word is written in this *way* (i.e. underlined and cursive) that it has additional information when you hover over it.

What is the current status of economic activity in the pilot? What is planned and what is the current stage of implementation?

What are the plans regarding the economic exploitation (products, target markets and demand) of the pilots?

Please indicate which economic / financial information is currently available for your pilot.

Financial feasibility study/information

☐ Information openly available (please attach document or share web link)

☐ Information available, but confidential

☐ Information not now, but later available

☐ Information not available

☐ Comments

If the information about the financial feasibility study is openly available, please upload the document here.

Socio-economic impact analysis

☐ Information openly available (please attach document or share web link)

☐ Information available, but confidential

☐ Information not now, but later available

☐ Information not available

☐ Comments

If the information about the socio-economic impact analysis is openly available, please upload the document here.

Business model/plan/strategy

☐ Information openly available (please attach document or share web link)

☐ Information available, but confidential

☐ Information not now, but later available

☐ Information not available

☐ Comments

If the information about the business model/plan/strategy is openly available, please upload the document here.

Pilot budget/cash balances

☐ Information openly available (please attach document or share web link)

☐ Information available, but confidential

☐ Information not now, but later available

☐ Information not available

☐ Comments

If the information about the pilot budget/cash balances is openly available, please upload the document here.

Please specify any other economic / financial information currently available for your pilot.

Parties that collaborate through a partnership in the pilot project probably possess part of the information requested under question 3. It is important to take stock of all available financial and economic information to develop optimized business cases in the course of the UNITED project. If necessary, we would like to contact these parties to collect information in the next phase of the project.

Examples of roles and services

	Is it a project partner or external stakeholder?	What is the role of the partner in the pilot project/which service do they provide?	What is the main interest of the partner to participate in the pilot project?	Who is the main contact person (first name, last name, email address)?
Partner 1				
Partner 2				
Partner 3				
Partner 4				
Partner 5				
Partner 6				
Partner 7				
Partner 8				
Partner 9				
Partner 10				

What are expected *synergies* of combined use of the offshore platform? Please name some specific examples.

What is the potential to scale up the existing solution?

Has any environmental impact assessment considering ecological impacts during the construction and operation phase been undertaken at the pilot or at the specific activity levels?

○ No, namely:

○ Yes (please attach document or share web link)

If you have chosen yes in the above question and have a document to upload, please do so here.

If you answered yes to the above question, have ecological/environmental impacts of multi-use been measured with indicators?

○ No

○ Yes, please specify

What would you like to obtain from business and economic analyses in UNITED in relation to your pilot: Which key socio-economic questions/challenges/aspects should be addressed for your pilot? Please ask your pilot partners also.

Bearing in mind the project's objectives and activities as described in the project proposal, how do you see the role of economic/financial tasks within the UNITED project with respect to your pilot?

Do you have economic / financial expertise within the pilot partners?

- ○ No
- ○ Yes, namely:

Environment

The set of questions on this page addresses possible barriers that you might encounter and is used to inform the work of WP 1.1.

Environmental barriers

Please rate whether you agree or disagree with the following statements.

The following environmental elements of operating a Multi-use platform (MUP) pose a considerable barrier to realize the project:

	Completely disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Completely agree	Not applicable
Increased traffic of MUP support vessels resulting in damage to the ecosystem.	○	○	○	○	○	○
Increasing risk of pollution events (mainly excessive nutrient load and other substances) due to the installation of aquaculture cages.	○	○	○	○	○	○
Potential, real and perceived, conflicts among marine ecosystem flora and fauna due to artificial introduction of invasive species.	○	○	○	○	○	○
Risk of the cumulative effect of several aquaculture locations and the disturbance they can cause for the local ecosystem.	○	○	○	○	○	○
Underwater-noise disturbance of marine mammals such as wales.	○	○	○	○	○	○
Disturbance of the seabed sediments and seabed communities.	○	○	○	○	○	○
Collision risks to birds and bats above water	○	○	○	○	○	○
Attraction of unwanted invasive species at the location of the MUP.	○	○	○	○	○	○

Which environmental barrier do you consider as most problematic for the realization of your pilot?

Which important environmental barriers that hinder you from realizing your pilot have we missed?

Governance / Legal

The set of questions on this page addresses possible barriers that you might encounter and is used to inform the work of WP 1.1.

Governance and legal barriers

Please rate whether you agree or disagree with the following statements.

The following governance or legal elements of operating a Multi-use platform (MUP) pose a considerable barrier to realize the project:

	Completely disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Completely agree	Not applicable
Unclear and fragmented regulation for MUPs on national level.	○	○	○	○	○	○
Unclear and fragmented regulation for MUPs on European level.	○	○	○	○	○	○
Strict security regulation that discourage setting up a MUP	○	○	○	○	○	○
The set of constrains related to safety distance to other users or distance form shore.	○	○	○	○	○	○
Separate environmental impact assessment processes (permitting) for each of the (hybrid) technologies and lack of guidance on cumulative impact assessment.	○	○	○	○	○	○
Lack of established licensing procedures for multi-use projects.	○	○	○	○	○	○
Lack of dialogue between public institutions and difficulties in identifying the administrative offices responsible for issuing permits.	○	○	○	○	○	○
Lack of cross-border cooperation in MUP projects.	○	○	○	○	○	○
Lack of established procedures for spatial planning of the sea with a focus on the the interests of different stakeholders.	○	○	○	○	○	○
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)	○	○	○	○	○	○
Lack of established safety assessment methods for MUPs.	○	○	○	○	○	○

Which governance related or legal barrier do you consider as most problematic for the realization of your pilot?

Which important governance or legal barriers that hinder you from realizing your pilot have we missed?

☐

Social

The set of questions on this page addresses possible barriers that you might encounter and is used to inform the work of WP 1.1.

This is the last set of questions you will be asked with regard to barriers.

Social barriers

Please rate whether you agree or disagree with the following statements.

The following social elements of operating a Multi-use platform (MUP) pose a considerable barrier to realize the project:

	Completely disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Completely agree	Not applicable
Lack of social acceptance of the MUP by society in general.	○	○	○	○	○	○
Lack of acceptance of the MUP by the local affected community.	○	○	○	○	○	○
Lack of consensus about the MUP from multiple stakeholders in private and public sector.	○	○	○	○	○	○
Lack of trust between industry sectors directly involved in the MUP.	○	○	○	○	○	○
Lack of public awareness about implications of multi-use.	○	○	○	○	○	○
Low individual financial power and overall capacity to join MUP from local collaborators.	○	○	○	○	○	○
Conflicts of interest between different users of the sea (i.e. external tourist agencies, other energy producers, etc.).	○	○	○	○	○	○

Which social barrier do you consider as most problematic for the realization of your pilot?

☐

Which important social barriers that hinder you from realizing your pilot have we missed?

☐

WP 5

On the following pages you answer questions for WP 5, specifically about the social pillar of the MUP project.

When we talk about stakeholders, we imply the following definition:

“We define stakeholders as individuals or institutions that may – directly or indirectly, positively or negatively – affect or be affected by a project or programme, in this case, the change from single use of a maritime space to the reality of having more uses in the same space”

Who do YOU consider to be your stakeholders?

Can you imagine people you may overlook but that will consider THEMSELVES to be a stakeholder in your activities?

How would you qualify your **identification** of local stakeholders in your pilot at the current point in time? (i.e. March 2020)

○ Key stakeholders are yet to be identified

○ Some stakeholders identified

○ Most or all stakeholder identified

How would you qualify your **knowledge** of local stakeholders in your pilot at the current point in time? (i.e. March 2020)

○ Knowledge is incomplete or poor

○ Average knowledge

○ Good knowledge

○ Excellent knowledge

Have reflections already taken place regarding the stakeholder involvement process of the pilot?

○ No

○ Yes, namely

Which activities involving stakeholders have already taken place in the pilot’s site?

○ Written communication toward local stakeholders

○ One-to-one meetings with targeted stakeholders

○ Collective meetings (workshops…)

○ Written consultation (questionnaire)

○ Other, namely:

○ No activities have taken place, yet.

Please indicate which stakeholder information is currently available for your pilot.

○ A list of contacts, or stakeholder database

○ Reports or minutes of meeting with stakeholders

○ Results from a stakeholder consultation

○ Others, namely:

○ None

What do you expect from stakeholder involvement in your pilot?

What do you expect from the guidelines provided in WP5 for stakeholder involvement in the pilots? (please express your needs)

Do you have stakeholder involvement or facilitation expertise within the pilot partners?

○ No

○ Yes, namely:

End of survey

Thank you for filling out this survey.

You will be informed about the results of this survey in the form of the deliverables of the different work packages.

If you have any questions or feedback contact Marvin Kunz at marvin.kunz@wur.nl

ANNEX 4 – RESPONSE FINO 3

Q1.

Dear Sir or Madam, dear UNITED participant,

Welcome to this internal questionnaire for the European Union Horizon 2020 - UNITED project.

The here generated insights will directly benefit you in the further planning of your pilot as well as allow you to generalize potential insights that you have in the current setting you operate into slightly different scenarios.

The use of this information will be going towards publications and other deliveries that in one way or the other will be publicly disseminated. However, we will keep your identity confidential and we will treat all information anonymously when communicated to people outside of the Horizon 2020 - UNITED project.

The questionnaire will require some of your time. In an effort to take up as little of your time as possible, the answers you provide here will inform 4 different work packages - WP 1, WP 2, WP 3, and WP 5.

In case, you have any questions or something remains unclear, you can send an email to:
Marvin Kunz at marvin.kunz@wur.nl

Description. The following questions are necessary to help us understand your other answers better.

Pilot. In which pilot (country) are you participating in?

- ○ Belgium
- ○ Denmark
- ● Germany
- ○ Netherlands
- ○ Greece

Position. What is your position within the pilot?
(If you do not have a position, shortly describe your main responsibilities)

Pilot Lead: responsible for pre-operational phase, operational-phase and post-operational phase

Q77. How many partners do you currently work with in realizing the MUP?

0 2 4 6 8 10 12 14 16 18 20

Number of partners 1

Description. The set of questions on this page addresses possible barriers that you might encounter and is used to inform the work of WP 1.1.

WP1 Q1. **Technological barriers**

Please rate whether you agree or disagree with the following statements.

The following technical elements of operating a multi-use platform (MUP) pose a considerable barrier to realize the project:

	Completely disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Completely agree	Not applicable
Lack of general technological knowledge available from the industry involved in MUPs in general (outside of the scope of UNITED).	○	○	○	●	○	○
Lack of general technological readiness level of all the parties involved with the MUP.	○	●	○	○	○	○
Lack of technological knowledge to allow MUP structure to withstand adverse weather conditions	○	○	●	○	○	○
Damage due to extreme adverse environmental catastrophic events (storms or underwater earthquakes)	○	○	○	●	○	○
Structural risk for MUP from accidental collision with (aquaculture) equipment	○	●	○	○	○	○
Vibration from wind turbines (when working with wind turbines)	●	○	○	○	○	○
Lack of infrastructure for energy provision for MUP	●	○	○	○	○	○
Risk of power failure	○	●	○	○	○	○
Risk of anchoring vessels damaging power supply cables	●	○	○	○	○	○
Lack of knowledge about specific anchoring techniques required	○	●	○	○	○	○
Risk of damage in case of mooring failure	○	○	○	●	○	○

WP1 Q1.2. Which technical barrier do you consider as most problematic for the realization of your pilot?

• High energetic environment, the Pilot1 location is not accessible at severe weather conditions Vessels depend even more on fairly low winds and waves Divers (for installation) can work only with wave heights below 1m • Automatization of remote data recording via sensors and biofouling • Anchoring/mooring • due to off shore site: time to reach the site is to long for high frequency of visits, hence maintenance of algae and Mussel culture lines has to be minimal, or automated

WP1 Q1.3. Which important technical barriers that hinder you from realizing your pilot have we missed?

• None, however harvest, treatment and transport of products might be a technical problem- special harvesting and processing ships might be necessary in the future

Q20. While the previous section asked questions about broader technical barriers, now, we want to know from you more details about the technological situation of your pilot.

This part of the questionnaire will include 2 pages with open questions and they are used to inform the work of WP 2.

WP2 Q1. Which technological issues did/do you encounter in the design/implementation/operation of the multi-use experiments in your pilot?

Those have been identified risks for the already existing single-use at the pilot location: • Possibility of failure when ramming the monopile into the ground due to stones and scour • Acoustic emission during installation that negatively affects marine mammals • Risk of loading the components for monopile onto floating transportation vessels • Risk of production, transport and assembly of material on land and at sea • Bad weather conditions during installation of platform • Obstacles regarding the construction site and ramming • Obtaining special spare parts • Plant is not accessible for a longer period of time Identified risks for the multi-use project: • Availability and limited access to technological know-how and solutions • Availability of skilled labour (offshore experience) • Need of great flexibility for the implementation planning (schedule) due to risk of severe weather conditions • Insufficient existence of biological data for that location, e.g. time and scale of spat fall, growth rates of mussels and seaweed • Limited knowledge about mooring prerequisites for mussel and algae longlines at site

WP2 Q1a. How did you overcome these issues?
(Or in case they still pose a problem, how do you plan on overcoming them?)

• Reducing risk by mitigation: The monopile was rammed into an area of the ground where due to (seismic) measurements sea bottom horizons were solid and possibly more homogeneous. Further measures include: core drilling and pressure sounding/penetration testing, the following soil properties and bearing densities were estimated. • Risk mitigation measures: In the construction and first phase of operation, noise emissions to nearby harbour porpoise habitats and bird migration are of particular interest and will be monitored and prevented by an oscillating veil of soundproofing air bubbles • Reducing risk by transferring it: Risk of production, transport and assembly on land and at sea shall be covered by the Contractor's insurance (personal injury, damage to property, etc.); proof of this shall be submitted before the start of the work. This includes assembly and construction insurance. • Reducing risk by transferring it: Days lost due to bad weather are not considered as force majeure. Downtimes, including those due to bad weather, are therefore to be determined by the Contractor itself and included in its quotation prices for transport and sea assembly. If necessary, the Contractor shall take out appropriate insurance policies for downtimes at its expense. • Warranty period for spare parts of plant: The Contractor shall provide a written spare parts guarantee for all plant components. • Long-term monitoring of climate/weather data to derive conclusions about when the plant won't be accessible coordinating logistics based on these results • Pre-tests for time periods and concentration of spat fall, material for collectors • Flexible schedule • Knowledge of other mooring systems from existing offshore locations will be gathered and implemented to ensure safe conditions

WP2 Q1b.
Which type of information/tool/equipment could have helped to avoid or reduce the impact of this issue on the experiment?

• Test materials, technical equipment such as sensors, software, maintenance intervals, handling of measuring devices,… as much as possible at the nearshore site to minimize problems at the offshore site • Have sufficient insurance for all steps along the implementation and operating phase • Have experienced and well-trained contractors in the field of offshore engineering that own/have access to all necessary equipment/measurement devices/ tools • Long-time data (hydrographic) series of the location • Better access to technological know-how (offshore aquaculture) • Contact to and communication with off-shore experts of the other pilots

WP2 Q1c.
Which processes/parameters have you been monitoring since the start of your pilot?

• Several parameters measured during the last years until today: e.g. • Meteorological data (windspeed 40 m a.s.l, 106 m a.s.l.; temperature, direction of wind, rel. humidity, air pressure, global radiation, precipitation) • Hydrological data: direction of swell, significant wave height, max. swell/wave, water level, water surface temperature, water temperature 6/12/18 m at LAT)

WP2 Q2. Which technological issues/challenges do you see for the future upscaling of your experiment?

• In General: Offshore marine equipment can be physically complex, expensive, safety 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. Thus, every planning process is based on the fundamental understanding of diverse design parameters and how they interact. Design standards and guidelines exist for conventional equipment and structures, however a misunderstanding of these parameters or even a change in the operating environment can result in failure. • Damage risks of mechanical loads, collisions with vessels/ships/fishing boats • Drifting aquaculture construction strikes the turbine foundation; damage to the foundation? Extra drag force; drifting aquaculture construction gets stuck around the turbine foundation, increasing its surface area • Equipment/material that is resistant to: antifouling, high forces acting on installation (waves, tides, current, storms, mooring), high salinity leading to corrosion • Remote control/operation of plant (monitoring devices have to be automated) with high durability: autonomous up to one year (maintenance is expensive); deployment, service/maintenance and recovery of different materials/ measuring devices should be possible within one work stage • Sufficient database of biotic/abiotic factors (fields of: meteorology, physical oceanography, marine chemistry, biology, geology, geography) is needed to run realistic models during the planning/conception phase (simulation and calculation are based on long-term data recordings) • Material/equipment and installation processes do not negatively affect the environment (negative environmental impact is reduced !!) • Well-functioning of Data Acquisition and Control System (DACS) as well as a communication system needs Interactive real-time Internet connection to the DACS for data retrieval and/or reconfiguration of mission control is possible. • Access to all available data for marine scientists!!! • Takes a long time to get permits from the government • Size of aquaculture farm does matter to make future growth profitable and hence economical feasible • Quick response/ fast track food and fodder quality tests is not yet established within the EU needs technical issue like a fast track test in Ireland is not validated in EU; establishing in EU will take another 5 years

WP2 Q2a.
Which type of information/tool/equipment would help you to make upscaling of your multi-use activities possible?

• Broad data bases on biotic/abiotic factors and reliable models; software for analysis • Experienced/well trained staff and standardized procedures; training offshore facilities, experts in the field of offshore engineering • Planning tool to organize logistics (optimal maintenance windows/ harvest/ installation) and find optimal point in time to save resources (minimize labour input), to minimize economic losses (due to harvest/product quality losses), e.g.: “seasonal variability, where the highest yields of laminanarin and mannitol coincided with the lowest yields in ash, protein, moisture and polyphenols. Clearly, the harvest strategy must be adjusted to the product the kelp shall be converted to (human consumption, biochemicals, biomass). • Administrative guidance tool: to bring all relevant political and administrative workers together and create a guideline or a single contact person (contact office for future permissions)

WP2 Q2b.
Would operational and/or forecasted data be helpful, such as certain physical or biological sea conditions?
If yes, which parameters?

○ No

● Yes, - Hydrology: direction of current, significant wave height, max. swell/wave, water level, water temperature at different m at LAT - Oxygen, pH, Chlorophyll, Toxic Algae - predators: birds, fish, starfish

WP2 Q2c.
What type of research would you need to make upscaling of your multi-use activities possible?

• Long-term impact studies (e.g. 10 years) of plants/material/equipment, at different site locations, testing various aquaculture technologies • Automatization solutions for monitoring • Growth rates of Mussels, Seaweed at different locations • Automatization to monitor toxic algae blooms • Research and overview of current legal aspects to obtain a permission to grow algae, mussels, fish etc. in multi-use areas

WP2 Q2d. Which processes/parameters are you going to monitor, in addition to or instead what you have been monitoring so far?

• A lander will be installed, that will record the following additional data to the already recorded hydrological and meteorological data listed under question 10. Sensor Detected parameters 1 Combined CTD and O2-Sensor Conductivity, Temperature, depth, O2, salinity 2 PH-Sensor PH-Value 3 Fluor Sensor Chlorophyll and Algea-Values 4 Echosonder Water contents (concentration of faeces) 5 Pan- and tilt-device echosonder Ensure wide angels (movement of longline) 6 Electronic and transponder echosonder Necessary for function 7 ADCP Local current velocity 8 Light sensors Day light intensity 9 Turbidity sensor Turbidity 10 Cameras (4 pc.) Photos (mussels, fish, antifouling) 11 LED Lights (4 pc) Next to cameras 12 NO3 Sensor NO3 and UV Light 13 Biofouling Sensor (15 pc.) Biofouling

WP2 Q3. Which (technological) KPI's are you using to measure the success of your multi-use experiment?

Top-down framework with Key Performance Indicators (KPI= A KPI is a quantifiable measure that is used to gauge or compare performance in terms of meeting strategic and operational goals.) are developed that represent the level of successfulness of set-up from various perspectives. They are linked to a set of Critical Success Factors (CSF) as reported in the simulation literature. A single measure called Project’s Success Measure (PSM), which represents the project’s total success level, is proposed. Success must also be seen from a time-based perspective. In the short-term it may appear that few benefits accrue from a specific project, but in the longer term the full impact of a project may be much greater. The use of CSF (cover achievement of project) as a key component of a wider framework that takes a multi-faceted and multi-perspective approach to develop quantitative performance indicators. top-down framework is presented which links CSFs to a set of KPIs. The principal aim is to start from the quite vague and ambitious goals or objectives, namely project’s success, to CSFs and finally towards the very concrete and measurable outcomes (KPIs). Such an approach allows a top-down connection between strategic and operational activities, where CSFs represent strategic focus areas and KPIs represent operational performances. Two interim steps, namely the development of Statements of success and Common Features, are proposed in order to enable an informed path from CSFs to KPIs. Figure 1 demonstrates this top-down, hierarchical framework. KPI for Pilot1: adapted and based on the paper of Jahangirian et al., 2017 “KPIs for project management should: a) include non-financial measures; b) be measured frequently; c) clearly indicate what actions are required by staff; d) be measures that tie responsibility down to a team; e) have significant impact and; f) encourage appropriate action” • Total number of tests run of measuring devices/lander, that will be run before pre-op phase (in the lab), carried out by 4H-Jena (if certificates exist assuring the equipment’s functionality no lab tests are required) • Total number of tests run of measuring devices/lander at nearshore side, carried out by 4H-Jena (if certificates exist assuring the equipment’s functionality no lab tests are required) • Number of staff in the project with offshore engineering/mechanical engineering experience: (Staffs are arguably the best source of knowledge in an organisation. Also, the number of experts allocated to a project could demonstrate teamwork synergies in conducting simulation work. • Total number of previous projects conducted carried out by the 4H-Jena-Team, FUE • Risk reduction (name risk mitigation actions, to which level shall risks be reduced: tolerable, high, low) • Operating cost reduction (stick to budget tendering for subcontractors) • Responsiveness (faster implementation of changes at the set-up when s.th. does not work, flexibility) • Number of Engineering changes • Percentage of project’s lateness (best and easiest means to measure on time delivery) • Communication and Interaction (Frequency of communication, Communication effectiveness, Information to share within team) • Requirements Creep – The percentage of requirements that were determined and added to the product specification after the initial description and selection of the original product specifications • Cost of Failure – Expresses the average expense related to the research & development of merchandise that is unsuccessful at some instance during the conceptualization or research & development phase

Description. The set of questions on this page addresses possible barriers that you might encounter and is used to inform the work of WP 1.1.

WP1 Q2. **Economic barriers**

Please rate whether you agree or disagree with the following statements.

The following economic elements of operating a Multi-use platform (MUP) pose a considerable barrier to realize the project:

	Completely disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Completely agree	Not applicable
Lack of economic assessment tools to examining the economic viability of MUP.	○	●	○	○	○	○
Lack of certainty of effects of far offshore MUP on fish or oysters in aquacultures (with regard to economic effects).	○	○	○	○	○	●
Lack of attractiveness for private investors.	○	○	●	○	○	○
Lack of standardized procedures to co-use aspects related to the MUP (i.e. sharing cable equipment or ships)	○	○	○	●	○	○
High maintenance cost of aquaculture sites.	○	○	○	●	○	○
High cost of decommissioning of the MUP (potential costs after the end of the multi-use).	○	○	○	●	○	○
High insurance cost due to lack of of experience in co-location/MUP projects.	○	○	○	●	○	○
High insurance cost due to inherent risk associated with multiple use of the same platform.	○	○	○	●	○	○
High costs for grid connection.	○	○	●	○	○	○
Lack of expertise with business models and best practices.	○	○	●	○	○	○
Insufficient subsidies from the government.	○	○	●	○	○	○
High cost of maintenance.	○	○	○	●	○	○
High cost of operating staff.	○	●	○	○	○	○

WP1 Q2.1. Which economic barrier do you consider as most problematic for the realization of your pilot?

• Lack of standardized procedures to co-use aspects related to the MUP (i.e. sharing cable equipment or ships) The highest cost factor is the charter for ships: The number of suitable shipping companies with reasonable offers for such a comparable small demander, like FUE, is very limited. This applies also to the terms and conditions of the contract. At the pilot site we have an exception concerning staff, energy supply,..The research platform FINO3 provides an exceptional high technological standard that can be used. This would be impossible in a wind park. • Insufficient subsidies from the government • Insurance and maintenance costs • market price of produced goods dictates a low price, hence scaling up will be necessary

WP1 Q2.2. Which important economic barriers that hinder you from realizing your pilot have we missed?

• Access to market/marketing strategies, that improves the possibility for a stable level of turnover for mussels/seaweed. • Costs for bringing products to the market

Description. On the following 4 pages you will answer questions for WP 3.1.
These questions look in detail at the economic situation of your pilot and will be used to give as a better understanding of the economic pillar for MUPs.

Description. The following questions are looking at the economic factors concering your pilot in more detail.

Please note, that when a word is written in this *way* (i.e. underlined and cursive) that it has additional information when you hover over it.

WP3 Q1.
What is the current status of economic activity in the pilot? What is planned and what is the current stage of implementation?

Current status: Pilot1 is a research platform, which does not rely on economic activity to financially sustain itself. Due to various national research projects, that aim to run tests in an offshore environment, the platform does not have any economic output. Thus, different research projects are financing and economically justifying Pilot1 and its maintenance, e.g.: • Model-scale wave power plant: The test facility serves as a new energy research infrastructure with a “real laboratory” character. • Scratch resistant anti-biofouling coatings: Sensorial monitoring systems typically have significant deficiencies in corrosion resistance and inhibition of growth, severely limiting the life of these devices. • Current and sea loads: The sea loads of large monopile structures are determined by means of a simulation method for free-surface frictional flows in order to be able to construct larger, more efficient offshore wind turbines with high stability in the future. • Bird migration: FINO3 belongs to a network of automatic receiving stations in the area of the German Bight, which receive signals from songbirds, which are equipped with tiny radio telemetry transmitters. • Hydrography: Oceanographic data are collected on and in the immediate field of the platform by means of a sea buoy, an acoustic flow meter and CTD and oxygen probes. In general, the research platform is unmanned, but maintenance personnel and researchers will work on the platform at regular intervals. The basic fundament of the platform follows the same characteristics as has been constructed for the offshore wind farm turbines in the area. The experiences from its operation and the results of the numerous scientific research projects carried out so far on and at the platform have helped the wind farm operators and wind turbine manufacturers in the planning, building, and future operation of offshore wind farms. The dynamic characteristics of this region including stormy winters, remote access, and high demand of automation will enable the application of automatization and optimization measures between wind turbine parks and planned bi-valve maricultural uses. Planned: The planned activities at Pilot1 aim to demonstrate the societal acceptance multi-use offshore plants and their benefits. The R&D Research Centre Fachhochschule Kiel University of Applied Sciences GmbH will install a mussel and seaweed farm, operate it and evaluate different scientific aspects. FINO3 is well placed to take up an offshore wind and aquaculture demonstration project and advise its development from pilot scale to potential commercial application. Based on the results of a feasibility study, completed in June 2018, the most feasible scenarios with the best scoring results (considering a wide range of biological, economic and technical factors) were the cultivation of Mytilus edulis and Saccharina latissima. In addition to this study recent reports show that OWF developers consider combination with extractive aquaculture more favourably compared to fed aquaculture, as it entails less frequent visits to and smaller-scale operations taking place within the OWF. Therefore, a demonstration aquaculture farm of Mytilus edulis and Saccharina latissima in combination with a monitoring concept for the platform and the aquaculture farm will be implemented to examine the described synergy effects of a multi-use concept. Implementation stage: An extensive feasibility study was conducted for Pilot1 assessing five different multi-use concepts at the given offshore-location, including business plans, risk assessment studies and demands of the international aquaculture industry. A risk assessment study with a list of specific risks and their evaluation was carried out according to GESAMP (Joint Group of Experts on Scientific Aspects of Marine Environmental Protection, 2008) and FAO (2008). At this point, the preparations for the implementation of a mussel and a seaweed longline cultivation at FINO3 is planned. However, no equipment has yet been installed at Pilot1. The compilation of requirement specifications for the planned offshore set-up are in progress and equipment tests will be run during 2020 (during the pre-operational phase) before the installations will be conducted at FINO3 in 2021.

WP3 Q2.
What are the plans regarding the economic exploitation (products, target markets and demand) of the pilots?

Pilot1 will engage multiple interested OWF developers but will ensure full transparency of the project results so that these could be taken in to consideration in the future OWF planning rounds, by both industrial players and authorities. Additional project outputs and potential products for interested OWF operators, operators/owner of decommissioned oil platforms and maritime coastal planners are: • Providing a database dealing with the effects of offshore installations on the environment, e.g. creating information on site attractiveness for invertebrates and fishes, use as fish habitat, fish refugium acting as nursery area, all potentially affect windfarms and operators should know about these situations while using them as compensatory measures • Improving HSE (Health, Safety and Environmental), develop a concept to be used for other offshore projects (e.g. involvement of other stakeholders, such as tourist attractions which can also be used to enhance public knowledge and public acceptance) • Creating public awareness and public acceptance: The course development could finally lead to a guideline or learning manual • Providing solutions, blueprints on how and to what degree synergies can be used • Identifying risks and critical points for future multi-use projects • Developing recruitment options of staff for multi-purpose industry of the future • Conducting risk assessments for future insurance procedures • Testing the remote automated recording of environmental data Moreover, the demonstrator project will provide small and medium-size companies or EU institutions with an opportunity to build up reference guidelines and demonstrate their performance capability under realistic conditions.

WP3 Q3. Please indicate which economic / financial information is currently available for your pilot.

WP3 Q4. *Financial feasibility study/information*

☑

Information openly available (please attach document or share web link)

• Information openly available: Financial feasibility study (in German): https://www.fh-kiel-gmbh.de/files/aktuelles/pdf/Machbarkeitsstudie_Offshore_Aquakultur_FuE-GmbH.pdf • Information available, but confidential: The FuE holds all financial information regarding the operation costs of the platform. Thus, we can conduct a detailed analysis. However, some data will have to be handled confidentially. • Information not now, but later available • Information not available • Comments: financial feasibility study was conducted for this particular location. The objective of the feasibility study was to analyse if it is possible to operate any aquaculture at this location and what sort of aquaculture could be recommended for a research project with the focus of upscaling. So five different scenarios were investigated: mussel longline cultivation (Mytilus edulis), Macroalgae (Saccharina latissima), Oysters (Ostrea edulis), trout in cages (Oncorhynchus mykiss) and IMTA (Mytilus edulis and Saccharina latissmia). However, neither scenario was discussed in such detail as if it was the object of a single feasibility study, so more details may still be required for mussel/seaweed cultivation. • To achieve financial feasibility of the pilots the budgets of KMF, 4H-Jena have to be considered as on-top costs to Pilot1 (extra cost for testing/developing equipment for the pilot)

☐ Information available, but confidential

☐ Information not now, but later available

☐ Information not available

☐ Comments

WP3 Q5. If the information about the financial feasibility study is openly available, please upload the document here.

Machbarkeitsstudie_Offshore_Aquakultur_FuE-GmbH.pdf
3.4MB
application/pdf

WP3 Q6. *Socio-economic impact analysis*

☑ Information openly available (please attach document or share web link)

• Information openly available (please attach document or share web link) https://www.fh-kiel-gmbh.de/files/aktuelles/pdf/Machbarkeitsstudie_Offshore_Aquakultur_FuE-GmbH.pdf in German • Information available, but confidential • Information not now, but later available • Information not available • Comments: Socio-economic factors are discussed in the feasibility study but it was not the major focus of this study.

☐ Information available, but confidential

☐ Information not now, but later available

☐ Information not available

☑ Comments

Please have a look at the file above.

WP3 Q7. If the information about the socio-economic impact analysis is openly available, please upload the document here.

WP3 Q8. Business model/plan/strategy

☑ Information openly available (please attach document or share web link)

• Information openly available (please attach document or share web link) in German https://www.fh-kiel-gmbh.de/files/aktuelles/pdf/Machbarkeitsstudie_Offshore_Aquakultur_FuE-GmbH.pdf • Information available, but confidential • Information not now, but later available • Information not available • Comments • Some information is available but it was not the focus of feasibility study: scoring of different 5 usage scenarios according to biological, technical, economic and political feasibility (and overall risk analysis)

☐ Information available, but confidential

☐ Information not now, but later available

☐ Information not available

☑ Comments

Please have a look at the file above.

WP3 Q9. If the information about the business model/plan/strategy is openly available, please upload the document here.

WP3 Q10. Pilot budget/cash balances

☑ Information openly available (please attach document or share web link)

• Information openly available (please attach document or share web link) in German https://www.fh-kiel-gmbh.de/files/aktuelles/pdf/Machbarkeitsstudie_Offshore_Aquakultur_FuE-GmbH.pdf • Information available, but confidential • Information not now, but later available • Information not available • Comments: feasibility study: • Costs (investment, service/maintenance, transportation, equipment, decommissioning, etc.) and revenues (due to selling of mussels) of mussel cultivation at FINO3 for a period of 4 years

☐ Information available, but confidential

☐ Information not now, but later available

☐ Information not available

☑ Comments: Please have a look at the file above.

WP3 Q11. If the information about the pilot budget/cash balances is openly available, please upload the document here.

WP3 Q12. Please specify any other economic / financial information currently available for your pilot.

• See question 24 • The FINO3 research platform was funded from public funds, starting in 2005. The research and measurement results are therefore generally available to the public. The maximum grant for the FINO3 research platform can be found on the homepage of the Federal Environment Ministry (BMU), Federal Ministry of Economics (BMWI) or the responsible project executing agency.

WP3 Q13.

Parties that collaborate through a partnership in the pilot project probably possess part of the information requested under question 3. It is important to take stock of all available financial and economic information to develop optimized business cases in the course of the UNITED project. If necessary, we would like to contact these parties to collect information in the next phase of the project.

Examples of roles and services

	Is it a project partner or external stakeholder?	What is the role of the partner in the pilot project/which service do they provide?	What is the main interest of the partner to participate in the pilot project?	Who is the main contact person (first name, last name, email address)?
Partner 1 KMF	Project Partner	Nearshore site operation/Producer/Consultant	Research results	Tim Staufenberger info@kieler-meeresfarm.de
Partner 2 Contros successor	Project Partner	Responsible for technical functioning, solutions, software of sensors, Monitoring devices	Research results, improving the remote automated data recording of sensors	?

Partner 3 Bundesamt für Seeschifffahrt und Hydrographie (BSH) – Federal Maritime and Hydrographic Agency (BSH)	External SH	Approves/supervises maritime legislation	Granting licence for the pilot Controls that the implementation, operation and decommissioning of the pilot is according to national legislation	posteingang@bsh.de
Partner 4 Shipping company	External SH	Offshore vessel for implementation, maintenance, decommissioning- Transport of material and staff	Economic interests, obtain contracts	Will be selected after calling for tenders
Partner 5 Helicopter company	External SH	Transport of material and staff	Economic interests, obtain contracts	Will be selected after calling for tenders
Partner 6 Company providing industrial divers	External SH	Implementation and decommissioning phase – connecting aquaculture farm with platform via seacable	Economic interests, obtain contracts	Will be selected after calling for tenders
Partner 7 Tank ship company	External SH	In charge of filling up the tank at FINO3	Subcontractor of FINO3	?
Partner 8 Insurance company	External SH	Insures the pilot	Subcontractor of FINO3	?
Partner 9 Other projects conducted at FINO3: •Model-scale wave power plant •Scratch resistant anti-biofouling coatings •Current and sea loads •Bird migration •Meteorology •Hydrography •Georeferencing •Water quality •Gamma radiation	External SH	No active participation, however other projects will take place at the same location at the same time	Research results	Björn Lehmann-Matthaei lehmann.matthaei@fh-kiel-gmbh.de Jan Bachmann jan.bachmann@fh-kiel-gmbh.de
Partner 10 x	x	x	x	x

WP3 Q14.
What are expected *synergies* of combined use of the offshore platform? Please name some specific examples.

Financial benefits also to the OWF sector through outsourcing the operational activities below will be possible to test and demonstrate not only in theory but also in practise at the location FINO3 by examining the following shared uses of: • environmental monitoring data and surveillance • permissions and licenses • certified offshore staff (including multi-disciplinary education of personnel) The following synergies are focus of the multi-use of offshore installation of wind energy and aquaculture: • Logistics: Closely engaging industry, Pilot1 will also assess factors that affect the financial viability of such multi-use concept, including: distance to shore: For example, shellfish (mussels, oysters, scallops) usually require a 2-day window for distribution to the next step of the supply-chain; the distributor. For far offshore locations it is difficult to predict when harvesting and subsequent distribution can take place. Also, storage space and workshop at the offshore site will be shared. • Transportation: Pilot1 will also analyse the optimal operational interactions between the two sectors at the project level e.g. type of vessel, helicopter to be shared. • Planning and maintenance work: Means of communication, timetables for maintenance, training requirements and procedures (emergency response) for minimising risks at the site. • Energy: The whole monitoring and surveillance program (type of sensors, possible parameters, duration of measurements) will not be limited by the availability of batteries. The aquaculture farm will be supplied with power from the platform. • Social Acceptance: Workshops will be conducted to demonstrate students (offshore engineering, architecture and aquaculture students) as well as other stakeholders benefits and challenges to developing multi-use offshore. • Insurance: Pilot1 addresses the question of how insurance premiums required by the insurance companies, are to be shared between the two developers (aquaculture and offshore wind). • Security of tenure: Most OW are licensed for around 25 years, after which all infrastructure has to be completely removed. If the aquaculture farm is successful, this requires consideration of what will happen when OWF are to be decommissioned.

WP3 Q15. What is the potential to scale up the existing solution?

Amendment by Rianne Van Duinen March 23rd 2020: The way I see it right now, the potential to scale up multi-use solutions addresses two issues: First it addresses the challenge to develop commercial-ready solutions that can be rolled out. At what stage is the pilot right now? What is required to reach the ‘commercial-ready stage’? Requirements are for example technological developments, contractual arrangements, financial/financing requirements; evolvement of the demand for multi-use solutions etc. Secondly, the question rises to which extent tested multi-use solutions can be applied elsewhere. If we consider all barriers and requirements; where could multi-use solutions eventually be developed (in Europe?); which market could be potentially served, and what would be environmental and economic impacts? The survey question mainly addresses the first issue. Pilot1 is currently at TRL 5 and is supposed to reach TRL7 with the input of UNITED. In order to reach TRL7 the following aspects need to be addressed: - Functionality of MUCL: Evidence on the effectiveness of MUCL is needed, while reducing the risk for implementation/operation at affordable costs - Administration/ government: Solutions for governance (obtaining permissions and licences) that comply with legal standards need to be found/described - Investors and sales plan: The decision-making process on investing into MUCL needs to be simplified with special/reliable offers for investors regarding financing models/business plans while reducing the overall economic risk (defining risk government actions) effective marketing strategies need to be defined to generate a stable turnover of products, there is no “go to market strategy” for the products (mussel, seaweed) yet - Standardized infrastructure: A whole infrastructure for operating a MUCL needs to be created in order to reduce various risks: training certified offshore staff, optimizing the scheduling of logistics, transportation and maintenance work, reducing energy need, etc - Technological development: Technological feasible/affordable concepts for the offshore installation of semi-submerged longlines in high energy environments need to be tested and confirmed - Environment: environmental data is required to investigate the impact of MUCL on the environment at that location. If there are negative impacts, these need to be known before any upscaling can happen. Potential usage scenarios of MU solutions could be: - other Windfarms - decommissioned oil rigs - cable lines/pipelines - Certain tourist spots creating “artificial reefs” Markets: - Seaweed: cosmetics industry/pharma industry - Seaweed: Restaurants/organic food trade/construction (insulating material) - Seaweed: Water remediation systems, sewage treatment plants - Mussels: animal food production The environmental impact would have to be proved for each location separately due to its own characteristics. In general mussels and seaweed have a low or no or even positive impact on the environment. One reason is the fact that no additional nutrients (e.g. like fish food in fish aquaculture) will be added to the ecosystem. Economic impacts: Shellfish producer in the EU are predicted to increase their output by 30% by 2030, while the current annual growth rate is just 1.3%. In most of the Member States mussel aquaculture has been considered the most promising type of aquaculture for MU with OWFs. The North Sea is a suitable option for developing a pilot as it is the most advanced in examining different technological options for this combination. The seaweed market is expected to grow in Europe. There is a strong potential for seaweed cultivation in the North Sea, especially for the production of feed additives and chemical building blocks. Pilot1 will develop a business case considering an economically viable value chain and further products that could be derived from seaweed as to ensure that seaweed production is feasible in a MU context. Moreover, seaweed can be cultivated for food, animal feed, bio-chemicals, energy and other valuable products. For investors, proof of the concept is needed before engaging more actively. For this reason, it is important to work together with OWF operators and developers to demonstrate the feasibility and benefits of multi-use within the FINO3. Some of the questions to be addressed include: What are suitable (financial, regulatory) incentives for multi-use to happen, what EIA requirement should be imposed. Therefore, the pilot will involve established businesses to address the aquaculture sector and traditional fishermen, willing to invest in this future sector. Due to reduced fishing quotas and declining fish stocks, aquaculture can represent a profitable alternative future for fishermen. • Making such business cases visible and attracting other commercial actors and investors, such as retail, utilities, and established aquaculture businesses, is an important step to increase the commercial readiness level of such combinations in the future by building up references and demonstrate the performance capability under realistic conditions. • Regulatory and financial incentives from high-level policy support are pre-requisites for these endeavours. Such frameworks have so far been established in Belgium and the UK, attracting financiers to investigate the potential for commercialisation of such MU solutions. Due to its overall low presence in Europe, individual seaweed businesses have, so far, had limited capacity for engagement with MU concept. In most projects where OWF companies have been engaged so far most of the business models and main project findings have stayed proprietary, not available to other developers and interested investors. With low transparency of projects and involvement only of some OWF companies, multi-use project results are less likely to be exploited. There is a need to develop possible business models and explore local cooperative ownership opportunities while also creating a positive “climate” in the public at large particularly because offshore facilities are in need of strong support from land-based stations. Moreover, such joint (multi-stakeholder) activity can also benefit both development in regards to shared costs, better social/environmental image of involved businesses and overall increased financial yield for investors. An opportunity for certain eco label/small spatial footprint certification can also be explored, both for marketing the aquaculture products as well as for the renewable energy derived from the multi-use site. In this, it also seems promising to examine a technology utilization concept that is needed in aquaculture and, in cooperation with the established industry, to introduce niche products into the global market in order to gradually increase their share. With such partners, market shares can be expanded on the basis of "win-win" scenarios, while many operational requirements can be further exploited and learning processes can be designed cost-effectively. This way, costs for parallel and future-oriented developments could be minimized. These measures will help to attract "newcomers" and develop a basis of trust for long-term cooperation and division of labour. Feasibility study: based on the feasibility study, conducted for FINO3, the implementation of mussel longline cultivation has proven to be applicable and when following a long-term approach (20 years) will enable positive revenues. Due to technical and biological challenges and the high level of required investment, there are still considerable problems and open questions regarding the scale-up potential. So-called "multi-use" approaches are considered, to still be part of the research and experimental stage with no commercial operation of such a plant in Germany. In addition to the selection of suitable organisms that can withstand the harsh offshore conditions, the use of stable and safe techniques for installation and operation as well as very good organisation and management of these offshore facilities are essential

WP3 Q19a.

Has any environmental impact assessment considering ecological impacts during the construction and operation phase been undertaken at the pilot or at the specific activity levels?

○ No, namely: ☐

●

Yes (please attach document or share web link)

There was no need to carry out an environmental impact assessment study prior to the approval or construction of the research platform. The Offshore Installations Regulations in 2006 explicitly supported the possibility/idea of building offshore research facilities in the North Sea. The Offshore Installations Regulations, stipulated that the competent authority, the Federal Maritime and Hydrographic Agency (BSH), is informed about the project's location, content, scope and construction. The Offshore Installations Regulations was amended in 2009. Today, a simplified approval procedure has to be passed. The FINO research platform defined the basis for conducting environmental impact studies for offshore wind turbines in the North Sea and Baltic Sea. • Feasibility study: An overview of possible impacts as well as their probability and degree of severity are part of the feasibility study (see above, in German) were identified to assess the suitability of different usage scenarios.

WP3 Q19 Upload. If you have chosen yes in the above question and have a document to upload, please do so here.

WP3 Q19b. If you answered yes to the above question, have ecological/environmental impacts of multi-use been measured with indicators?

○ No

● Yes, please specify

• A large number of ecological research projects were carried out at the FINO3 platform. The impacts of multi-use have not yet been measured with indicators. Finished projects that were conducted at FINO3 which can serve as additional information to measure the environmental impact of multi-use at the location are: - Corrosion protection: Development and testing of novel corrosion protection surfaces for use on offshore structures. (final report in German) - Pillar foundation: The aim of the measurements is to investigate the mechanical-dynamic phenomena in the soil and thus to clarify the question of which mechanisms must be assumed to be decisive in the investigation and proof of stability. - Structure of the ground: Under dynamic load caused by currents, waves and wind pressure, changes in the sediment structure may occur in the immediate vicinity of offshore structures. The aim is to determine the temporal evolution and spatial extent of these effects through dynamic loading. - Wave behavior: Radar measurement of wave combs is designed to clarify the behavior of large, steep waves at sea. The new process is being tested for the first time as a permanent operation on FINO3. (final report in German) - Wind turbulence: The aim of the project is to investigate turbulences in on- and offshore wind. For this, piezoelectric sensors are used to measure high-frequency aerodynamic wind components at different locations. (final report in German available, poster in English) Ecologic Projects: https://www.fino3.de/en/research/research-archive/ecology.html o Bird migration: The research activities provide information on the spatial-temporal course of flight movements of birds as well as the variability of species-specific train intensities in the daily and annual course in the German part of the North Sea. o Acoustic field: The objective is to measure the acoustic field at FINO3 as well as possible change resulting from the building and operation of the DanTysk and Sandbank24 offshore wind farms. o Sound pressure level: The aim is to reliably forecast the sound pressure levels in the North Sea area, where wind farms are being built. The development of the forecast calculations is carried out depending on location and time and taking into account possible temporal overlapping of several construction projects. o Noise protection: The aim is to minimize the risk to marine mammals by underwater noise. As part of the sound insulation concept, a bubble curtain was developed and kept in operation during ongoing pile driving, which was operated with maximum compressed air during the entire pile driving time.

WP3 Q16. What would you like to obtain from business and economic analyses in UNITED in relation to your pilot: Which key socio-economic questions/challenges/aspects should be addressed for your pilot? Please ask your pilot partners also.

• A strong need for action is required in the area of legal conditions and authorisation procedures, which at the present revealed great uncertainty about responsibilities and their overall relevance. These are only a few reasons that complicate the preparation and planning of an aquaculture project for stakeholders. • Efforts in the past to establish large-scale aquaculture in Germany also failed due to a negative image of this industry. Therefore, it is indispensable to involve the public, local administration and politics in future pro-jects from the very beginning. This includes different activities of a stakeholder outreach program. • Time to obtain permits is too long and socio-economic challenge needs to be overcome

WP3 Q17.
Bearing in mind the project's objectives and activities as described in the project proposal, how do you see the role of economic/financial tasks within the UNITED project with respect to your pilot?

Very important, in regard to identifying upscaling possibilities as well as engaging stakeholders. While the technology might be viable (high technology readiness level), its application depends on the Commercial Readiness Level of such solutions. This implies that a deep understanding of the target application and market is needed, including a. a comprehensive cost-performance model created to further validate the value of the business proposition b. a financial model built with initial projections for short- and long-term costs, revenue, margins, etc., and in response.

WP3 Q18. Do you have economic / financial expertise within the pilot partners?

○ No

● Yes, namely:

• FUE: Economic/financial experience in designing, constructing and operating the platform FINO3 since 2005
• FUE has initiated and completed over 1500 projects for clients in the private and public sector.
• KMF is operating a mussel and seaweed aquaculture farm since 2014.

Description. The set of questions on this page addresses possible barriers that you might encounter and is used to inform the work of WP 1.1.

WP1 Q3. **Environmental barriers**

Please rate whether you agree or disagree with the following statements.

The following environmental elements of operating a Multi-use platform (MUP) pose a considerable barrier to realize the project:

	Completely disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Completely agree	Not applicable
Increased traffic of MUP support vessels resulting in damage to the ecosystem.	○	●	○	○	○	○
Increasing risk of pollution events (mainly excessive nutrient load and other substances) due to the installation of aquaculture cages.	○	○	○	○	○	●

Potential, real and perceived, conflicts among marine ecosystem flora and fauna due to artificial introduction of invasive species.	●	○	○	○	○	○
Risk of the cumulative effect of several aquaculture locations and the disturbance they can cause for the local ecosystem.	○	●	○	○	○	○
Underwater-noise disturbance of marine mammals such as wales.	●	○	○	○	○	○
Disturbance of the seabed sediments and seabed communities.	●	○	○	○	○	○
Collision risks to birds and bats above water	●	○	○	○	○	○
Attraction of unwanted invasive species at the location of the MUP.	○	●	○	○	○	○

WP1 Q3.1. Which environmental barrier do you consider as most problematic for the realization of your pilot?

Harsh environment: wave action, low concentration of spat

WP1 Q3.2. Which important environmental barriers that hinder you from realizing your pilot have we missed?

• Concentration of Increased traffic by maintenances/ operating vessels? • However, for planning and up-scaling of mussel farming, potential carrying capacity models should provide insight in the maximum level that can be sustained in a given area. • low growth rate of algae might make it unfeasible (due to low temperature), • growth and settling rates of mussels might be to low o mussel spat is not sufficient to cultivate o Unknown possibility of harmful algae blooms o Climate change: High water temperatures for a longer period of time o Current is too strong for mussels to attach to long lines o Current is too strong for thallus of kelp to stay attached to longline

Description. The set of questions on this page addresses possible barriers that you might encounter and is used to inform the work of WP 1.1.

WP1 Q4. **Governance and legal barriers**

Please rate whether you agree or disagree with the following statements.

The following governance or legal elements of operating a Multi-use platform (MUP) pose a considerable barrier to realize the project:

	Completely disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Completely agree	Not applicable
Unclear and fragmented regulation for MUPs on national level.	○	○	○	●	○	○
Unclear and fragmented regulation for MUPs on European level.	○	○	○	●	○	○
Strict security regulation that discourage setting up a MUP	○	○	○	●	○	○
The set of constrains related to safety distance to other users or distance form shore.	○	○	○	○	●	○
Separate environmental impact assessment processes (permitting) for each of the (hybrid) technologies and lack of guidance on cumulative impact assessment.	○	○	○	●	○	○
Lack of established licensing procedures for multi-use projects.	○	○	○	○	●	○

Lack of dialogue between public institutions and difficulties in identifying the administrative offices responsible for issuing permits.	○	○	○	○	●	○
Lack of cross-border cooperation in MUP projects.	○	○	○	○	●	○
Lack of established procedures for spatial planning of the sea with a focus on the the interests of different stakeholders.	○	○	○	○	●	○
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)	○	○	○	○	●	○
Lack of established safety assessment methods for MUPs.	○	○	○	●	○	○

WP1 Q4.1. Which governance related or legal barrier do you consider as most problematic for the realization of your pilot?

Unclear legal status for MUP, lack of dialogue between stakeholder

WP1 Q4.2. Which important governance or legal barriers that hinder you from realizing your pilot have we missed?

Food safety, Lack of established procedures for spatial planning of the sea with a focus on the interests of different stakeholders. Lack of knowledge “who is responsible “ for the permits and long time to obtain them for future multi-use scenarios Fodder safety regulations , see answer to question 11 “fast track test” Non-deterioration: Determination that there is no negative environmental impact of mussel and algae aquaculture due to sedimentation. Cannot offset the nutrient uptake (P-/N-/C-uptake) of mussels against overfertilization on land.

Description. The set of questions on this page addresses possible barriers that you might encounter and is used to inform the work of WP 1.1.

This is the last set of questions you will be asked with regard to barriers.

WP1 Q5. **Social barriers**

Please rate whether you agree or disagree with the following statements.

The following social elements of operating a Multi-use platform (MUP) pose a considerable barrier to realize the project:

	Completely disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Completely agree	Not applicable
Lack of social acceptance of the MUP by society in general.	○	○	●	○	○	○
Lack of acceptance of the MUP by the local affected community.	○	○	●	○	○	○
Lack of consensus about the MUP from multiple stakeholders in private and public sector.	○	○	○	●	○	○
Lack of trust between industry sectors directly involved in the MUP.	○	○	○	○	●	○
Lack of public awareness about implications of multi-use.	○	○	●	○	○	○
Low individual financial power and overall capacity to join MUP from local collaborators.	○	○	○	○	●	○

Conflicts of interest between different users of the sea (i.e. external tourist agencies, other energy producers, etc.).	○	○	○	○	●	○

WP1 Q5.1. Which social barrier do you consider as most problematic for the realization of your pilot?

Lack of trust between industry sectors directly involved in the MUP. Low individual financial power and overall capacity to join MUP from local collaborators.

WP1 Q5.2. Which important social barriers that hinder you from realizing your pilot have we missed?

“Bad reputation” of aquaculture Needs improvement of market acceptance of aquaculture products.

Description. On the following pages you answer questions for WP 5, specifically about the social pillar of the MUP project.

Description. When we talk about stakeholders, we imply the following definition:

“We define stakeholders as individuals or institutions that may – directly or indirectly, positively or negatively – affect or be affected by a project or programme, in this case, the change from single use of a maritime space to the reality of having more uses in the same space”

This question was not displayed to the respondent.

Stakeholders1. Who do YOU consider to be your stakeholders?

This question was not displayed to the respondent.

Stakeholders2. Can you imagine people you may overlook but that will consider THEMSELVES to be a stakeholder in your activities?

This question was not displayed to the respondent.

WP5 Q1. How would you qualify your **identification** of local stakeholders in your pilot at the current point in time? (i.e. March 2020)

○ Key stakeholders are yet to be identified

● Some stakeholders identified

○ Most or all stakeholder identified

WP5 Q2. How would you qualify your **knowledge** of local stakeholders in your pilot at the current point in time? (i.e. March 2020)

○ Knowledge is incomplete or poor

● Average knowledge

○ Good knowledge

○ Excellent knowledge

WP5 Q3. Have reflections already taken place regarding the stakeholder involvement process of the pilot?

○ No

● Yes, namely

Draft for a offshore course curriculum started. This course will be designed especially for stakeholders.

WP5 Q4. Which activities involving stakeholders have already taken place in the pilot's site?

○ Written communication toward local stakeholders

● One-to-one meetings with targeted stakeholders

○ Collective meetings (workshops…)

○ Written consultation (questionnaire)

○ Other, namely:

○ No activities have taken place, yet.

WP5 Q5. Please indicate which stakeholder information is currently available for your pilot.

○ A list of contacts, or stakeholder database

○ Reports or minutes of meeting with stakeholders

● Results from a stakeholder consultation

○ Others, namely:

○ None

WP5 Q6. What do you expect from stakeholder involvement in your pilot?

Overcome barriers for future cooperation, better public acceptance of marine aquaculture, overcome legal barriers (government)

WP5 Q7. What do you expect from the guidelines provided in WP5 for stakeholder involvement in the pilots? (please express your needs)

Practice-orientated stakeholder involvement as an overall objective.

WP5 Q8.
Do you have stakeholder involvement or facilitation expertise within the pilot partners?

○ No

● Yes, namely:

```
FUE: Contacts from former or ongoing projects
KMF: Contacts to other mussel growers in the Baltic Sea and research institutions
```

End. Thank you for filling out this survey.

You will be informed about the results of this survey in the form of the deliverables of the different work packages.

If you have any questions or feedback contact Marvin Kunz at marvin.kunz@wur.nl

Location Data

Location: (53.495300292969, 10.359893798828)

Source: GeoIP Estimation

ANNEX 5 – RESPONSE NORTH SEA INNOVATION LAB

Q1.

Dear Sir or Madam, dear UNITED participant,

Welcome to this internal questionnaire for the European Union Horizon 2020 - UNITED project.

The here generated insights will directly benefit you in the further planning of your pilot as well as allow you to generalize potential insights that you have in the current setting you operate into slightly different scenarios.

The use of this information will be going towards publications and other deliveries that in one way or the other will be publicly disseminated. However, we will keep your identity confidential and we will treat all information anonymously when communicated to people outside of the Horizon 2020 - UNITED project.

The questionnaire will require some of your time. In an effort to take up as little of your time as possible, the answers you provide here will inform 4 different work packages - WP 1, WP 2, WP 3, and WP 5.

In case, you have any questions or something remains unclear, you can send an email to:
Marvin Kunz at marvin.kunz@wur.nl

Description. The following questions are necessary to help us understand your other answers better.

Pilot. In which pilot (country) are you participating in?

○ Belgium
○ Denmark
○ Germany
● Netherlands
○ Greece

Position. What is your position within the pilot?
(If you do not have a position, shortly describe your main responsibilities)

Coordinator pilot 2 (North Sea Farm)

Q77. How many partners do you currently work with in realizing the MUP?

0 2 4 6 8 10 12 14 16 18 20

Number of partners 5

Description. The set of questions on this page addresses possible barriers that you might encounter and is used to inform the work of WP 1.1.

WP1 Q1. **Technological barriers**

Please rate whether you agree or disagree with the following statements.

The following technical elements of operating a multi-use platform (MUP) pose a considerable barrier to realize the project:

	Completely disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Completely agree	Not applicable
Lack of general technological knowledge available from the industry involved in MUPs in general (outside of the scope of UNITED).	○	○	●	○	○	○
Lack of general technological readiness level of all the parties involved with the MUP.	○	○	●	○	○	○
Lack of technological knowledge to allow MUP structure to withstand adverse weather conditions	○	○	●	○	○	○
Damage due to extreme adverse environmental catastrophic events (storms or underwater earthquakes)	○	○	○	○	●	○
Structural risk for MUP from accidental collision with (aquaculture) equipment	○	○	○	●	○	○
Vibration from wind turbines (when working with wind turbines)	○	○	○	○	○	●
Lack of infrastructure for energy provision for MUP	○	○	○	○	○	●
Risk of power failure	○	○	○	○	○	●
Risk of anchoring vessels damaging power supply cables	○	○	○	○	○	●
Lack of knowledge about specific anchoring techniques required	○	●	○	○	○	○
Risk of damage in case of mooring failure	○	●	○	○	○	○

WP1 Q1.2. Which technical barrier do you consider as most problematic for the realization of your pilot?

This will become clear during the project, not possible to answer yet. Same for the questions "Lack of general technological knowledge" above

WP1 Q1.3. Which important technical barriers that hinder you from realizing your pilot have we missed?

Same: this will become clear during the proejct, after scope setting and start of implementation/realization

Q20. While the previous section asked questions about broader technical barriers, now, we want to know from you more details about the technological situation of your pilot.

This part of the questionnaire will include 2 pages with open questions and they are used to inform the work of WP 2.

WP2 Q1. Which technological issues did/do you encounter in the design/implementation/operation of the multi-use experiments in your pilot?

Not possible to answer yet: this will become clear during the proejct, after scope setting and start of implementation/realization

WP2 Q1a. How did you overcome these issues?
(Or in case they still pose a problem, how do you plan on overcoming them?)

Not possible to answer yet

WP2 Q1b.
Which type of information/tool/equipment could have helped to avoid or reduce the impact of this issue on the experiment?

Not possible to answer yet

WP2 Q1c.
Which processes/parameters have you been monitoring since the start of your pilot?

At the North Sea Innovation Lab (the Dutch testlocation of the pilot 2), currently the following parameters will be measured / are measured as part of the IMPAQT project (other H2020 project): turbidity,chlorophyll-A, conductivity, temperature and vertical flow profile.

WP2 Q2. Which technological issues/challenges do you see for the future upscaling of your experiment?

Not possible to answer yet

WP2 Q2a.
Which type of information/tool/equipment would help you to make upscaling of your multi-use activities possible?

Not possible to answer yet

WP2 Q2b.
Would operational and/or forecasted data be helpful, such as certain physical or biological sea conditions?
If yes, which parameters?

○ No

● Yes, to be defined with partners (wave heigth is possibly one)

WP2 Q2c.
What type of research would you need to make upscaling of your multi-use activities possible?

Not possible to answer yet

WP2 Q2d. Which processes/parameters are you going to monitor, in addition to or instead what you have been monitoring so far?

To be defined with the partners. Oceans of Energy will probably measure wave height to be able to get insight in the wave demping possibilities of floating solar energy/panel structures

WP2 Q3. Which (technological) KPI's are you using to measure the success of your multi-use experiment?

Not possible to answer yet, to be defined with the partners

Description. The set of questions on this page addresses possible barriers that you might encounter and is used to inform the work of WP 1.1.

WP1 Q2. **Economic barriers**

Please rate whether you agree or disagree with the following statements.

The following economic elements of operating a Multi-use platform (MUP) pose a considerable barrier to realize the project:

	Completely disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Completely agree	Not applicable
Lack of economic assessment tools to examining the economic viability of MUP.	○	○	●	○	○	○
Lack of certainty of effects of far offshore MUP on fish or oysters in aquacultures (with regard to economic effects).	○	○	●	○	○	○
Lack of attractiveness for private investors.	○	○	●	○	○	○
Lack of standardized procedures to co-use aspects related to the MUP (i.e. sharing cable equipment or ships)	○	○	●	○	○	○
High maintenance cost of aquaculture sites.	○	○	○	●	○	○
High cost of decommissioning of the MUP (potential costs after the end of the multi-use).	○	○	○	●	○	○
High insurance cost due to lack of of experience in co-location/MUP projects.	○	○	○	○	●	○
High insurance cost due to inherent risk associated with multiple use of the same platform.	○	○	○	○	●	○
High costs for grid connection.	○	○	○	○	●	○
Lack of expertise with business models and best practices.	○	○	○	●	○	○
Insufficient subsidies from the government.	○	○	○	○	●	○
High cost of maintenance.	○	○	○	●	○	○
High cost of operating staff.	○	○	○	●	○	○

WP1 Q2.1. Which economic barrier do you consider as most problematic for the realization of your pilot?

Not possible to answer yet, to be defined with the partners after scope setting and tobe figured out during the project. Filled in questionaire above is just a first impression, has to become clear during the project. In general there is an economic challenge for starting offshore multi-use activities

WP1 Q2.2. Which important economic barriers that hinder you from realizing your pilot have we missed?

Not possible to answer yet, to be defined with the partners after scope setting and tobe figured out during the project.

Description. On the following 4 pages you will answer questions for WP 3.1.
These questions look in detail at the economic situation of your pilot and will be used to give as a better understanding of the economic pillar for MUPs.

Description. The following questions are looking at the economic factors concering your pilot in more detail.

Please note, that when a word is written in this *way* (i.e. underlined and cursive) that it has additional information when you hover over it.

WP3 Q1.
What is the current status of economic activity in the pilot? What is planned and what is the current stage of implementation?

Not yet possible to answer, to be discussed with the partners

WP3 Q2.
What are the plans regarding the economic exploitation (products, target markets and demand) of the pilots?

Not yet possible to answer, to be discussed with the partners

WP3 Q3. Please indicate which economic / financial information is currently available for your pilot.

WP3 Q4. *Financial feasibility study/information*

- ☐ Information openly available (please attach document or share web link)
- ☐ Information available, but confidential
- ☐ Information not now, but later available
- ☑ Information not available
- ☑ Comments Might become available during the project, depending on the scope

WP3 Q5. If the information about the financial feasibility study is openly available, please upload the document here.

WP3 Q6. *Socio-economic impact analysis*

- ☐ Information openly available (please attach document or share web link)
- ☐ Information available, but confidential
- ☐ Information not now, but later available
- ☑ Information not available
- ☑ Comments: Might become available during the project, depending on the scope

WP3 Q7. If the information about the socio-economic impact analysis is openly available, please upload the document here.

WP3 Q8. *Business model/plan/strategy*

- ☐ Information openly available (please attach document or share web link)
- ☐ Information available, but confidential
- ☐ Information not now, but later available
- ☑ Information not available
- ☑ Comments: Might become available during the project, depending on the scope

WP3 Q9. If the information about the business model/plan/strategy is openly available, please upload the document here.

WP3 Q10. *Pilot budget/cash balances*

- ☐ Information openly available (please attach document or share web link)
- ☐ Information available, but confidential
- ☑ Information not now, but later available
- ☐ Information not available
- ☐ Comments

WP3 Q11. If the information about the pilot budget/cash balances is openly available, please upload the document here.

WP3 Q12. Please specify any other economic / financial information currently available for your pilot.

No more information available then stated in the project plan / application, might become available after scope definition & during the project

WP3 Q13.
Parties that collaborate through a partnership in the pilot project probably possess part of the information requested under question 3. It is important to take stock of all available financial and economic information to develop optimized business cases in the course of the UNITED project. If necessary, we would like to contact these parties to collect information in the next phase of the project.

Examples of roles and services

	Is it a project partner or external stakeholder?	What is the role of the partner in the pilot project/which service do they provide?	What is the main interest of the partner to participate in the pilot project?	Who is the main contact person (first name, last name, email address)?
Partner 1 Oceans of Energy	Project partner	Company floating solar	Towards commercial floating solar energy, using project for testnig and demonstration of certain aspects to higher TRL level	Brigitte Vlaswinkel; brigitte.vlaswinkel@oceansofenergy.blue
Partner 2 The Seaweed Company	Project partner	Commercial seaweed company	Towards commercial large scale offshore seaweed cultivation	Joost Wouters; joost.wouters@theseaweedcompany.com
Partner 3 TNO	Project partner	Supports with research on floating solar energy offshore	Research	Ton Veltkamp; ton.veltkamp@tno.nl
Partner 4 Ventolines	Project partner	Service provider of onshore wind and solar and offshore wind projects	Role in future development	Arnout van de Bosch; arnoutvandenbosch@ventolines.nl
Partner 5 Deltares	Project partner	Support technical questions	Research	Roderick Hoekstra; Roderik.Hoekstra@deltares.nl
Partner 6				
Partner 7				
Partner 8				
Partner 9				
Partner 10				

WP3 Q14.
What are expected *synergies* of combined use of the offshore platform? Please name some specific examples.

To be defined But cost reduction due to combination of activities will be certainly one. Additionally Oceans of Energy wants to test the wave demping effect of floating solar, which might be potentially beneficial for seaweed (or other aquaculture) cultivation

WP3 Q15. What is the potential to scale up the existing solution?

Goal multi-use between offshore windfarms, including the two techniques of this pilot (seaweed cultivation & floating solar energy). Size of scale up to be defined

WP3 Q19a.
Has any environmental impact assessment considering ecological impacts during the construction and operation phase been undertaken at the pilot or at the specific activity levels?

● No, namely: as far as NSF knows

○ Yes (please attach document or share web link)

WP3 Q19 Upload. If you have chosen yes in the above question and have a document to upload, please do so here.

WP3 Q19b. If you answered yes to the above question, have ecological/environmental impacts of multi-use been measured with indicators?

○ No

○ Yes, please specify

WP3 Q16. What would you like to obtain from business and economic analyses in UNITED in relation to your pilot: Which key socio-economic questions/challenges/aspects should be addressed for your pilot? Please ask your pilot partners also.

Not yet possible to answer, to be defined

WP3 Q17.
Bearing in mind the project's objectives and activities as described in the project proposal, how do you see the role of economic/financial tasks within the UNITED project with respect to your pilot?

It's extremely important to focus on a solid business case for future development of multi-use activities in offshore wind farms. Economic feasibility should therefore be one of the focus points in the pilot development and project. Based on input of the pilot sites and companies involved, the business case for large scale multi-use should be defined.

WP3 Q18. Do you have economic / financial expertise within the pilot partners?

● No

○

Yes, namely:

Description. The set of questions on this page addresses possible barriers that you might encounter and is used to inform the work of WP 1.1.

WP1 Q3. **Environmental barriers**

Please rate whether you agree or disagree with the following statements.

The following environmental elements of operating a Multi-use platform (MUP) pose a considerable barrier to realize the project:

	Completely disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Completely agree	Not applicable
Increased traffic of MUP support vessels resulting in damage to the ecosystem.	○	●	○	○	○	○
Increasing risk of pollution events (mainly excessive nutrient load and other substances) due to the installation of aquaculture cages.	○	○	●	○	○	○
Potential, real and perceived, conflicts among marine ecosystem flora and fauna due to artificial introduction of invasive species.	○	○	●	○	○	○
Risk of the cumulative effect of several aquaculture locations and the disturbance they can cause for the local ecosystem.	○	○	●	○	○	○
Underwater-noise disturbance of marine mammals such as wales.	○	●	○	○	○	○
Disturbance of the seabed sediments and seabed communities.	○	○	●	○	○	○
Collision risks to birds and bats above water	●	○	○	○	○	○
Attraction of unwanted invasive species at the location of the MUP.	○	○	●	○	○	○

WP1 Q3.1. Which environmental barrier do you consider as most problematic for the realization of your pilot?

Not yet able to answer these questions, to be determined within the project. Addtionally aquaculture is expected to be as well of added value to the environment

WP1 Q3.2. Which important environmental barriers that hinder you from realizing your pilot have we missed?

Not yet able to answer these questions, to be determined within the project.

Description. The set of questions on this page addresses possible barriers that you might encounter and is used to inform the work of WP 1.1.

WP1 Q4. **Governance and legal barriers**

Please rate whether you agree or disagree with the following statements.

The following governance or legal elements of operating a Multi-use platform (MUP) pose a considerable barrier to realize the project:

	Completely disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Completely agree	Not applicable
Unclear and fragmented regulation for MUPs on national level.	○	○	○	●	○	○
Unclear and fragmented regulation for MUPs on European level.	○	○	○	●	○	○
Strict security regulation that discourage setting up a MUP	○	○	○	●	○	○
The set of constrains related to safety distance to other users or distance form shore.	○	○	○	●	○	○
Separate environmental impact assessment processes (permitting) for each of the (hybrid) technologies and lack of guidance on cumulative impact assessment.	○	○	○	●	○	○
Lack of established licensing procedures for multi-use projects.	○	○	○	●	○	○
Lack of dialogue between public institutions and difficulties in identifying the administrative offices responsible for issuing permits.	○	○	○	●	○	○
Lack of cross-border cooperation in MUP projects.	○	○	○	●	○	○
Lack of established procedures for spatial planning of the sea with a focus on the the interests of different stakeholders.	○	○	○	●	○	○
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)	○	○	○	●	○	○
Lack of established safety assessment methods for MUPs.	○	○	○	●	○	○

WP1 Q4.1. Which governance related or legal barrier do you consider as most problematic for the realization of your pilot?

Not possible to answer yet in detail, information might be available, this has to be checked after the scope setting of the pilot. In general there is a lack of procedures & regulation as multi-use in offshore wind farms is a new business, so this still has to be developed. Therefore all aspects are scored as somewhat agree

WP1 Q4.2. Which important governance or legal barriers that hinder you from realizing your pilot have we missed?

Not yet possible to answer, to be defined in the project

Description. The set of questions on this page addresses possible barriers that you might encounter and is used to inform the work of WP 1.1.

This is the last set of questions you will be asked with regard to barriers.

WP1 Q5. **Social barriers**

Please rate whether you agree or disagree with the following statements.

The following social elements of operating a Multi-use platform (MUP) pose a considerable barrier to realize the project:

	Completely disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Completely agree	Not applicable
Lack of social acceptance of the MUP by society in general.	○	●	○	○	○	○
Lack of acceptance of the MUP by the local affected community.	○	●	○	○	○	○
Lack of consensus about the MUP from multiple stakeholders in private and public sector.	○	○	●	○	○	○
Lack of trust between industry sectors directly involved in the MUP.	○	○	●	○	○	○
Lack of public awareness about implications of multi-use.	○	○	○	●	○	○
Low individual financial power and overall capacity to join MUP from local collaborators.	○	○	○	●	○	○
Conflicts of interest between different users of the sea (i.e. external tourist agencies, other energy producers, etc.).	○	○	○	●	○	○

WP1 Q5.1. Which social barrier do you consider as most problematic for the realization of your pilot?

Not able to asnwer yet, to be defined in the project

WP1 Q5.2. Which important social barriers that hinder you from realizing your pilot have we missed?

Not able to asnwer yet, to be defined in the project

Description. On the following pages you answer questions for WP 5, specifically about the social pillar of the MUP project.

Description. When we talk about stakeholders, we imply the following definition:

“We define stakeholders as individuals or institutions that may – directly or indirectly, positively or negatively – affect or be affected by a project or programme, in this case, the change from single use of a maritime space to the reality of having more uses in the same space”

This question was not displayed to the respondent.

Stakeholders1. Who do YOU consider to be your stakeholders?

This question was not displayed to the respondent.

Stakeholders2. Can you imagine people you may overlook but that will consider THEMSELVES to be a stakeholder in your activities?

This question was not displayed to the respondent.

WP5 Q1. How would you qualify your **identification** of local stakeholders in your pilot at the current point in time? (i.e. March 2020)

- ● Key stakeholders are yet to be identified
- ○ Some stakeholders identified
- ○ Most or all stakeholder identified

WP5 Q2. How would you qualify your **knowledge** of local stakeholders in your pilot at the current point in time? (i.e. March 2020)

- ● Knowledge is incomplete or poor
- ○ Average knowledge
- ○ Good knowledge
- ○ Excellent knowledge

WP5 Q3. Have reflections already taken place regarding the stakeholder involvement process of the pilot?

- ● No
- ○ Yes, namely

WP5 Q4. Which activities involving stakeholders have already taken place in the pilot's site?

- ○ Written communication toward local stakeholders
- ○ One-to-one meetings with targeted stakeholders
- ○ Collective meetings (workshops…)
- ○ Written consultation (questionnaire)
- ○ Other, namely:
- ● No activities have taken place, yet.

WP5 Q5. Please indicate which stakeholder information is currently available for your pilot.

- ○ A list of contacts, or stakeholder database
- ○ Reports or minutes of meeting with stakeholders
- ○ Results from a stakeholder consultation
- ○

Others, namely:

● None

WP5 Q6. What do you expect from stakeholder involvement in your pilot?

Yet to be defined with the pilot partners

WP5 Q7. What do you expect from the guidelines provided in WP5 for stakeholder involvement in the pilots? (please express your needs)

Yet to be defined with the pilot partners

WP5 Q8.
Do you have stakeholder involvement or facilitation expertise within the pilot partners?

● No

○ Yes, namely:

End. Thank you for filling out this survey.

You will be informed about the results of this survey in the form of the deliverables of the different work packages.

If you have any questions or feedback contact Marvin Kunz at marvin.kunz@wur.nl

Location Data

Location: [(51.919097900391, 4.44140625)]()

Source: GeoIP Estimation

ANNEX 6 – RESPONSE BELWIND

Q1.

Dear Sir or Madam, dear UNITED participant,

Welcome to this internal questionnaire for the European Union Horizon 2020 - UNITED project.

The here generated insights will directly benefit you in the further planning of your pilot as well as allow you to generalize potential insights that you have in the current setting you operate into slightly different scenarios.

The use of this information will be going towards publications and other deliveries that in one way or the other will be publicly disseminated. However, we will keep your identity confidential and we will treat all information anonymously when communicated to people outside of the Horizon 2020 - UNITED project.

The questionnaire will require some of your time. In an effort to take up as little of your time as possible, the answers you provide here will inform 4 different work packages - WP 1, WP 2, WP 3, and WP 5.

In case, you have any questions or something remains unclear, you can send an email to:
Marvin Kunz at marvin.kunz@wur.nl

Description. The following questions are necessary to help us understand your other answers better.

Pilot. In which pilot (country) are you participating in?

- ● Belgium
- ○ Denmark
- ○ Germany
- ○ Netherlands
- ○ Greece

Position. What is your position within the pilot?
(If you do not have a position, shortly describe your main responsibilities)

Pilot Lead: organization of pre-operational phase, operational-phase and decommissioning.

Q77. How many partners do you currently work with in realizing the MUP?

0 2 4 6 8 10 12 14 16 18 20

Number of partners	6

Description. The set of questions on this page addresses possible barriers that you might encounter and is used to inform the work of WP 1.1.

WP1 Q1. **Technological barriers**

Please rate whether you agree or disagree with the following statements.

The following technical elements of operating a multi-use platform (MUP) pose a considerable barrier to realize the project:

	Completely disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Completely agree	Not applicable
Lack of general technological knowledge available from the industry involved in MUPs in general (outside of the scope of UNITED).	○	○	○	●	○	○
Lack of general technological readiness level of all the parties involved with the MUP.	○	○	○	●	○	○
Lack of technological knowledge to allow MUP structure to withstand adverse weather conditions	●	○	○	○	○	○
Damage due to extreme adverse environmental catastrophic events (storms or underwater earthquakes)	○	○	○	○	●	○
Structural risk for MUP from accidental collision with (aquaculture) equipment	○	●	○	○	○	○
Vibration from wind turbines (when working with wind turbines)	●	○	○	○	○	○
Lack of infrastructure for energy provision for MUP	○	○	○	○	○	●
Risk of power failure	○	○	○	○	○	●
Risk of anchoring vessels damaging power supply cables	○	○	○	○	○	●
Lack of knowledge about specific anchoring techniques required	○	●	○	○	○	○
Risk of damage in case of mooring failure	○	○	○	●	○	○

WP1 Q1.2. Which technical barrier do you consider as most problematic for the realization of your pilot?

Damage due to extreme adverse environmental conditions is considered most important.

WP1 Q1.3. Which important technical barriers that hinder you from realizing your pilot have we missed?

Sampling + monitoring at depth. Requirement of specific vessels :- They have to fulfil the requirement imposed by the windfarms. - They need to be equipped with crane to lit the backbone to access to the oysters. This requires specialized equipment and knowledge

Q20. While the previous section asked questions about broader technical barriers, now, we want to know from you more details about the technological situation of your pilot.

This part of the questionnaire will include 2 pages with open questions and they are used to inform the work of WP 2.

WP2 Q1. Which technological issues did/do you encounter in the design/implementation/operation of the multi-use experiments in your pilot?

• Insufficient existence of biological data for that location, e.g. time and scale of spat fall, growth rates of oysters and seaweed • Insufficient knowledge on behaviour of some of the test equipment in open see • Not enough knowledge on existing technological solutions Those have been identified risks for the already existing single-use at the pilot location: - Loss of equipment due to storms - Inadequate material - Difficulties to install and retrieve equipment (restrictions of the boat)

WP2 Q1a. How did you overcome these issues?
(Or in case they still pose a problem, how do you plan on overcoming them?)

• Proper insurance (casco and for third parties) • Long-term monitoring of climate/weather data to derive conclusions about when the plant won't be accessible -> coordinating logistics based on these results • Pre-tests for time periods and concentration of spat fall, material for collectors • Flexible schedule • Knowledge of other mooring systems from existing offshore locations will be gathered and implemented to ensure safe conditions • A lot of internal meetings to come up with best solutions and take advantage of the expertise of the project partners

WP2 Q1b.
Which type of information/tool/equipment could have helped to avoid or reduce the impact of this issue on the experiment?

None

WP2 Q1c.
Which processes/parameters have you been monitoring since the start of your pilot?

• Several parameters measured during the last years until today: e.g. Hydrological data: direction of swell, significant wave height, max. swell/wave, water level, water surface temperature, water temperature 6/12/18 m at LAT) Technical data: wave height, forces on ropes to be applied,… Biological data: oyster growth, spat fall,…

WP2 Q2. Which technological issues/challenges do you see for the future upscaling of your experiment?

• In General: Offshore marine equipment can be physically complex, expensive, safety 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. Thus, every planning process is based on the fundamental understanding of diverse design parameters and how they interact. Design standards and guidelines exist for conventional equipment and structures, however a misunderstanding of these parameters or even a change in the operating environment can result in failure. • Damage risks of mechanical loads, collisions with vessels/ships/fishing boats • Drifting aquaculture construction strikes the turbine foundation -> damage to the foundation? Extra drag force -> drifting aquaculture construction gets stuck around the turbine foundation, increasing its surface area • Equipment/material that is resistant to: antifouling, high forces acting on installation (waves, tides, current, storms -> mooring), high salinity -> corrosion • Remote control/operation of plant (monitoring devices have to be automated) with high durability: autonomous up to one year (maintenance is expensive); deployment, service/maintenance and recovery of different materials/ measuring devices should be possible within one work stage • Sufficient database of biotic/abiotic factors (fields of: meteorology, physical oceanography, marine chemistry, biology, geology, geography) is needed to run realistic models during the planning/conception phase (simulation and calculation are based on long-term data recordings) • Material/equipment and installation processes do not negatively affect the environment (negative environmental impact is reduced) • Well-functioning of Data Acquisition and Control System (DACS) as well as a communication system -> Interactive real-time Internet connection to the DACS for data retrieval and/or reconfiguration of mission control is possible. • Access to all available data for marine scientists • Takes a long time to get permits from the government • Size of aquaculture farm does matter to make future growth profitable and hence economical feasible • Quick response/ fast track food and fodder quality tests is not yet established within the EU -> technical issue -> fast track test in Ireland is not validated in EU -> establishing in EU will take another 5 years

WP2 Q2a.
Which type of information/tool/equipment would help you to make upscaling of your multi-use activities possible?

• Broad data bases on biotic/abiotic factors and reliable models; software for analysis • Governmental support to develop the whole value chain • New tools for monitoring offshore • New technology to enhance connection between offshore and coast (reduction of travel time, independent from wheather conditions, …)

WP2 Q2b.

Would operational and/or forecasted data be helpful, such as certain physical or biological sea conditions? If yes, which parameters?

○ No

● Yes, - Hydrology: direction of current, significant wave height, max. swell/wave, water level, water temperature at different m at LAT, - pH, Chlorophyll, Toxic Algae , - predators: birds, fish, starfish, - Biological: spat fall, presence of oysters, presence of parasites (Bonamia, Marteilia)

WP2 Q2c.
What type of research would you need to make upscaling of your multi-use activities possible?

• Long-term impact studies (e.g. 10 years) of plants/material/equipment, at different site locations, testing various aquaculture technologies • Automatization solutions for monitoring • Growth rates of Oysters, Seaweed at different locations in the North Sea • Automatization to monitor toxic algae blooms • Automatization to monitor presence of parasites (Bonamia, Marteilia) • Research and overview of current legal aspects to obtain a permission to grow algae, oysters, etc. in multi-use areas

WP2 Q2d. Which processes/parameters are you going to monitor, in addition to or instead what you have been monitoring so far?

• Presence of parasites (Bonamia and Marteilia) which has never before been done for the Belgian part of the North Sea • Oyster spat fall • Oyster growth • Oyster restoration on the structures set out at sea • Kelp growth • If possible cameras or with AUV monitoring of settlement and restoration of material set at sea • Lander would have been interesting but is unfortunately no longer available

WP2 Q3. Which (technological) KPI's are you using to measure the success of your multi-use experiment?

The LCA and the economic feasibility study will determine whether the multi-use experiment can be expanded to a full commercial scale. The pilot (=experiment) is successful if the proposed deliveries are met. We hope to achieve the following: - Identification of good spat collector material that can be used as scour protection material for windfarms - A flat oyster growth model for the North Sea that can predict growth in function of the environmental factors (such as temperature, chla and POM) - Natural flat oyster seed is present in the North Sea - The ideal growth conditions for flat oysters in the North Sea are identified - Future windfarms use the scour protection that promotes the return of the flat oyster bed in the North Sea - Aquaculture of flat oyster and seaweed is possible in offshore conditions

Description. The set of questions on this page addresses possible barriers that you might encounter and is used to inform the work of WP 1.1.

WP1 Q2. **Economic barriers**

Please rate whether you agree or disagree with the following statements.

The following economic elements of operating a Multi-use platform (MUP) pose a considerable barrier to realize the project:

	Completely disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Completely agree	Not applicable
Lack of economic assessment tools to examining the economic viability of MUP.	○	○	○	●	○	○
Lack of certainty of effects of far offshore MUP on fish or oysters in aquacultures (with regard to economic effects).	○	○	○	○	●	○
Lack of attractiveness for private investors.	○	○	●	○	○	○
Lack of standardized procedures to co-use aspects related to the MUP (i.e. sharing cable equipment or ships)	○	●	○	○	○	○

High maintenance cost of aquaculture sites.	○	○	○	○	●	○
High cost of decommissioning of the MUP (potential costs after the end of the multi-use).	○	○	○	○	●	○
High insurance cost due to lack of of experience in co-location/MUP projects.	○	○	○	○	●	○
High insurance cost due to inherent risk associated with multiple use of the same platform.	○	○	○	○	●	○
High costs for grid connection.	○	○	○	○	○	●
Lack of expertise with business models and best practices.	○	○	○	●	○	○
Insufficient subsidies from the government.	○	●	○	○	○	○
High cost of maintenance.	○	○	○	○	●	○
High cost of operating staff.	○	○	○	○	●	○

WP1 Q2.1. Which economic barrier do you consider as most problematic for the realization of your pilot?

- Insurance and maintenance costs

WP1 Q2.2. Which important economic barriers that hinder you from realizing your pilot have we missed?

- Market potential and profit of the aquaculture enterprise

Description. On the following 4 pages you will answer questions for WP 3.1.
These questions look in detail at the economic situation of your pilot and will be used to give as a better understanding of the economic pillar for MUPs.

Description. The following questions are looking at the economic factors concering your pilot in more detail.

Please note, that when a word is written in this *way* (i.e. underlined and cursive) that it has additional information when you hover over it.

WP3 Q1.
What is the current status of economic activity in the pilot? What is planned and what is the current stage of implementation?

There have been no meetings for WP3. The economic activities will mostly take place in the last year of the project, when we have enough input data to make a business analysis

WP3 Q2.
What are the plans regarding the economic exploitation (products, target markets and demand) of the pilots?

Products: - flat oysters (Ostrea edulis) - ecosystem services - seaweed - energy Target markets: consumers of seafood, consumers of green energy, (client of ecosystem services = ecosystem itself?) Demand: demand for oysters and seaweed on the Belgian market (export possible too). Oysters: regional product in BE, NL, FR and surrounding. Seaweed: variation on possibilities – food, additives, bio-energy, biorefinement Demand for green energy Demand for ecosystem services

WP3 Q3. Please indicate which economic / financial information is currently available for your pilot.

WP3 Q4. *Financial feasibility study/information*

☐ Information openly available (please attach document or share web link)
☑ Information available, but confidential
☐ Information not now, but later available
☐ Information not available
☐ Comments

WP3 Q5. If the information about the financial feasibility study is openly available, please upload the document here.

WP3 Q6. *Socio-economic impact analysis*

☐ Information openly available (please attach document or share web link)
☐ Information available, but confidential
☑ Information not now, but later available
☐ Information not available
☐ Comments

WP3 Q7. If the information about the socio-economic impact analysis is openly available, please upload the document here.

WP3 Q8. *Business model/plan/strategy*

☐ Information openly available (please attach document or share web link)
☐ Information available, but confidential
☑ Information not now, but later available
☐ Information not available
☐ Comments

WP3 Q9. If the information about the business model/plan/strategy is openly available, please upload the document here.

WP3 Q10. *Pilot budget/cash balances*

☐ Information openly available (please attach document or share web link)

☑ Information available, but confidential

☐ Information not now, but later available

☐ Information not available

☐ Comments

WP3 Q11. If the information about the pilot budget/cash balances is openly available, please upload the document here.

WP3 Q12. Please specify any other economic / financial information currently available for your pilot.

See question about business model

WP3 Q13.
Parties that collaborate through a partnership in the pilot project probably possess part of the information requested under question 3. It is important to take stock of all available financial and economic information to develop optimized business cases in the course of the UNITED project. If necessary, we would like to contact these parties to collect information in the next phase of the project.

Examples of roles and services

	Is it a project partner or external stakeholder?	What is the role of the partner in the pilot project/which service do they provide?	What is the main interest of the partner to participate in the pilot project?	Who is the main contact person (first name, last name, email address)?
Partner 1 UGent	Project partner	Lead	Research results	Nancy Nevejan, Nancy.nevejan@ugent.be
Partner 2 Jan De Nul	Project partner	Responsible for technical functioning offshore, design structures offshore, design matrasses, solutions	Results	Simon Petit and Emile Lemey, project.united@jandenul.com
Partner 3 Brevisco	Project partner	Responsible for technical functioning nearshore	Results on aquaculture product	Stephanie Debels, stephaniedebels@hotmail.com
Partner 4 Parkwind	Project partner	Facilitator of the windmill parks, insurance	Applicability of multi-use of space	Dirk Vandercammen, Dirk.Vandercammen@Parkwind.eu
Partner 5 Colruyt	Project partner	LCA, economics	Possibility on producing oysters and algae and upscaling feasibility	Laura Pilgrim, laura.pilgrim@colruytgroup.com
Partner 6 RBINS	Project partner	Biological studies, Ecological implications	Research results	Steven Degraer , sdegraer@naturalsciences.be
Partner 7				

Partner 8

Partner 9

Partner 10

WP3 Q14.
What are expected *synergies* of combined use of the offshore platform? Please name some specific examples.

It is one of the goals in our pilot to identify these synergies, and so this will be an output of the project. Currently we expect some synergies, but they remain to be researched: - synergies in boat transfer for maintenance and monitoring in both the windmills, restoration and aquaculture activities. - synergies in the use of service vehicles. - synergies in the use of port facilities. - the ban of fisheries and boats to enter the windparks creates the perfect environment for restoration and aquaculture activities

WP3 Q15. What is the potential to scale up the existing solution?

High potential. Belgian windparks are restricted for fisheries, thus there is space for aquaculture and restoration activities.

WP3 Q19a.
Has any environmental impact assessment considering ecological impacts during the construction and operation phase been undertaken at the pilot or at the specific activity levels?

○ No, namely:

● Yes (please attach document or share web link) • They will be included in the risk analysis, but environmental risk are minimum during the operational phase. • Since we are working in a Natura 2000 area during the pre-operational phase, an evaluation had to be made.

WP3 Q19 Upload. If you have chosen yes in the above question and have a document to upload, please do so here.

WP3 Q19b. If you answered yes to the above question, have ecological/environmental impacts of multi-use been measured with indicators?

○ No

●

Yes, please specify	Possible risks, Effect of culture systems on sea mammals, Effect of paint release due to loose aquaculture systems rubbing against the turbines, Collison of crew vessels with loose aquaculture systems and leading to loss of fuel

WP3 Q16. What would you like to obtain from business and economic analyses in UNITED in relation to your pilot: Which key socio-economic questions/challenges/aspects should be addressed for your pilot? Please ask your pilot partners also.

- economic feasibility of aquaculture in the windmillparks (distance, structures that have to be robust,..) - identification of synergies between restoration, aquaculture and activities in the wind mill parks - socio-economic question: how does the consumer look at aquaculture products from wind mill parks? Are consumers sceptic or are they convinced of the nice story?

WP3 Q17.
Bearing in mind the project's objectives and activities as described in the project proposal, how do you see the role of economic/financial tasks within the UNITED project with respect to your pilot?

Calculate economic feasibility, identify possible synergies that can ameliorate the economic feasibility. This by gathering data throughout the project.

WP3 Q18. Do you have economic / financial expertise within the pilot partners?

○ No

● Yes, namely:

Colruyt Group as Belgian retailer (knowledge on market prices, consumers preferences, volumes, …)

Description. The set of questions on this page addresses possible barriers that you might encounter and is used to inform the work of WP 1.1.

WP1 Q3. **Environmental barriers**

Please rate whether you agree or disagree with the following statements.

The following environmental elements of operating a Multi-use platform (MUP) pose a considerable barrier to realize the project:

	Completely disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Completely agree	Not applicable

Increased traffic of MUP support vessels resulting in damage to the ecosystem.	○	●	○	○	○	○
Increasing risk of pollution events (mainly excessive nutrient load and other substances) due to the installation of aquaculture cages.	○	○	○	●	○	○
Potential, real and perceived, conflicts among marine ecosystem flora and fauna due to artificial introduction of invasive species.	○	○	○	●	○	○
Risk of the cumulative effect of several aquaculture locations and the disturbance they can cause for the local ecosystem.	○	●	○	○	○	○
Underwater-noise disturbance of marine mammals such as wales.	●	○	○	○	○	○
Disturbance of the seabed sediments and seabed communities.	○	○	○	●	○	○
Collision risks to birds and bats above water	○	○	○	○	○	●
Attraction of unwanted invasive species at the location of the MUP.	○	○	○	○	●	○

WP1 Q3.1. Which environmental barrier do you consider as most problematic for the realization of your pilot?

Although we do not consider any environmental effect as a problematic barrier for realising the pilot, we do have concerns about the installation of additional hard structures which might act as substrates for unwanted invasive species; and about the organic enrichment of the seabed (although the currents in this marine zone might 'dilute' the organic enrichment).

WP1 Q3.2. Which important environmental barriers that hinder you from realizing your pilot have we missed?

None

Description. The set of questions on this page addresses possible barriers that you might encounter and is used to inform the work of WP 1.1.

WP1 Q4. **Governance and legal barriers**

Please rate whether you agree or disagree with the following statements.

The following governance or legal elements of operating a Multi-use platform (MUP) pose a considerable barrier to realize the project:

	Completely disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Completely agree	Not applicable
Unclear and fragmented regulation for MUPs on national level.	●	○	○	○	○	○
Unclear and fragmented regulation for MUPs on European level.	○	○	●	○	○	○
Strict security regulation that discourage setting up a MUP	○	●	○	○	○	○
The set of constrains related to safety distance to other users or distance form shore.	○	●	○	○	○	○

Separate environmental impact assessment processes (permitting) for each of the (hybrid) technologies and lack of guidance on cumulative impact assessment.	●	○	○	○	○	○
Lack of established licensing procedures for multi-use projects.	●	○	○	○	○	○
Lack of dialogue between public institutions and difficulties in identifying the administrative offices responsible for issuing permits.	●	○	○	○	○	○
Lack of cross-border cooperation in MUP projects.	○	○	●	○	○	○
Lack of established procedures for spatial planning of the sea with a focus on the the interests of different stakeholders.	●	○	○	○	○	○
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)	○	○	○	○	●	○
Lack of established safety assessment methods for MUPs.	○	○	○	●	○	○

WP1 Q4.1. Which governance related or legal barrier do you consider as most problematic for the realization of your pilot?

None

WP1 Q4.2. Which important governance or legal barriers that hinder you from realizing your pilot have we missed?

None

Description. The set of questions on this page addresses possible barriers that you might encounter and is used to inform the work of WP 1.1.

This is the last set of questions you will be asked with regard to barriers.

WP1 Q5. **Social barriers**

Please rate whether you agree or disagree with the following statements.

The following social elements of operating a Multi-use platform (MUP) pose a considerable barrier to realize the project:

	Completely disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Completely agree	Not applicable
Lack of social acceptance of the MUP by society in general.	○	●	○	○	○	○
Lack of acceptance of the MUP by the local affected community.	●	○	○	○	○	○
Lack of consensus about the MUP from multiple stakeholders in private and public sector.	○	●	○	○	○	○
Lack of trust between industry sectors directly involved in the MUP.	○	○	●	○	○	○
Lack of public awareness about implications of multi-use.	○	○	○	●	○	○

Low individual financial power and overall capacity to join MUP from local collaborators.	○	○	○	○	●	○
Conflicts of interest between different users of the sea (i.e. external tourist agencies, other energy producers, etc.).	○	○	○	○	●	○

WP1 Q5.1. Which social barrier do you consider as most problematic for the realization of your pilot?

Low individual financial power and overall capacity to join MUP from local collaborators.

WP1 Q5.2. Which important social barriers that hinder you from realizing your pilot have we missed?

None

Description. On the following pages you answer questions for WP 5, specifically about the social pillar of the MUP project.

Description. When we talk about stakeholders, we imply the following definition:

“We define stakeholders as individuals or institutions that may – directly or indirectly, positively or negatively – affect or be affected by a project or programme, in this case, the change from single use of a maritime space to the reality of having more uses in the same space”

This question was not displayed to the respondent.

Stakeholders1. Who do YOU consider to be your stakeholders?

This question was not displayed to the respondent.

Stakeholders2. Can you imagine people you may overlook but that will consider THEMSELVES to be a stakeholder in your activities?

This question was not displayed to the respondent.

WP5 Q1. How would you qualify your **identification** of local stakeholders in your pilot at the current point in time? (i.e. March 2020)

- ○ Key stakeholders are yet to be identified
- ● Some stakeholders identified
- ○ Most or all stakeholder identified

WP5 Q2. How would you qualify your **knowledge** of local stakeholders in your pilot at the current point in time? (i.e. March 2020)

- ○ Knowledge is incomplete or poor
- ● Average knowledge
- ○ Good knowledge
- ○ Excellent knowledge

WP5 Q3. Have reflections already taken place regarding the stakeholder involvement process of the pilot?

● No

○ Yes, namely

WP5 Q4. Which activities involving stakeholders have already taken place in the pilot's site?

○ Written communication toward local stakeholders

● One-to-one meetings with targeted stakeholders

○ Collective meetings (workshops…)

○ Written consultation (questionnaire)

○ Other, namely:

○ No activities have taken place, yet.

WP5 Q5. Please indicate which stakeholder information is currently available for your pilot.

○ A list of contacts, or stakeholder database

○ Reports or minutes of meeting with stakeholders

● Results from a stakeholder consultation

○ Others, namely:

○ None

WP5 Q6. What do you expect from stakeholder involvement in your pilot?

Overcome barriers for future cooperation, better public acceptance of marine aquaculture, overcome legal barriers (government)

WP5 Q7. What do you expect from the guidelines provided in WP5 for stakeholder involvement in the pilots? (please express your needs)

Supporting tools (examples - studies - ...) to motivate the stakeholders acceptance of MUP

WP5 Q8.
Do you have stakeholder involvement or facilitation expertise within the pilot partners?

○ No

● Yes, namely:

`not specified`

End. Thank you for filling out this survey.

You will be informed about the results of this survey in the form of the deliverables of the different work packages.

If you have any questions or feedback contact Marvin Kunz at marvin.kunz@wur.nl

Location Data

Location: (51.944107055664, 4.3838958740234)

Source: GeoIP Estimation

ANNEX 7 – RESPONSE MIDDELGRUNDEN WIND

Q1.

Dear Sir or Madam, dear UNITED participant,

Welcome to this internal questionnaire for the European Union Horizon 2020 - UNITED project.

The here generated insights will directly benefit you in the further planning of your pilot as well as allow you to generalize potential insights that you have in the current setting you operate into slightly different scenarios.

The use of this information will be going towards publications and other deliveries that in one way or the other will be publicly disseminated. However, we will keep your identity confidential and we will treat all information anonymously when communicated to people outside of the Horizon 2020 - UNITED project.

The questionnaire will require some of your time. In an effort to take up as little of your time as possible, the answers you provide here will inform 4 different work packages - WP 1, WP 2, WP 3, and WP 5.

In case, you have any questions or something remains unclear, you can send an email to:
Marvin Kunz at marvin.kunz@wur.nl

Description. The following questions are necessary to help us understand your other answers better.

Pilot. In which pilot (country) are you participating in?

- ○ Belgium
- ● Denmark
- ○ Germany
- ○ Netherlands
- ○ Greece

Position. What is your position within the pilot?
(If you do not have a position, shortly describe your main responsibilities)

manager

Q77. How many partners do you currently work with in realizing the MUP?

0 2 4 6 8 10 12 14 16 18 20

Number of partners 4

Description. The set of questions on this page addresses possible barriers that you might encounter and is used to inform the work of WP 1.1.

WP1 Q1. **Technological barriers**

Please rate whether you agree or disagree with the following statements.

The following technical elements of operating a multi-use platform (MUP) pose a considerable barrier to realize the project:

	Completely disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Completely agree	Not applicable
Lack of general technological knowledge available from the industry involved in MUPs in general (outside of the scope of UNITED).	○	○	●	○	○	○
Lack of general technological readiness level of all the parties involved with the MUP.	○	●	○	○	○	○
Lack of technological knowledge to allow MUP structure to withstand adverse weather conditions	○	●	○	○	○	○
Damage due to extreme adverse environmental catastrophic events (storms or underwater earthquakes)	●	○	○	○	○	○
Structural risk for MUP from accidental collision with (aquaculture) equipment	○	○	○	○	○	●
Vibration from wind turbines (when working with wind turbines)	●	○	○	○	○	○
Lack of infrastructure for energy provision for MUP	○	○	○	○	○	●
Risk of power failure	●	○	○	○	○	○
Risk of anchoring vessels damaging power supply cables	●	○	○	○	○	○
Lack of knowledge about specific anchoring techniques required	○	○	●	○	○	○
Risk of damage in case of mooring failure	○	○	○	○	○	●

WP1 Q1.2. Which technical barrier do you consider as most problematic for the realization of your pilot?

no technical barriers

WP1 Q1.3. Which important technical barriers that hinder you from realizing your pilot have we missed?

non

Q20. While the previous section asked questions about broader technical barriers, now, we want to know from you more details about the technological situation of your pilot.

This part of the questionnaire will include 2 pages with open questions and they are used to inform the work of WP 2.

WP2 Q1. Which technological issues did/do you encounter in the design/implementation/operation of the multi-use experiments in your pilot?

no technological barriers

WP2 Q1a. How did you overcome these issues?
(Or in case they still pose a problem, how do you plan on overcoming them?)

not relevant

WP2 Q1b.
Which type of information/tool/equipment could have helped to avoid or reduce the impact of this issue on the experiment?

non

WP2 Q1c.
Which processes/parameters have you been monitoring since the start of your pilot?

number of visitors and trips

WP2 Q2. Which technological issues/challenges do you see for the future upscaling of your experiment?

no technical challenges

WP2 Q2a.
Which type of information/tool/equipment would help you to make upscaling of your multi-use activities possible?

not relevant

WP2 Q2b.
Would operational and/or forecasted data be helpful, such as certain physical or biological sea conditions?
If yes, which parameters?

○ No

● Yes, forecast of wave and current

WP2 Q2c.
What type of research would you need to make upscaling of your multi-use activities possible?

safety issues when climb a turbine; how to evacuate a person from a wind tower when having a leg broken or similar

WP2 Q2d. Which processes/parameters are you going to monitor, in addition to or instead what you have been monitoring so far?

missed opportunities for visit caused by lack of inferstructure

WP2 Q3. Which (technological) KPI's are you using to measure the success of your multi-use experiment?

non

Description. The set of questions on this page addresses possible barriers that you might encounter and is used to inform the work of WP 1.1.

WP1 Q2. **Economic barriers**

Please rate whether you agree or disagree with the following statements.

The following economic elements of operating a Multi-use platform (MUP) pose a considerable barrier to realize the project:

	Completely disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Completely agree	Not applicable
Lack of economic assessment tools to examining the economic viability of MUP.	●	○	○	○	○	○
Lack of certainty of effects of far offshore MUP on fish or oysters in aquacultures (with regard to economic effects).	○	○	○	○	○	●
Lack of attractiveness for private investors.	○	○	○	●	○	○
Lack of standardized procedures to co-use aspects related to the MUP (i.e. sharing cable equipment or ships)	○	○	●	○	○	○
High maintenance cost of aquaculture sites.	○	○	○	○	○	●
High cost of decommissioning of the MUP (potential costs after the end of the multi-use).	○	○	○	○	○	●
High insurance cost due to lack of of experience in co-location/MUP projects.	○	○	○	●	○	○
High insurance cost due to inherent risk associated with multiple use of the same platform.	○	○	○	●	○	○
High costs for grid connection.	○	○	○	○	○	●
Lack of expertise with business models and best practices.	○	○	○	●	○	○
Insufficient subsidies from the government.	○	○	○	○	●	○
High cost of maintenance.	○	○	●	○	○	○
High cost of operating staff.	○	○	○	●	○	○

WP1 Q2.1. Which economic barrier do you consider as most problematic for the realization of your pilot?

cost of operating staff

WP1 Q2.2. Which important economic barriers that hinder you from realizing your pilot have we missed?

non

Description. On the following 4 pages you will answer questions for WP 3.1.
These questions look in detail at the economic situation of your pilot and will be used to give as a better understanding of the economic pillar for MUPs.

Description. The following questions are looking at the economic factors concering your pilot in more detail.

Please note, that when a word is written in this *way* (i.e. underlined and cursive) that it has additional information when you hover over it.

WP3 Q1.
What is the current status of economic activity in the pilot? What is planned and what is the current stage of implementation?

we want to open for new groups and new activities like divers

WP3 Q2.
What are the plans regarding the economic exploitation (products, target markets and demand) of the pilots?

we have to discuss with the stake holders especially the owners of the wind farm about their attitude to increased activity

WP3 Q3. Please indicate which economic / financial information is currently available for your pilot.

WP3 Q4. *Financial feasibility study/information*

- ☐ Information openly available (please attach document or share web link)
- ☑ Information available, but confidential
- ☑ Information not now, but later available
- ☐ Information not available
- ☑ Comments the economy of new activities is not known

WP3 Q5. If the information about the financial feasibility study is openly available, please upload the document here.

WP3 Q6. Socio-economic impact analysis

- ☐ Information openly available (please attach document or share web link) ☐
- ☐ Information available, but confidential
- ☐ Information not now, but later available
- ☑ Information not available
- ☐ Comments

WP3 Q7. If the information about the socio-economic impact analysis is openly available, please upload the document here.

WP3 Q8. Business model/plan/strategy

- ☐ Information openly available (please attach document or share web link)
- ☑ Information available, but confidential
- ☐ Information not now, but later available
- ☑ Information not available
- ☑ Comments: the new activities have not been discussed with all partners to be involved

WP3 Q9. If the information about the business model/plan/strategy is openly available, please upload the document here.

WP3 Q10. Pilot budget/cash balances

- ☐ Information openly available (please attach document or share web link)
- ☑ Information available, but confidential
- ☐ Information not now, but later available
- ☑ Information not available
- ☑ Comments: as above

WP3 Q11. If the information about the pilot budget/cash balances is openly available, please upload the document here.

vist Middelgrunden 2020.pdf
154.6KB
application/pdf

WP3 Q12. Please specify any other economic / financial information currently available for your pilot.

A standard description of different trips are available

WP3 Q13.
Parties that collaborate through a partnership in the pilot project probably possess part of the information requested under question 3. It is important to take stock of all available financial and economic information to develop optimized business cases in the course of the UNITED project. If necessary, we would like to contact these parties to collect information in the next phase of the project.

Examples of roles and services

	Is it a project partner or external stakeholder?	What is the role of the partner in the pilot project/which service do they provide?	What is the main interest of the partner to participate in the pilot project?	Who is the main contact person (first name, last name, email address)?
Partner 1 Boat provider	externaal stakeholder	boat service	service provider	NA now
Partner 2 Copenhagen divers	external stakeholder	want to provide services	develop diving oportunities	NA now
Partner 3				
Partner 4				
Partner 5				
Partner 6				
Partner 7				
Partner 8				
Partner 9				
Partner 10				

WP3 Q14.
What are expected *synergies* of combined use of the offshore platform? Please name some specific examples.

open up for new opportunitets for tourisme

WP3 Q15. What is the potential to scale up the existing solution?

Not considered

WP3 Q19a.
Has any environmental impact assessment considering ecological impacts during the construction and operation phase been undertaken at the pilot or at the specific activity levels?

● No, namely: not relevant

○ Yes (please attach document or share web link)

WP3 Q19 Upload. If you have chosen yes in the above question and have a document to upload, please do so here.

WP3 Q19b. If you answered yes to the above question, have ecological/environmental impacts of multi-use been measured with indicators?

○ No

○ Yes, please specify

WP3 Q16. What would you like to obtain from business and economic analyses in UNITED in relation to your pilot: Which key socio-economic questions/challenges/aspects should be addressed for your pilot? Please ask your pilot partners also.

feasibility

WP3 Q17.
Bearing in mind the project's objectives and activities as described in the project proposal, how do you see the role of economic/financial tasks within the UNITED project with respect to your pilot?

essential

WP3 Q18. Do you have economic / financial expertise within the pilot partners?

○ No

●

Yes, namely:

standard business school knowledge

Description. The set of questions on this page addresses possible barriers that you might encounter and is used to inform the work of WP 1.1.

WP1 Q3. **Environmental barriers**

Please rate whether you agree or disagree with the following statements.

The following environmental elements of operating a Multi-use platform (MUP) pose a considerable barrier to realize the project:

	Completely disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Completely agree	Not applicable
Increased traffic of MUP support vessels resulting in damage to the ecosystem.	●	○	○	○	○	○
Increasing risk of pollution events (mainly excessive nutrient load and other substances) due to the installation of aquaculture cages.	○	○	○	○	○	●
Potential, real and perceived, conflicts among marine ecosystem flora and fauna due to artificial introduction of invasive species.	○	○	○	○	○	●
Risk of the cumulative effect of several aquaculture locations and the disturbance they can cause for the local ecosystem.	○	○	○	○	○	●
Underwater-noise disturbance of marine mammals such as wales.	○	○	○	○	○	●
Disturbance of the seabed sediments and seabed communities.	○	○	○	○	○	●
Collision risks to birds and bats above water	○	○	○	○	○	●
Attraction of unwanted invasive species at the location of the MUP.	○	○	○	○	○	●

WP1 Q3.1. Which environmental barrier do you consider as most problematic for the realization of your pilot?

grabish from visitors

WP1 Q3.2. Which important environmental barriers that hinder you from realizing your pilot have we missed?

the risk of having more tourism at the site may open up for the general public so they beleive it is a public site - stakeholders are afraid of having a Disney Land image for a production facility

Description. The set of questions on this page addresses possible barriers that you might encounter and is used to inform the work of WP 1.1.

WP1 Q4. **Governance and legal barriers**

Please rate whether you agree or disagree with the following statements.

The following governance or legal elements of operating a Multi-use platform (MUP) pose a considerable barrier to realize the project:

	Completely disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Completely agree	Not applicable
Unclear and fragmented regulation for MUPs on national level.	○	○	○	○	●	○
Unclear and fragmented regulation for MUPs on European level.	○	○	○	○	●	○
Strict security regulation that discourage setting up a MUP	○	○	○	○	●	○
The set of constrains related to safety distance to other users or distance form shore.	●	○	○	○	○	○
Separate environmental impact assessment processes (permitting) for each of the (hybrid) technologies and lack of guidance on cumulative impact assessment.	○	○	●	○	○	○
Lack of established licensing procedures for multi-use projects.	○	○	○	○	○	●
Lack of dialogue between public institutions and difficulties in identifying the administrative offices responsible for issuing permits.	○	○	○	○	●	○
Lack of cross-border cooperation in MUP projects.	●	○	○	○	○	○
Lack of established procedures for spatial planning of the sea with a focus on the the interests of different stakeholders.	○	○	●	○	○	○
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)	●	○	○	○	○	○
Lack of established safety assessment methods for MUPs.	○	○	○	○	●	○

WP1 Q4.1. Which governance related or legal barrier do you consider as most problematic for the realization of your pilot?

saftety

WP1 Q4.2. Which important governance or legal barriers that hinder you from realizing your pilot have we missed?

non

Description. The set of questions on this page addresses possible barriers that you might encounter and is used to inform the work of WP 1.1.

This is the last set of questions you will be asked with regard to barriers.

WP1 Q5. **Social barriers**

Please rate whether you agree or disagree with the following statements.

The following social elements of operating a Multi-use platform (MUP) pose a considerable barrier to realize the project:

	Completely disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Completely agree	Not applicable
Lack of social acceptance of the MUP by society in general.	○	○	○	●	○	○
Lack of acceptance of the MUP by the local affected community.	○	○	○	○	●	○
Lack of consensus about the MUP from multiple stakeholders in private and public sector.	○	○	○	○	●	○
Lack of trust between industry sectors directly involved in the MUP.	○	○	○	○	●	○
Lack of public awareness about implications of multi-use.	○	○	○	○	●	○
Low individual financial power and overall capacity to join MUP from local collaborators.	○	○	○	○	●	○
Conflicts of interest between different users of the sea (i.e. external tourist agencies, other energy producers, etc.).	○	○	○	○	●	○

WP1 Q5.1. Which social barrier do you consider as most problematic for the realization of your pilot?

Low individual financial power and overall capacity to join MUP from local collaborators

WP1 Q5.2. Which important social barriers that hinder you from realizing your pilot have we missed?

non

Description. On the following pages you answer questions for WP 5, specifically about the social pillar of the MUP project.

Description. When we talk about stakeholders, we imply the following definition:

“We define stakeholders as individuals or institutions that may – directly or indirectly, positively or negatively – affect or be affected by a project or programme, in this case, the change from single use of a maritime space to the reality of having more uses in the same space”

This question was not displayed to the respondent.

Stakeholders1. Who do YOU consider to be your stakeholders?

This question was not displayed to the respondent.

Stakeholders2. Can you imagine people you may overlook but that will consider THEMSELVES to be a stakeholder in your activities?

This question was not displayed to the respondent.

WP5 Q1. How would you qualify your **identification** of local stakeholders in your pilot at the current point in time? (i.e. March 2020)

○ Key stakeholders are yet to be identified
○ Some stakeholders identified
● Most or all stakeholder identified

WP5 Q2. How would you qualify your **knowledge** of local stakeholders in your pilot at the current point in time? (i.e. March 2020)

○ Knowledge is incomplete or poor
○ Average knowledge
○ Good knowledge
● Excellent knowledge

WP5 Q3. Have reflections already taken place regarding the stakeholder involvement process of the pilot?

● No
○ Yes, namely

WP5 Q4. Which activities involving stakeholders have already taken place in the pilot's site?

● Written communication toward local stakeholders
○ One-to-one meetings with targeted stakeholders
○ Collective meetings (workshops…)
○ Written consultation (questionnaire)
○ Other, namely:

○ No activities have taken place, yet.

WP5 Q5. Please indicate which stakeholder information is currently available for your pilot.

● A list of contacts, or stakeholder database
○ Reports or minutes of meeting with stakeholders
○ Results from a stakeholder consultation
○

Others, namely:

○ None

WP5 Q6. What do you expect from stakeholder involvement in your pilot?

not to be foreseen

WP5 Q7. What do you expect from the guidelines provided in WP5 for stakeholder involvement in the pilots? (please express your needs)

no special needs

WP5 Q8.
Do you have stakeholder involvement or facilitation expertise within the pilot partners?

● No

○ Yes, namely:

End. Thank you for filling out this survey.

You will be informed about the results of this survey in the form of the deliverables of the different work packages.

If you have any questions or feedback contact Marvin Kunz at marvin.kunz@wur.nl

Location Data

Location: (55.850006103516, 12.183303833008)

Source: GeoIP Estimation

ANNEX 8 – RESPONSE KASTELLORIZO

Q1.

Dear Sir or Madam, dear UNITED participant,

Welcome to this internal questionnaire for the European Union Horizon 2020 - UNITED project.

The here generated insights will directly benefit you in the further planning of your pilot as well as allow you to generalize potential insights that you have in the current setting you operate into slightly different scenarios.

The use of this information will be going towards publications and other deliveries that in one way or the other will be publicly disseminated. However, we will keep your identity confidential and we will treat all information anonymously when communicated to people outside of the Horizon 2020 - UNITED project.

The questionnaire will require some of your time. In an effort to take up as little of your time as possible, the answers you provide here will inform 4 different work packages - WP 1, WP 2, WP 3, and WP 5.

In case, you have any questions or something remains unclear, you can send an email to:
Marvin Kunz at marvin.kunz@wur.nl

Description. The following questions are necessary to help us understand your other answers better.

Pilot. In which pilot (country) are you participating in?

- ○ Belgium
- ○ Denmark
- ○ Germany
- ○ Netherlands
- ● Greece

Position. What is your position within the pilot?
(If you do not have a position, shortly describe your main responsibilities)

Pilot Leader

Q77. How many partners do you currently work with in realizing the MUP?

0 2 4 6 8 10 12 14 16 18 20

Number of partners	3

Description. The set of questions on this page addresses possible barriers that you might encounter and is used to inform the work of WP 1.1.

WP1 Q1. **Technological barriers**

Please rate whether you agree or disagree with the following statements.

The following technical elements of operating a multi-use platform (MUP) pose a considerable barrier to realize the project:

	Completely disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Completely agree	Not applicable
Lack of general technological knowledge available from the industry involved in MUPs in general (outside of the scope of UNITED).	○	●	○	○	○	○
Lack of general technological readiness level of all the parties involved with the MUP.	○	○	○	●	○	○
Lack of technological knowledge to allow MUP structure to withstand adverse weather conditions	○	○	○	●	○	○
Damage due to extreme adverse environmental catastrophic events (storms or underwater earthquakes)	○	○	○	○	●	○
Structural risk for MUP from accidental collision with (aquaculture) equipment	○	○	●	○	○	○
Vibration from wind turbines (when working with wind turbines)	○	○	●	○	○	○
Lack of infrastructure for energy provision for MUP	○	●	○	○	○	○
Risk of power failure	○	○	○	●	○	○
Risk of anchoring vessels damaging power supply cables	○	○	○	○	●	○
Lack of knowledge about specific anchoring techniques required	○	○	○	●	○	○
Risk of damage in case of mooring failure	○	●	○	○	○	○

WP1 Q1.2. Which technical barrier do you consider as most problematic for the realization of your pilot?

Network connectivity

WP1 Q1.3. Which important technical barriers that hinder you from realizing your pilot have we missed?

N/A

Q20. While the previous section asked questions about broader technical barriers, now, we want to know from you more details about the technological situation of your pilot.

This part of the questionnaire will include 2 pages with open questions and they are used to inform the work of WP 2.

WP2 Q1. Which technological issues did/do you encounter in the design/implementation/operation of the multi-use experiments in your pilot?

Potential issues that might be encountered are: 1) connectivity issues (no 4G available on site), 2) secure installation of camera and sensors (equipment to be securely placed in the aquaculture infrastructure), 3) Adequate power supply

WP2 Q1a. How did you overcome these issues?
(Or in case they still pose a problem, how do you plan on overcoming them?)

1) Regarding connectivity, we could find alternative connectivity protocols and transmission systems such as LoRA, ZigBee, wifi, in order to transmit data from aquaculture devices to an in-between node that would be closer to a 4G network. 2) Regarding successful installation of cameras and sensors, we should be prepared, make visits to the aquaculture site to plan and design proper installation and ask expert advice on what is the best way to install such devices to the existing infrastructure 3) In order to check that existing power supply in site is adequate for the devices to work, we need to check beforehand the consumption of the devices and to check the power supply options available on site

WP2 Q1b.
Which type of information/tool/equipment could have helped to avoid or reduce the impact of this issue on the experiment?

Partly answered on previous question. In the case of inadequate connectivity, we will need a loRA gateway and the in-between node. In the case of power supply, we will need to install extra solar panels.

WP2 Q1c.
Which processes/parameters have you been monitoring since the start of your pilot?

We have conducted interviews with aquaculture stakeholder, providing us information regarding cleaning processes of the site, monitoring infrastructure, and quality parameters are collected manually via sampling methods. Data from quality monitoring could be requested by the stakeholder. Connectivity and power information have also been provided.

WP2 Q2. Which technological issues/challenges do you see for the future upscaling of your experiment?

Maintenance-calibration issues (more devices more maintenance), network load (multiple sensors/cameras), power issues (maybe panels wont be able to cover the site's needs)

WP2 Q2a.
Which type of information/tool/equipment would help you to make upscaling of your multi-use activities possible?

Increase of the network bandwidth, to support multi equipment transmission, install extra solar panels to cover the power needs

WP2 Q2b.
Would operational and/or forecasted data be helpful, such as certain physical or biological sea conditions?
If yes, which parameters?

○ No

● Yes, mostly the operational

WP2 Q2c.
What type of research would you need to make upscaling of your multi-use activities possible?

1) Measurements and analytics of network performance, 2) Identify the limits of the infrastructure to enhance if needed, 3) Research of power alternatives and calculation of power needs of possible camera equipment

WP2 Q2d. Which processes/parameters are you going to monitor, in addition to or instead what you have been monitoring so far?

Processes to be monitored will be: For aquaculture site: 1) feeding procedures, 2) Repairing infrastructure (nets, anchors), 3) Maintenance on technological equipment installed (sensors, cameras), 4) waste management processes, 5) behaviour monitoring , disease diagnosis for the fish. Regarding the Scuba Diving center: Timetable of scheduled expeditions to site, 2) Equipment used for expeditions. Parameters to be monitored: Water quality parameters, such as Dissolved oxygen, temperature, chlorophyll, nitrate

WP2 Q3. Which (technological) KPI's are you using to measure the success of your multi-use experiment?

Network performance (and what percentage of the desired use time is covered by the infrastructure), power coverage of the site (how much we would like to use in terms of how much power we can account for), and quality services KPIS as well, such as to list operator needs and percentages of them covered

Description. The set of questions on this page addresses possible barriers that you might encounter and is used to inform the work of WP 1.1.

WP1 Q2. **Economic barriers**

Please rate whether you agree or disagree with the following statements.

The following economic elements of operating a Multi-use platform (MUP) pose a considerable barrier to realize the project:

	Completely disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Completely agree	Not applicable
Lack of economic assessment tools to examining the economic viability of MUP.	○	○	○	●	○	○
Lack of certainty of effects of far offshore MUP on fish or oysters in aquacultures (with regard to economic effects).	○	○	○	○	○	●
Lack of attractiveness for private investors.	○	●	○	○	○	○
Lack of standardized procedures to co-use aspects related to the MUP (i.e. sharing cable equipment or ships)	○	○	○	○	●	○
High maintenance cost of aquaculture sites.	○	●	○	○	○	○
High cost of decommissioning of the MUP (potential costs after the end of the multi-use).	○	○	○	●	○	○
High insurance cost due to lack of of experience in co-location/MUP projects.	○	○	○	●	○	○
High insurance cost due to inherent risk associated with multiple use of the same platform.	○	○	○	●	○	○
High costs for grid connection.	○	○	●	○	○	○
Lack of expertise with business models and best practices.	○	○	○	○	●	○
Insufficient subsidies from the government.	○	○	○	○	●	○
High cost of maintenance.	○	○	○	●	○	○
High cost of operating staff.	○	●	○	○	○	○

WP1 Q2.1. Which economic barrier do you consider as most problematic for the realization of your pilot?

Lack of expertise with business models and best practices and insurance costs

WP1 Q2.2. Which important economic barriers that hinder you from realizing your pilot have we missed?

None

Description. On the following 4 pages you will answer questions for WP 3.1.
These questions look in detail at the economic situation of your pilot and will be used to give as a better understanding of the economic pillar for MUPs.

Description. The following questions are looking at the economic factors concering your pilot in more detail.

Please note, that when a word is written in this *way* (i.e. underlined and cursive) that it has additional information when you hover over it.

WP3 Q1.
What is the current status of economic activity in the pilot? What is planned and what is the current stage of implementation?

In the Greek pilot site, the current business activities that take place are the aquaculture business and the scuba diving tours taking place in the wider area. The plan is to combine these two business activities for the benefit of both. The current state is to enhance the aquaculture with technological tools to enhance the operations and monitoring of the site. As a second stage, we plan to create a set of activities that will require both businesses, such as scuba-diving tours in the aquaculture site as well as scuba diving divers and equipment to enhance the operations of the aquaculture site.

WP3 Q2.
What are the plans regarding the economic exploitation (products, target markets and demand) of the pilots?

Regarding the scuba-diving center, the plan is to introduce to their customers/members a new promising attraction and potentially increase the interest for scuba-diving tours. Diving in aquaculture sites is a rising trend that gives scuba divers the ability to enjoy the natural beauty created by the aquaculture (wild fish gathering to be fed by the food provided to fish inside cages). Regarding the aquaculture business, the monitoring and decision support platform that will be provided to them from this project will help them gain more control over their business, scedule better their operational activities and act timely to events (alerts and notifications will be sent to them through the platform). The scuba diving center will also enhance their coslty operational activities, by providing equipment such as ROVS (remote operating vehicles) for infrastructure inspections that are difficult to be carried out (such as anchors inspection). This overall improvement of operational activities will reflect to the end product of the aquaculture business.

WP3 Q3. Please indicate which economic / financial information is currently available for your pilot.

WP3 Q4. Financial feasibility study/information

- ☐ Information openly available (please attach document or share web link)
- ☐ Information available, but confidential
- ☑ Information not now, but later available
- ☐ Information not available
- ☐ Comments

WP3 Q5. If the information about the financial feasibility study is openly available, please upload the document here.

WP3 Q6. *Socio-economic impact analysis*

- ☐ Information openly available (please attach document or share web link) ☐
- ☐ Information available, but confidential
- ☑ Information not now, but later available
- ☐ Information not available
- ☐ Comments

WP3 Q7. If the information about the socio-economic impact analysis is openly available, please upload the document here.

WP3 Q8. *Business model/plan/strategy*

- ☐ Information openly available (please attach document or share web link)
- ☐ Information available, but confidential
- ☑ Information not now, but later available
- ☐ Information not available
- ☐ Comments

WP3 Q9. If the information about the business model/plan/strategy is openly available, please upload the document here.

WP3 Q10. *Pilot budget/cash balances*

- ☐ Information openly available (please attach document or share web link)
- ☐ Information available, but confidential
- ☐ Information not now, but later available
- ☑ Information not available
- ☐ Comments

WP3 Q11. If the information about the pilot budget/cash balances is openly available, please upload the document here.

WP3 Q12. Please specify any other economic / financial information currently available for your pilot.

Economic/financial information not yet available to pilot leader but can be provided upon request.

WP3 Q13.
Parties that collaborate through a partnership in the pilot project probably possess part of the information requested under question 3. It is important to take stock of all available financial and economic information to develop optimized business cases in the course of the UNITED project. If necessary, we would like to contact these parties to collect information in the next phase of the project.

Examples of roles and services

	Is it a project partner or external stakeholder?	What is the role of the partner in the pilot project/which service do they provide?	What is the main interest of the partner to participate in the pilot project?	Who is the main contact person (first name, last name, email address)?
Partner 1 Ioanna Drigkopoulou	project partner	first point of contact/ tasks coordinator	for project purposes	Ioanna Drigkopoulou, idrigopoulou@wings-ict-solutions.eu
Partner 2 Stavros Iatrou	project partner	main point of contact for aquaculture business	for project purposes	Stavros Iatrou, staiatrou@gmail.com
Partner 3 Maria Karavasiliadou	external stakeholder	financial manager of aquaculture	for project purposes	Maria Karavasiliadou, mkaravasiliadou@kastelorizo.com.gr
Partner 4 Kostas Thoctaridis	project partner	scuba diving center owner	for project purposes	Kostas Thoctaridis, info@planetblue.gr
Partner 5 Caterina Callitsis	project partner	point of contact for scuba diving center	for project purposes	Caterina Callitsis, info@planetblue.gr
Partner 6				
Partner 7				
Partner 8				
Partner 9				
Partner 10				

WP3 Q14.
What are expected *synergies* of combined use of the offshore platform? Please name some specific examples.

Synergies with aquaculture business and touristic activities taking place in the form of scuba-diving tours in the pilot site. Examples already mentioned in previous answers.

WP3 Q15. What is the potential to scale up the existing solution?

Scaling up of the solution will potentially take place in the technological part, with monitoring infrastructure that need to be deployed in site to make sure the environmental conditions are not disturbed, as well as aquaculture product is safe from the combined activities (behavior monitoring of fish through cameras).

WP3 Q19a.
Has any environmental impact assessment considering ecological impacts during the construction and operation phase been undertaken at the pilot or at the specific activity levels?

○ No, namely:

● Yes (please attach document or share web link) Needs to be translated

WP3 Q19 Upload. If you have chosen yes in the above question and have a document to upload, please do so here.

23124-1196_28-02-2020_ΑΕΠΟ 29,76 ΣΤΡ & 462,12 ΤΟΝ.pdf
713.1KB
application/pdf

WP3 Q19b. If you answered yes to the above question, have ecological/environmental impacts of multi-use been measured with indicators?

● No

○ Yes, please specify

WP3 Q16. What would you like to obtain from business and economic analyses in UNITED in relation to your pilot: Which key socio-economic questions/challenges/aspects should be addressed for your pilot? Please ask your pilot partners also.

1) Social acceptance of local community, 2) Growth of touristic interest in the area, 3) Advertisement of the aquaculture products (aquaculture owner also owns a great number of restaurants - potential benefit from UNITED synergies in the site), 4)local stakeholders (other local businesses such as local travel agencies, local restaurants, local press and public ministry) to support the synergies for long term benefit of the wider area

WP3 Q17.
Bearing in mind the project's objectives and activities as described in the project proposal, how do you see the role of economic/financial tasks within the UNITED project with respect to your pilot?

Economic/financial tasks within the UNITED project, will help to evaluate the overall benefit of businesses moving forward to synergies rather than acting individually in same marine space

WP3 Q18. Do you have economic / financial expertise within the pilot partners?

● No

○

Yes, namely:

Description. The set of questions on this page addresses possible barriers that you might encounter and is used to inform the work of WP 1.1.

WP1 Q3. **Environmental barriers**

Please rate whether you agree or disagree with the following statements.

The following environmental elements of operating a Multi-use platform (MUP) pose a considerable barrier to realize the project:

	Completely disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Completely agree	Not applicable
Increased traffic of MUP support vessels resulting in damage to the ecosystem.	○	○	○	●	○	○
Increasing risk of pollution events (mainly excessive nutrient load and other substances) due to the installation of aquaculture cages.	○	○	○	○	●	○
Potential, real and perceived, conflicts among marine ecosystem flora and fauna due to artificial introduction of invasive species.	○	○	●	○	○	○
Risk of the cumulative effect of several aquaculture locations and the disturbance they can cause for the local ecosystem.	○	○	○	●	○	○
Underwater-noise disturbance of marine mammals such as wales.	○	○	○	○	○	●
Disturbance of the seabed sediments and seabed communities.	○	○	○	●	○	○
Collision risks to birds and bats above water	○	○	○	○	●	○
Attraction of unwanted invasive species at the location of the MUP.	○	○	○	●	○	○

WP1 Q3.1. Which environmental barrier do you consider as most problematic for the realization of your pilot?

Increasing risk of pollution events (mainly excessive nutrient load and other substances) due to the installation of aquaculture cages and disturbance of seabed

WP1 Q3.2. Which important environmental barriers that hinder you from realizing your pilot have we missed?

None

Description. The set of questions on this page addresses possible barriers that you might encounter and is used to inform the work of WP 1.1.

WP1 Q4. **Governance and legal barriers**

Please rate whether you agree or disagree with the following statements.

The following governance or legal elements of operating a Multi-use platform (MUP) pose a considerable barrier to realize the project:

	Completely disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Completely agree	Not applicable
Unclear and fragmented regulation for MUPs on national level.	○	○	○	○	●	○
Unclear and fragmented regulation for MUPs on European level.	○	○	○	○	●	○
Strict security regulation that discourage setting up a MUP	○	○	○	○	●	○
The set of constrains related to safety distance to other users or distance form shore.	○	○	○	●	○	○
Separate environmental impact assessment processes (permitting) for each of the (hybrid) technologies and lack of guidance on cumulative impact assessment.	○	○	○	●	○	○
Lack of established licensing procedures for multi-use projects.	○	○	○	○	●	○
Lack of dialogue between public institutions and difficulties in identifying the administrative offices responsible for issuing permits.	○	○	○	●	○	○
Lack of cross-border cooperation in MUP projects.	○	○	●	○	○	○
Lack of established procedures for spatial planning of the sea with a focus on the the interests of different stakeholders.	○	○	○	○	●	○
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)	○	●	○	○	○	○
Lack of established safety assessment methods for MUPs.	○	○	○	●	○	○

WP1 Q4.1. Which governance related or legal barrier do you consider as most problematic for the realization of your pilot?

Strict security regulation that discourage setting up a MUP

WP1 Q4.2. Which important governance or legal barriers that hinder you from realizing your pilot have we missed?

Delays of gaining permits from public institutions

Description. The set of questions on this page addresses possible barriers that you might encounter and is used to inform the work of WP 1.1.

This is the last set of questions you will be asked with regard to barriers.

WP1 Q5. **Social barriers**

Please rate whether you agree or disagree with the following statements.

The following social elements of operating a Multi-use platform (MUP) pose a considerable barrier to realize the project:

	Completely disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Completely agree	Not applicable
Lack of social acceptance of the MUP by society in general.	○	○	●	○	○	○
Lack of acceptance of the MUP by the local affected community.	○	○	○	○	●	○
Lack of consensus about the MUP from multiple stakeholders in private and public sector.	○	○	○	○	●	○
Lack of trust between industry sectors directly involved in the MUP.	○	○	○	●	○	○
Lack of public awareness about implications of multi-use.	○	○	○	●	○	○
Low individual financial power and overall capacity to join MUP from local collaborators.	○	○	○	●	○	○
Conflicts of interest between different users of the sea (i.e. external tourist agencies, other energy producers, etc.).	○	○	○	●	○	○

WP1 Q5.1. Which social barrier do you consider as most problematic for the realization of your pilot?

Lack of consensus about the MUP from multiple stakeholders in private and public sector.

WP1 Q5.2. Which important social barriers that hinder you from realizing your pilot have we missed?

None

Description. On the following pages you answer questions for WP 5, specifically about the social pillar of the MUP project.

Description. When we talk about stakeholders, we imply the following definition:

“We define stakeholders as individuals or institutions that may – directly or indirectly, positively or negatively – affect or be affected by a project or programme, in this case, the change from single use of a maritime space to the reality of having more uses in the same space”

This question was not displayed to the respondent.

Stakeholders1. Who do YOU consider to be your stakeholders?

This question was not displayed to the respondent.

Stakeholders2. Can you imagine people you may overlook but that will consider THEMSELVES to be a stakeholder in your activities?

This question was not displayed to the respondent.

WP5 Q1. How would you qualify your **identification** of local stakeholders in your pilot at the current point in time? (i.e. March 2020)

- ○ Key stakeholders are yet to be identified
- ● Some stakeholders identified
- ○ Most or all stakeholder identified

WP5 Q2. How would you qualify your **knowledge** of local stakeholders in your pilot at the current point in time? (i.e. March 2020)

- ○ Knowledge is incomplete or poor
- ● Average knowledge
- ○ Good knowledge
- ○ Excellent knowledge

WP5 Q3. Have reflections already taken place regarding the stakeholder involvement process of the pilot?

- ○ No
- ● Yes, namely

main stakeholders, the owners of the synergies are positive and willing to participate

WP5 Q4. Which activities involving stakeholders have already taken place in the pilot's site?

- ○ Written communication toward local stakeholders
- ● One-to-one meetings with targeted stakeholders
- ○ Collective meetings (workshops…)
- ○ Written consultation (questionnaire)
- ○ Other, namely:
- ○ No activities have taken place, yet.

WP5 Q5. Please indicate which stakeholder information is currently available for your pilot.

- ● A list of contacts, or stakeholder database
- ○ Reports or minutes of meeting with stakeholders
- ○ Results from a stakeholder consultation
- ○

Others, namely:

○ None

WP5 Q6. What do you expect from stakeholder involvement in your pilot?

I expect a positive feedback and willingness to get involved from key stakeholders. Public institutions are expected to be neutral or possible negative. We are not sure the local community how will react to the synergies.

WP5 Q7. What do you expect from the guidelines provided in WP5 for stakeholder involvement in the pilots? (please express your needs)

To propose tools or ways of communication with stakeholders. To establish guidelines and best practices to keep them committed. And to evaluate the public acceptance before and after the synergies.

WP5 Q8.
Do you have stakeholder involvement or facilitation expertise within the pilot partners?

○ No

● Yes, namely:

technology provider, tasks coordinator

End. Thank you for filling out this survey.

You will be informed about the results of this survey in the form of the deliverables of the different work packages.

If you have any questions or feedback contact Marvin Kunz at marvin.kunz@wur.nl

Location Data

Location: (37.98420715332, 23.735305786133)

Source: GeoIP Estimation