MERMAID

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Summary

This report presents method, results and lessons learned from the participatory design process of the MERMAID project. The MERMAID project develops design concepts for the next generation of offshore activities for multi-use of ocean space. The work presented in this report consists of two evaluations: (1) an evaluation of the proposed designs of Multi-Use offshore Platforms (MUPs) in four European marine sites, and (2) an evaluation of the MERMAID participatory design process carried out with stakeholders in the four regions. Basis for the evaluations are the replies of stakeholders to a questionnaire on the proposed MUP design as well as questions to MERMAID colleagues about how MERMAID took into account stakeholders' recommendations, received during the entire MERMAID participatory design process. These comments are documented in MERMAID Deliverables 2.2 and 2.3. The evaluation questionnaire of the four proposed MUP designs was sent out to 74 stakeholders; 27 replied. This corresponds to an overall response rate of 36%, which, for such type of questionnaires is in line with reported response rates. Answers of certain stakeholder groups are lacking, which causes a potential bias. For example, the lack of involvement of particularly the government bodies in the Baltic case study might be a reason for the stakeholders' high uncertainty concerning the legal feasibility of a MUP (75% don't know).

The proposed MUP designs were developed through an inter- and transdisciplinary participatory design process: a cyclical, iterative participatory design methodology, involving all relevant stakeholders in the design process, and taking into consideration the integration of technical, economic, ecological, spatial and social aspects. The interactive process focused on working together with the users and other relevant stakeholders throughout the design and development process.

(1) Conclusions concerning the evaluation of the proposed MUP designs

The 24 respondents who participated in the evaluation of the proposed final designs were generally positive about the feasibility of a MUP in their region. Around 60% of all respondents were positive about the feasibility of MUPs in their region in general (67%), the technical feasibility (63%), and the potential for socio-economic benefits of the proposed MUP design (67%). 50% of the respondents indicated that the proposed MUP design meets their expectations.

The stakeholders' greatest concerns in all four sites relate to the financing of a MUP project. This concern is mainly due to lack of knowledge and information to be able to evaluate the financial feasibility (42% indicating "don't know").

(2) Conclusions concerning the evaluation of the MERMAID participatory design process

This report shows that the MERMAID participatory approach was feasible to be carried out in all four case studies, although the sites were different and were in different stages of realising a MUP in reality. In the first place, this process of interactively scoping, envisioning and learning has created a common understanding of MUPs and an awareness of the future potential of MUPs among the stakeholders. One MUP concept for each of the four MERMAID case study sites has been developed, proposed and evaluated.

In terms of gathering the technical knowledge and agreeing on a final MUP design, the four site specific processes can be considered efficient. In terms of involving the relevant stakeholders and communicating with them transparently, MERMAID has succeeded in creating awareness about MUPs, increasing stakeholders' knowledge, building networks to proceed further with in order to generate pilot studies.

The experience from the MERMAID participatory design methodology has resulted in a number of recommendations. (i) Before starting to design a MUP, it is recommended to start with an initial assessment of the context, i.e. investigate the situation and conditions of the site under consideration, including identification of stakeholders, project phase and internal project developments. (ii) Transparency in communication is crucial, as is always in a participatory processes. If stakeholders are asked for input and feedback at different stages is a process, it is important to communicate transparently not only once at the end of a project but at each stage, in order to allow stakeholders to easily trace back how their input has been used/ applied or not.

In order to promote the opportunities of MUPs, increased MUP awareness of governmental ministries is particularly important, because regulatory/legislative government incentives are urgently needed. Incentives are also needed to encourage pilot studies for activities that need to be tested offshore. For the future, interdisciplinary research and collaboration needs to focus intensively on getting the financial numbers right. In all four MERMAID MUP proposals, the greatest uncertainty concerns financial feasibility. If financial synergies of multi-use can be demonstrated to reduce costs, combining multi-use activities offshore can be viable in the future.

1. Introduction

The MERMAID project[1] develops design concepts for the next generation of offshore activities for multi-use of ocean space, focussing on four specific sites in European waters:

- Baltic Sea – Kriegers Flak
- North Sea – Gemini location 85 km off the Northern Dutch coast
- Atlantic – Cantabrian Offshore Site
- Mediterranean – Adriatic Sea off Venice

The MERMAID approach is inter- and transdisciplinary, taking into consideration the integration of technical, economic, ecological, spatial and social aspects, and involving all relevant stakeholders in the design process. The MERMAID project developed a cyclical, iterative participatory design methodology in order to facilitate the process of involving all relevant stakeholders in the design process (see D2.2 by Rasenberg et al., 2013). The focus of this participatory design process was to work together with the users and other relevant stakeholders throughout the design process. This participatory process of scoping, envisioning and learning should finally result in a common understanding of MUPs, shared by all stakeholders, and four MUP designs for each of the for MERMAID case study sites specifically.

Objective of the report

The aim of this report is to present an evaluation of the proposed MUP designs and the interactive process itself at the four sites, on the basis of:

(i) a stakeholder evaluation of the four MUP designs (questions for email interviews), and

(ii) an internal evaluation how MERMAID took into account stakeholders' recommendations (summarised from deliverables D2.2. and D2.3).

The design concepts were developed through the participatory design process, led by the site managers, and their teams (work packages (WPs) 2 and 7 of the MERMAID project: WP 2: Assessment of policy, planning and management strategies; and WP 7: innovative platform plan and design[1]).

[1] http://www.mermaidproject.eu/

Outline of the report

Chapter 2 presents the methodologies used: the interactive methodology of the MERMAID participatory design process and the chosen evaluation methodology of the last round of the participatory design process. Chapters 3 – 6 zoom in on the four MERMAID case studies. For each site an introduction to the site and the proposed design is presented, a summary of the MERMAID participatory design process as implemented in each case, the input from stakeholders and how it was taken into consideration, the stakeholders' evaluation of the proposed final design, and the site specific conclusions. Chapter 7 presents the main conclusions and recommendations regarding the MERMAID participatory design process. In addition, Annex 1 presents an example of a draft email sent out together with the list of 14 evaluation questions. Annexes 2-5 present summary presentations of the proposed design of a multi-use offshore platform (MUP) at the four MERMAID sites.

2. Methodology of the MERMAID participatory design process

2.1 MERMAID interactive participatory design process

The MERMAID participatory design process was developed to involve stakeholders in the process of designing the MUP. Two principles underlie this approach:

a) The principle of non-linear knowledge generation. This principle acknowledges that knowledge is developed in a complex, interactive process of co-production with a range of stakeholders involved (Gibbons et al., 1994; Rip, 2000).
b) The principle of social learning. This principle states that all one can do in complex and uncertain search processes for sustainable designs with no ready-made solutions at hand, is to experiment and learn from these experiments in a social environment through interaction with other actors and learn from each other's behaviour (Bandura, 1971).

The first step that was executed during the MERMAID participatory design process consisted of defining the views and needs of relevant stakeholders in the four different case studies. These four case studies were chosen during the first phase of the MERMAID project and are:

1. The Baltic Sea - a typical estuarine area with fresh water from rivers and salt water.
2. The transboundary area of the North Sea & Wadden Sea - a typical active morphology site
3. The Atlantic Ocean - a typical exposed deep water site
4. The Mediterranean Sea - a typical sheltered deep water site.

Figure 2.1 gives an overview of the participatory design process which is applied in these four case studies in the MERMAID project. The design process of MUPs in the four cases is organised in three steps:

1. Prepare the designs by identifying the views and needs of all stakeholders with interviews (Result: D2.2; Rasenberg et al., 2013)
2. Designing the MUP by organising a round table session involving all stakeholders (result D2.3; Rasenberg et al., 2014)
3. Evaluate the design by organising a round table session with all stakeholders (result D2.4; this report)

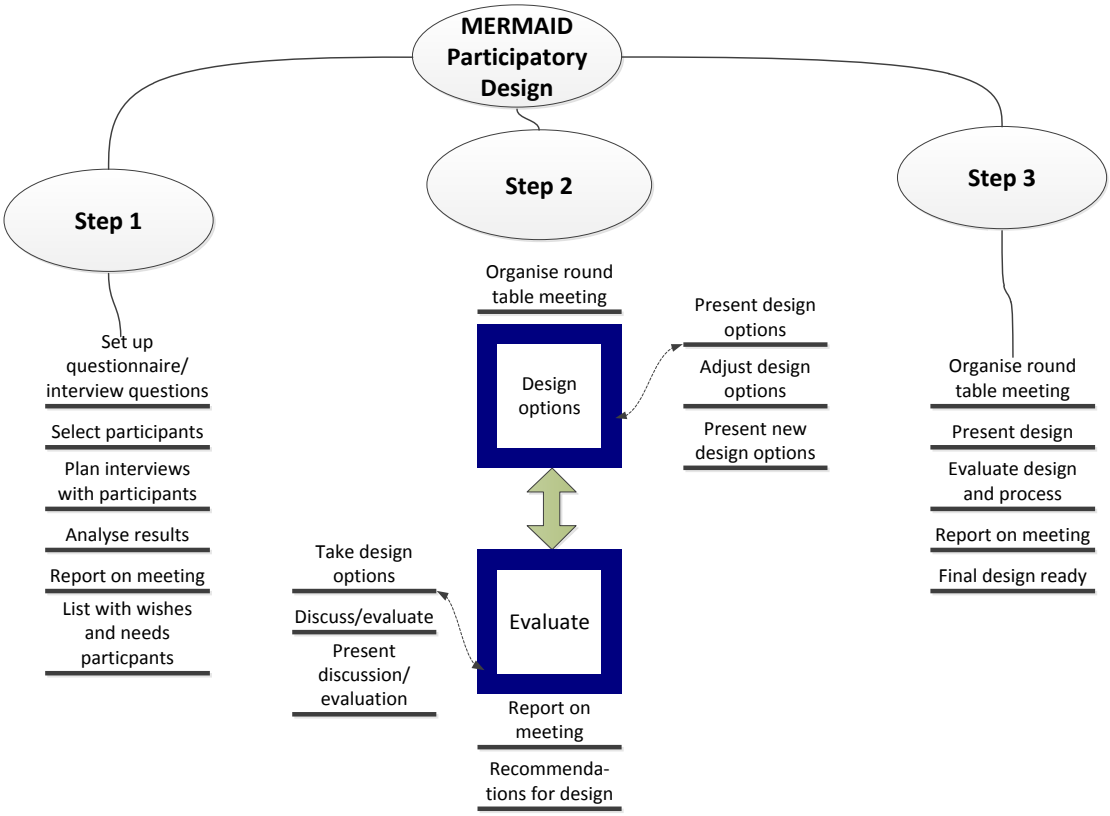

Figure 2.1 Overview of the MERMAID participatory design process

The work performed in the participatory process was not to make the final design, but to organise the input of the stakeholders that can be used to make the final design. The final design has been the responsibility of the site managers (each site has a site manager) for the different case studies in WP 7 of the MERMAID project. The site manager has also played a crucial role in organising the three steps of the participatory design.

Central in this approach are the interviews in step 1 with all the stakeholders and the two so-called round table sessions in steps 2 and 3. Steps 2 and 3 have a cyclical, iterative nature. In these round table sessions, the design was discussed and adapted according to the wishes of all stakeholders involved. Given the cyclical, iterative and participatory nature of the work a sequence of steps can be envisaged, which may be repeated. A group of representatives of all major types of stakeholders were invited for the interviews and round table sessions, where six stakeholder categories were identified:

1. Governing bodies/policy makers such as regional, national and European officers
2. End users of the MUP, e.g. energy companies and aquaculture entrepreneurs
3. Suppliers of the MUP such as cable companies and construction businesses
4. Representatives of other offshore activities such as fisheries, shipping, and mining sectors
5. Discourse community, including e.g. (environmental) NGO's, local citizens
6. Universities and research institutes

Step 1 took place in 2012 and the results of step 1 are reported in Rasenberg et al. (2013). In step 1, interviews were held with representatives of a wide range of stakeholders. Step 1 focussed on identifying different views on ecological, economic and social objectives of MUPs, challenges and technical, social-economic and ecological constraints faced. Equipped with a resulting wish list from this step, designers started working on developing the first MUP design options. These design options were discussed later in step 2, an interactive round table session involving all relevant stakeholders.

After step 1, the designers of each of the case studies made one or more design options based on technical feasibility and the earlier wishes expressed by the stakeholders. These options for design(s) were discussed with the stakeholders in step 2 of the participatory approach: the site specific round table meetings. These round tables represent an iterative cycle where draft design options were presented, stakeholders were asked for their feedback and further input, and designs were further developed. Involving stakeholders in the design process aimed at reaching agreement on the most feasible design in each of the case studies, taking into account the technical, economic, ecological, spatial and social possibilities in a complex, interactive process. Note that the process was not identically applied in all four case studies. Deliverable 2.3 (Rasenberg et al., 2014) describes the results of step 2. Based on the discussions in the round table sessions of these design options with regard to ecological, economic, social, technical and governance aspects, the design options were translated into a final design concept, which are presented in this report and in MERMAID Deliverable 7.2.

Step 3 was originally meant to be a round table session where the final design concept is evaluated with the participating stakeholders.
During a MERMAID project workshop in September 2014, which was meant to detail for each of the four sites how to move from step 2 (design cycle) to step 3 (the final design), the MERMAID project team unanimously decided to modify the original approach, because all site managers reported "stakeholder fatigue", indicating that no stakeholder would be willing to participate in a final MERMAID evaluation round table workshop. The main reason for this

fatigue is that there are still too many obstacles (regulatory, institutional, financial, social and economic) when it comes to implementing multi-use offshore platforms (MUPs) in real life: three of the four MUP sites are scientific research projects on paper. Only the Baltic Sea case study was initially relatively close to a real case, with the offshore wind park on Kriegers Flak in the phase of being built. However, the actual licence had only been given for building a single-use offshore wind park, not for building a MUP. In this respect, the Baltic Sea case study was similar to the North Sea case study, where there is a license for the single-use GEMINI wind parks.

In order to avoid a round table without participants, WP2 and site managers decided to adapt the original step 3 (as described in the WP2 inception report) of the MERMAID participatory approach: instead of organizing a final round table with stakeholders to evaluate the final design, it was agreed to carry out the stakeholder evaluation of the final designs through individual email interviews. The modified approach is as follows:

- Summary slides presenting the proposed MUP design.
  - Including summary of technical, environmental, socio/economic, financial assessments for each site
- Summary: How was stakeholders' info used in the preparation of the final conceptual designs?
  WP2 organized a workshop on 19 March 2015 with all site managers together to carry out the final internal evaluation. Deadline for finalized summaries was 24 February 2015.
- Email-interview questions for stakeholders, to evaluate the designs and the process.

This ultimately led to a design concept which is thoroughly analysed, technically feasible and preferably supported by all the stakeholders represented at the round table.

2.2 Evaluation methodology

The following two subsections describe the MERMAID evaluation methodology, consisting of two parts, i.e., the internal MERMAID evaluation (2.2.1), and the external stakeholder evaluation (2.2.2).

2.2.1 MERMAID internal evaluation

All stakeholder comments as reported in D2.2 and D2.3 were summarised and reflected upon, see individual site chapters 3.3, 4.3, 5.3 and 6.3. Furthermore, the answers were discussed and reflected upon by the MERMAID project team during the workshop in March 2015. The internal evaluation thus considers the question: Why and how have stakeholders' comments been taken into account or not? The workshop with site managers was carried out to clarify, to reflect and synthesize.

2.2.2 Stakeholders' evaluation

Due to the reported "stakeholder fatigue", the external stakeholder evaluation of the proposed MUP designs were carried out through individual email interviews. Annex 1 shows an example email sent out to the stakeholders with the list of 14 evaluation questions. The 14 questions are generic questions about the design; the evaluation is based on the stakeholders' present judgements. The email also contained a pdf file with a short (6-7 slides) summary presentation of the proposed MUP design, which also includes the main summary information from the technical, environmental, socio/economic, financial assessments. Stakeholders were asked to briefly answer (and comment on) 14 short evaluation questions, in order to evaluate and comments on the proposed MUP design, as presented in the summary slides attached to the email.

In the Baltic and Atlantic case studies, return rates of 57% and 50 % were reached, respectively. The return rate in the North Sea case study is 34%, and in the Mediterranean case study 13 %.

3. Baltic Sea site

In the Baltic Sea, the site of Kriegers Flak has been proposed as the location for a MUP design. It reflects a real business case.

3.1 The proposed final MUP design – Baltic Sea site

The summary presentation of the proposed design of a multi-use offshore platform (MUP), a wind-fish farm at Kriegers Flak in the Baltic Sea, is included in Annex 2. It is based on a summary prepared by MERMAID site manager: Ole Svenstrup Petersen, Date: 23.2.2015, and the slides present the following information:

1. Picture/figure(s) of the design; location; production estimates
2. Site characteristics; possible synergies of combined uses
3. Technical characteristics of each MUP element
4. Financial characteristics (cost & revenue estimates)
5. Legal/regulatory/institutional conditions to be met
6. Environmental effects (+/- estimates)
7. Social-economic benefits/ obstacles

3.2 The MERMAID participatory approach – Baltic Sea site

Stakeholders involved – Baltic Sea site

Participants were selected on the basis of involvement in the case study area of Kriegers Flak. Different categories of stakeholders were discerned. There are the potential entrepreneurs to participate in the development of a multi-use platform, i.e. the potential “End users of the MUP”, such as DONG Energy, MUSH Aquaculture, but also “suppliers of a MUP” and “stakeholders from other offshore activities”. There are “governing bodies” like Fishery Inspection (Fiskerikontrol øst) and the Shipping Authority (Soefartsstyrelsen) that have a voice in the spatial planning procedures. There is the “discourse community”, with, e.g., the non-governmental organisations, such as the environmental Green Centre, representing societal values. Also, parties from “Universities” (e.g. DTU and DHI) were interviewed that have a stake in the Research and Development of the multi-use platforms.

Round 1, December 2012: All relevant representatives from the 6 different stakeholder groups were invited to the first round table session (cf. D 2.2, p.16); 6 of the invited stakeholders attended the session, and afterwards 3 other stakeholders were interviewed.

Round 2, January 2014: 19 stakeholders were invited; Representatives of 7 different organisations (cf. D 2.3, p.39) attended the meeting, which was held in Danish. These representatives are active participants in the MERMAID project and are categorized as follows:

Stakeholder group	Representatives
Governing bodies/regulators/policy makers as regional, national and European officers	0
End users of the MUP, e.g. energy companies and aquaculture entrepreneurs	2
Suppliers of the MUP such as cable companies and construction businesses	0
Stakeholders from other offshore activities such as fisheries, shipping & mining sectors	1
Discourse community, including e.g. (environmental) NGO's, local citizens	3
Universities and research institutes	1

During this second round table meeting, MERMAID presented a draft design suggestion to the industry partners, and together they reflected on this design. The Baltic case study reflects a real business case, with actors involved to develop it further. Relevant stakeholders were selected based on their interest in a Baltic MUP.

Round 3, February-March 2015:
For this final evaluation of the MUP design proposed by the MERMAID Baltic site team, emails were sent out to 14 stakeholders, of which 8 have provided answers, i.e. a 57% response rate. The 14 stakeholders addressed are categorized as follows:

Stakeholder group	contacted	replied
Governing bodies/regulators/policy makers as regional, national and European officers	1	1
End users of the MUP, e.g. energy companies and aquaculture entrepreneurs	3	3
Suppliers of the MUP such as cable companies and construction businesses	1	0
Stakeholders from other offshore activities such as fisheries, shipping & mining sectors	1	0
Discourse community, including e.g. (environmental) NGO's, local citizens	5	2
Universities and research institutes	3	2

Has MERMAID missed any relevant stakeholder/ stakeholder group/ sector?

Stakeholders representatives from all identified relevant stakeholder groups were contacted, however, not all groups have actively become involved. During round 2, the governing bodies/regulators/policy makers were missing as well as suppliers of MUPs. During round 3, suppliers and stakeholders from other offshore activities were missing. The lack of involvement of particularly the government bodies might be a reason that the final MUP design will probably not be realised. The Baltic case study benefited from the fact that many relevant stakeholders were involved as active partners in the MERMAID project. The groups that were not represented are those not formally involved in MERMAID, i.e., the maritime and political organizations such as OSPAR or EMSA. Apparently these organisations have more priority on near-realizable projects. Also the construction side has been missing, apparently mostly due to commercial and competitive reasons.

3.3 Stakeholders' input and MERMAID internal evaluation – Baltic Sea site

The following tables (left column), summarise all comments, feedback and recommendations received from the stakeholders contacted during the MERMAID participatory process, rounds 1 and 2. All input has been clustered according to technical, financial, environmental, social-economic aspects, and one final table for general aspects.

The right columns in the tables below explain, for each issue raised by the stakeholders, how MERMAID has dealt with and responded to this input in the development and choice of the proposed MUP design.

Technical aspects	
Stakeholders' concerns	**MERMAID response**
Important conditions: Land proximity, shallow water, stable seabed, moderate met-ocean conditions, cold water located on main nutrient transport path	Yes, all these conditions are met at the chosen location of Kriegers Flak.

Focus on a combination of gravity or jacket based wind turbines and offshore aquaculture.	Yes, the proposed MUP is a wind-fish-seaweed farm. However: MERMAID proposes to use either gravity or monopile foundations for the wind turbines, because these two are today commercially the most efficient solution. Industrial jackets are coming into the horizon, but are still at TRL 2-3.
Risks associated with maintenance, monitoring, anchoring and transport. ==> Technical risk assessment required.	Technical risk assessment has been incorporated into the design process and the stakeholder discussion.
Establish site-specific database with met-ocean conditions and with climate variations and extreme events.	Database has been established.

Financial aspects	
Stakeholders' concerns	**MERMAID response**
Examine possible cost reductions and perform an analysis regarding possible arrangements and contracts.	Possible cost reductions have not been performed, as well as an analysis regarding possible arrangements and contracts, because at this stage our focus has been on developing the concept MUP.
Find alternative economic options by exploring MUP development strategies.	Alternative economic options have not been explored anymore, because at this stage focus has been on the development of efficient concepts. Alternatives have been considered in the earlier design process.

Environmental/ ecological aspects	
Stakeholders' concerns	**MERMAID response**
Required environmental characteristics: Located on the path for deep water renewal of the Baltic, and on the main path for nutrient transport out of the Baltic.	Yes, these conditions are all met at the chosen location of Kriegers Flak.
There should be no negative impact on ecological conditions. ==> Ecological risk assessment required.	Ecological risk assessment has been carried out.

Protect wind turbine foundations as artificial reefs. ==> place fish cages at sufficient distance!	Yes, fish cages are to be placed at 500 m distance from the wind turbines.

Social-economic aspects	
Stakeholders' concerns	**MERMAID response**
No negative effects on landscape views from the shore. Avoid visibility of wind turbines.	Visibility of the wind turbines from the shore depends on the weather conditions. Distance to shore is 30 km so only at special locations and in favourable weather conditions will visibility be an issue.
Formulate guidelines and rules to ensure safety.	Guidelines and rules have not yet been formulated.
Involve society. The final MUP design should be discussed with a wider group of stakeholders.	Additional stakeholder meetings/ contacts etc. with a wider group of stakeholders have (not) been organized and carried out yet. Stakeholder consultation is a pivotal part of the design activities, thus additional stakeholder consultation will be carried out at the final stages of this project.

General comments/recommendations	
Stakeholders' concerns	**MERMAID response**
Kriegers Flak is considered suitable for multi-use. Combination wind energy with aquaculture is considered the most viable option, generating the highest benefits.	Yes. Mermaid has focused on the suggested combination: wind energy with aquaculture (fish and seaweed) at Kriegers Flak.
Remain open for future MUP options. Develop cross-boundary MSP.	The proposed MUP design is still flexible to include other activities in the future. The planned activities are considered as the backbone of the project, however there are several additional and beneficial activities that may add value to the projects. Examples that have been discussed among the stakeholders are farming of seaweed, development of artificial habitats for rare

	species, wave-energy production.
Develop cross-boundary marine/maritime spatial planning (MSP).	Cross-boundary MSP in the Baltic is under development by other projects (e.g. BaltSeaPlan, VASAB...), not by MERMAID. This falls outside the scope of the MERMAID project.

3.4 Stakeholders' evaluation of the proposed final design – Baltic Sea site

The following table summarises all answers and comments received during the round 3 consultation of stakeholders to evaluate the proposed final MUP design. Column 3 shows the number of stakeholder votes received for the three multiple-choice answers: yes, no, don't know. Column 4 lists all the comments received. Note that not each respondent provided comments.

Baltic Sea site: Number (#) of stakeholders who replied/total contacted: 8/14			
Consideration of:		**#**	**Comments**
Feasibility in region?	Yes	5	- If co-existence of productions (wind & farming) is considered a MUP then it is feasible - Possibility for removing nutrients in selected areas - yes - but will require a lot of negotiations between the interested parties to sort out any potential interest of conflicts. - Most OWFs relatively close to shore, relatively low wave exposure in OWFs in inner Danish waters
	No	1	- Analysis show that limited synergies exist in the Baltic region. Increased complexity may lead to costs of co-location exceeding the benefits
	Don't know	2	- Because of to low water depth (it seems)
Technical feasibility?	Yes	5	- We already have an offshore farm in the Baltic (near the Island of Bornholm) and we do not consider this site to be much different except for the distance to the coast - Many OWFs, shallow water depth and little wave exposure in many sites

	No	0	-
	Don't know	3	- Further testing and upscaling needed - The current design (if the drawings are interpreted correctly), the Aquaculture is sited close to the WTG's and sub-station which may not be feasible. - only interest in MUP is safety for shipping
Financial feasibility?	Yes	3	- We do not see any special challenges that should make it more costly than other sea farms. - Yes - as it is more a political decision - how is the production subsidised
	No	1	- Analysis show that limited synergies exist in the Baltic region. Increased complexity may lead to costs of co-location exceeding the benefits
	Don't know	4	- Many unknowns…..
Legal feasibility?	Yes	1	-
	No	1	-
	Don't know	6	- The regulations regarding licensing of sea farms is difficult and we do not know the regulations regarding the windfarms. - Don't know internal law of the sea. - MSP is just being implanted in Denmark. The legalisation can therefore change in the coming years - We do foresee a number of legal obstacles
Beneficial from social-economic perspective?	Yes	4	- It will directly and indirectly create a lot of jobs in the local communities, worldwide food sources are scarce and the environmental impact will be minimal compared with other food productions. - I'm a firm believer in renewable energy - even if it is more expensive - MUP can be placed in regions where there is little other business activities / work opportunities
	No	2	- The individual activities may have large socio-economic benefits, but it is difficult to see how the MUP combination will provide additional benefits
	Don't know	2	-
Environmental benefit?	Yes	3	- Fish production is a very cost efficient protein production compared with land-based protein productions - However mussels should also be considered due to uptake of particulate matter, - algae only removes dissolved nutrients! - Any energy production that reduces fossil based energy production is good

	No	3	- It has an impact and so what? - No/Yes: No special environmental benefits compared with separate locations
	Don't know	2	- Many unknowns
Does our proposed MUP design meet your expectations?	Yes	3	- It focuses on co-existence, which is practically possible with the current technologies and not full integration, which is not possible with current technologies. - Looks very ambitious - Yes with the given location and border-criteria, this is probably the best possible suggestion. However, there are very limited synergies as mentioned above.
	No	1	- Analysis show that limited synergies exist in the Baltic region. Increased complexity may lead to costs of co-location exceeding the benefits
	Don't know	3	- Did not really have any expectations
Has stakeholder feedback been considered properly in our proposed MUP design?	Yes	3	- PARTLY: Aquaculture has not been sited within the wind-farm, but on the edge.
	No	0	-
	Don't know	4	- Don't know how the feedback has been considered - Have not been involved in the work previous so I don't know
Appropriate for reaching policy objectives on future food production?	Yes	3	- Sea weed will together with fish farms and of course wind and other WEC. - Yes I think so as it seems to be sustainable - Looks very ambitious
	No	1	- mussels not considered protein production
	Don't know	3	- We do not know enough about the policy objectives or to know if this is sufficient.
Appropriate for reaching future energy production/ provision policy objectives?	Yes	4	- According to wind fish farms or seaweed (Perhaps fish farms is too far from shore - As it is in the direction of having a fossil-free energy production - There is an increasing demand for space at the sea, and many conflicting activities. OWF with their huge demand for space have to implement / allow other activities to coexist
	No	1	- cascading bio-refinery should be considered
	Don't know	3	- We do not know enough about the policy objectives or to know if this is sufficient. - No difference in energy production compared to separate facilities.

3.5 Conclusions – Baltic Sea site

The Baltic Sea case study was characterized by other initial conditions than the other MERMAID MUP sites. The project location and focus on offshore wind were given: Kriegers Flak is a realistic case, a chosen site for the construction of offshore wind farms. The initial research hypothesis was also clear: the economy could improve with a MUP instead of a single-use platform (SUP). The investigation focused on possible combinations of various aquaculture possibilities with offshore wind. The main multi-use research question for MERMAID was therefore: Is there a conflict with, or are there benefits from aquaculture?

Further, the case study team consisted already from the outset of the main wind energy and aquaculture experts, hence, this case study started with an existing network of stakeholders from science and industry. The main stakeholders involved were thus MERMAID project partners, and it was decided that broader involvement was not necessary. It is concluded that this "narrow" approach of stakeholder involvement worked well, because all relevant experts of the relevant different fields had been involved in MERMAID and had the resources and the willingness to actively collaborate on all the necessary different assessments (technical, financial, legal, environmental, social and economic).

Impact of MERMAID over the course of the project

The MERMAID research related to the Baltic Sea site has created new knowledge and the application of the MERMAID participatory methodology has initiated a dialogue with stakeholders about MUPs. Therefore, there is now a clear set-up available for a MUP at Kriegers Flak in the Baltic Sea. MERMAID scientists have gathered evidence for its feasibility. Additionally, an environmental impact assessment (EIA) is available and ready to use.

It can be concluded that mussel and seaweed farming appear not to be feasible at Kriegers Flak, whereas fish farming would be feasible. The case study continued with a focus on fish farming despite general political resistance against fish farming due to environmental concerns.

The proposed offshore wind-fish-farm still appears to be unrealistic, mainly because of the long distance from shore. Currently, fish farmers would always prefer to apply for locations closer to the coast.

The estimated financial assessments suggest that economic improvement of the proposed MUP is not feasible in comparison with a SUP, at least not with the existing technology. No significant cost reductions can be shown. However, it should be kept in mind that neither possible cost reduction scenarios have not been performed, nor possible arrangements and contracts analysed, because the MERMAID analyses focused more on developing the conceptual MUP design from a technical perspective. In the future, these aspects should should be analysed more carefully.

A benefit is expected for fish farmers if they join up with the wind sector. For the wind sector, however, MERMAID was not able to show financial benefits from joining up with aquaculture.

4. North Sea site

The North Sea site is an area with typical active morphology. The Dutch MERMAID partners unanimously decided that the interesting test study area lies above the Wadden Sea Islands in the North of the Netherlands.

4.1 The proposed final MUP design – North Sea site

The summary presentation of the proposed design of a multi-use offshore platform (MUP), and wind-mussel-seaweed farm at the GEMINI site in the North Sea, is included in Annex 3. It is based on a summary prepared by the MERMAID North Sea team (Jan Joost Schouten (site manager), C Röckmann, A Wortel, T Söderqvist, R Garção, J Norrman, J Schipper et al., Date: 28.5.2015, and the slides present the following information:

1. Picture/figure(s) of the design; location; production estimates
2. Site characteristics; possible synergies of combined uses
3. Technical characteristics of each MUP element
4. Financial characteristics (cost & revenue estimates)
5. Legal/regulatory/institutional conditions to be met
6. Environmental effects (+/- estimates)
7. Social-economic benefits/ obstacles

4.2 The MERMAID participatory approach – North Sea site

Stakeholders involved – North Sea site

Participants were selected on the basis of interest in discussions about multi-use activities in the North Sea. For the Gemini site the following groups of Dutch stakeholders are already interested and were considered: offshore wind, offshore aquaculture, fisheries, and tourism. Next to these stakeholders, MERMAID also approached the following three stakeholder groups: Governing bodies/regulators/policy makers such as regional, national and European officers; Stakeholders from other offshore activities from for example shipping, and mining sectors; NGO’s and local citizens.

Round 1, December 2012 - February 2013: This first participation round was carried out in the form of face-to-face interviews with six stakeholders individually. By interviewing the participant individually (instead of in a round table meeting), MERMAID was able to get more insights into the stakeholders' wishes and comments regarding a MUP in the North Sea. The stakeholders were contacted separately for holding an interview with a MERMAID site representative (DELTARES/ DLO-IMARES). A questionnaire was sent to the interviewees one week in advance of the face-to-face meeting.
The eight interviewed stakeholders represented the three stakeholder groups, which would be involved most directly and actively in constructing a MUP, i.e., stakeholders with more indirect/ passive interest were not contacted in this first round.

Stakeholder group	Round 1: interviewed
Governing bodies/regulators/policy makers as regional, national and European officers	2 a
End users of the MUP, e.g. energy companies and aquaculture entrepreneurs	4 b
Suppliers of the MUP such as cable companies and construction businesses	2 c
Stakeholders from other offshore activities such as fisheries, shipping & mining sectors	0
Discourse community, including e.g. (environmental) NGO's, local citizens	0
Universities and research institutes	0

[a] RWS, Energyvalley; [b] ENECO, NUON, PO Mossel, Gemini; [c] Bakker, VanOord

Round 2, 12 March 2014: 45 relevant stakeholders for the round table session in the North Sea were selected based on their interest in a MUP in the North Sea. This list of stakeholders was discussed in a selective group of MERMAID project participants involved in the North Sea case study (Deltares/DLO-IMARES). All 45 selected stakeholders received an invitation to join the round table session; 22 stakeholders confirmed their attendance; 9 of the invited 45 stakeholders finally attended the meeting, which was held in Dutch. In addition, 5 persons from the MERMAID project were present and brought in their expertise into the round table discussion (cf. D 2.3, p.41). The participating 9 stakeholders are categorised as follows:

Stakeholder group	participants
Governing bodies/regulators/policy makers as regional, national and European officers	2
End users of the MUP, e.g. energy companies and aquaculture entrepreneurs	3
Suppliers of the MUP such as cable companies and construction businesses	0
Stakeholders from other offshore activities such as fisheries, shipping & mining sectors	1
Discourse community, including e.g. (environmental) NGO's, local citizens	1
Universities and research institutes	2

Round 3, March 2015:

For the final evaluation of the MUP design proposed by the MERMAID North Sea site team, emails were sent out to 35 stakeholders (10 of the 45 stakeholders selected and targeted in Round 2 were not active in the field anymore and were therefore excluded from the stakeholder list). One new stakeholder from the mussel sector was added. 12 stakeholders have sent in their replies, yielding a response rate of 34 %. The 35 stakeholders addressed are categorized as follows:

Stakeholder group	contacted	replied
Governing bodies/regulators/policy makers as regional, national and European officers	7	2
End users of the MUP, e.g. energy companies and aquaculture entrepreneurs	15	3
Suppliers of the MUP such as cable companies and construction businesses	3	2
Stakeholders from other offshore activities such as fisheries, shipping & mining sectors	3	2
Discourse community, including e.g. (environmental) NGO's, local citizens	5	2
Universities and research institutes	2	1

Has MERMAID missed any relevant stakeholder/ stakeholder group/ sector?

All relevant types of stakeholders (i.e. from all relevant sectors) were contacted and invited to the round table meeting (Round 2 of the MERMAID participatory approach), as well as to the final evaluation via email. Stakeholders from the mussel sector and the construction companies did not respond to the invitation for the round table and were therefore absent. The absence of this potential end user group of the proposed North Sea wind-mussel-seaweed farm MUP might have led to a certain lack of realism in the technical characteristics of the MUP design proposal. A certain lack of realism could be concluded from a few negative evaluations of the MUP's technical feasibility (cf. section 4.4). Nonetheless, for round 3, the North Sea MERMAID team was able to identify one new stakeholder from the mussel sector, and this stakeholder did enthusiastically participate in the final email evaluation. The final MERMAID MUP proposal for the North Sea is furthermore now stimulating advanced discussions with the Dutch government, maritime sectors, scientists and NGOs about realizing MUP pilots in the North Sea (Rozemeijer et al. 2015).

4.3 Stakeholders' input and MERMAID internal evaluation – North Sea site

The following tables (left column), summarise all comments, feedback and recommendations received from the stakeholders contacted during the MERMAID participatory process, rounds 1 and 2. All input has been clustered according to technical, financial, environmental, social-economic aspects, and one final table for general aspects.
The right columns in the tables below explain, for each issue raised by the stakeholders, how MERMAID has dealt with and responded to this input in the development and choice of the proposed MUP design.

Technical aspects	
Stakeholders' concerns	**MERMAID response**
Stakeholders suggested to focus on offshore shellfish and bottom fishing due to the shallow water. However, there was no consensus or decision whether to go for a MUP with mussel or seaweed farming. It was suggested to exclude fish culture from any MUP design in this Dutch part of North Sea, because of the relatively shallow water depth in combination with a too high water temperature during the summer. In the near future, it might be possible to include fish aquaculture, if a different type of fish species can be found that can be cultivated in these conditions.	Yes, fish culture is currently not considered. Mussel culture is included in the design only at the outer edges of the wind farms (i.e. 4 lines of mussel culture), whereas seaweed culture is integrated between the wind turbines and in the area in between the two Gemini sites. Moreover, a combination of seaweed and mussel culture represents an Integrated Multi-Trophic Aquaculture (IMTA). Any future developments are left open to also considering fish aquaculture in the future.
The Gemini location has limited potential for wave and tidal energy converters.	Yes, these types of multi-use were excluded.
It is feasible from a construction point of view to attach aquaculture support structures to the offshore wind turbines. However, it is important that multi-use installations do not hinder the wind turbines, do not pose obstacles for O&M activities.	To leave significant space around the offshore wind turbines and cables for O&M, the proposed design takes into account a safety zone with a diameter of 100 m around each wind turbine. Therefore, it was also decided to integrate aquaculture installations inside the wind farm, i.e. between the wind turbines, instead of just outside the farm (here: seaweed cultivation inside the wind

	park and mussel cultivation at the edges). Note that mussel cultivation cleans seawater, and at the same time, it may reduce on-growth on other structures within IMTA.
For successful aquaculture, nutrient rich and clear water is required. There are doubts whether nutrient concentrations are high enough that far offshore at the GEMINI location, hence there are doubts whether the GEMINI location is suitable for offshore aquaculture.	A technical study was carried out on the feasibility of aquaculture at this offshore site. According to this initial study, nutrient concentrations should be just high enough to enable offshore aquaculture at the GEMINI site (Terradellas Vilella 2014). The final design (seaweed inside the wind farm, mussels outside at the edges) takes into account that nutrient concentrations might be around the lower limit for aquaculture.
Co-use of infrastructure to reduce O&M costs.	Yes, co-use of O&M infrastructure is considered the main potential synergy to reduce costs. The proposed MUP design therefore contains not only the offshore wind-mussel-seaweed farms, but it also includes an offshore hotel and support centre.
Modular components, plug & play installations. Technical requirements for fishing boats. Many unknown technical & biological requirements for off-shore aquaculture	These issues, raised during round 1, have been considered. Modular components have been used as building block for each function to reduce complexity. Uncertainties and unknown requirements have been investigated through the individual MERMAID assessments. The best way forward now is to test offshore in the field.

Financial aspects	
Stakeholders' concerns	**MERMAID response**
The North Sea has a good potential for growing seaweed: enough space and sufficient nutrients. Moreover, there is a demand for -specifically wet – seaweed, which cannot be imported from outside Europe.	Therefore seaweed cultivation is included in the proposed MUP design.

There is a demand for an increase of yearly mussel production. Currently, the production of mussels is declining, however the demand is increasing. The Dutch mussel sector sees market opportunities for a total yearly production of 100,000 tons of mussels; this is almost twice as much as the currently declining production and can only be achieved if new areas for mussel production become available (interviews, summarised in Lagerveld et al. 2014).	Therefore mussel cultivation is included in the proposed MUP design.

Environmental aspects	
Stakeholders' concerns	**MERMAID response**
It is not acceptable that a MUP has a detrimental effect on the existing ecosystem. An environmental impact assessment must take place to investigate potential effects on the environment.	Based on experiences from existing wind parks and aquaculture, no major negative impacts on the environment are expected. Therefore, it was decided to finalize this MUP concept for the GEMINI location.

Social-economic aspects	
Stakeholders' concerns	**MERMAID response**
Reduction of O&M costs is important. Fishing, O&M, tourism should all be combined, if possible. Additional fishing grounds for shell-fish sector are needed.	Yes, O&M cost reductions (e.g. by combining fishing/aquaculture with O&M activities) are expected and included in the proposed design: shared offshore hotel and support centre. However, the GEMINI location is considered too far offshore to be used currently for tourism.

General comments/recommendations	
Stakeholders' concerns	**MERMAID response**
None	-

4.4 Stakeholders' evaluation of the proposed final design – North Sea site

The following table summarises all answers and comments received during the round 3 consultation of stakeholders to evaluate the proposed final MUP design. Column 3 shows the number of stakeholder votes received for the three multiple-choice answers: yes, no, don't know. Column 4 lists all the comments received. Note that not each respondent provided comments.

North Sea site: Number (#) of stakeholders who replied/total contacted: 12/35			
Consideration of:		**#**	**Comments**
Feasibility in region?	Yes	8	- Not only the North Sea region but also worldwide (see IMARES Blueprint feasibility study and WUR Seaweed report) - more space at sea than on land - Yes, but not in the way as elaborated for the Gemini wind parks. When aiming at the mixture with wind parks one should not focus on existing wind parks, or wind parks to be built until 2023. One should focus on the next generation of windparks for which you make an integrated design of wind park development including other functions. - If this concept is taken into account right from the start of the development and at the beginning of the design process this should be possible from a technical point of view. If the concept will be applied after the construction of a wind farm (without taking this concept into account during the design of the farm), this will be more complicated. Nothing can be attached to the monopiles and if it is an anchored system, there will be risks and interference with the inner array cables. - Because there is a growing demand for new areas for mussel farming - It is a good example of innovation in the fisheries/aquaculture sector - Yes, if properly and cost efficient designed, MUPS can contribute to solve the problem of a lack of space and the increasing need for (sustainably produced) food and energy - There is enough space between wind turbines, and tests from a.o. the Noordzeeboerderij show that the cultivation of seaweed, for example, is working well even under harsh conditions

	No	3	- we are just a seaweed selling company, and will not grow our own seaweed - Yes, but in a limited way. Other activities such as fisheries and other maritime activities need to be taken into account, as proposed by the project group "Vissen voor de wind (VVW) - A MUP as drawn does not combine the interests of the OWF developer. This will be perceived by the OWF developer as an additional interface and risk
	Don't know	1	-
Technical feasibility?	Yes	5	- Investors needed with commitment of fisheries sector - I believe there is space on the North Sea - With the proper design combinations it will be feasible - We have excellent institutes in the Netherlands (f.i. TU Delft/Delares/IMARES/) - Much experience with mussel farming and aquaculture in our region
	No	5	- No, because of maintenance procedures in wind parks the proposed design is not realistic. - Tides and waves in our region (Dutch coast) are rough. Therefore, the big problems that need to be solved first are: reliable anchoring and sufficient strength of the constructions. Moreover, the proposed MUP design covers much space, both in terms of multiple-use as well as in terms of O&M of the turbines. - On the project site a continued presence of larger offshore vessel (approx. 70 meters) is required for the Wind Turbine Generators (WTG), these vessels require more space then foreseen in the design - Yes from a purely technical perspective, but according to the conceptual figure of to the proposed design, the wind turbines will not be accessible for maintenance...
	Don't know	2	- I have insufficient information for proper evaluation - I do not know yet, I couldn't understand from the summary whether maintenance lanes for, and safety zones around the windturbines have been taken into account, and whether the mussels and seaweed cultures are attached to the turbines.
Financial feasibility?	Yes	2.5	- first a transparent business plan to be drafted and then investors/sector will be interested - If developed fully, I believe in - Mussel farming: yes
	No	4.5	- No, because of maintenance procedures in wind parks the proposed design is not realistic.

			- The assumed seaweed price is too high; investment costs are high, so the investment costs are too high for current market prices - Not yet There is still no good business-mode - The costs are relatively high - Seaweed farming: not yet
	Don't know	5	- We did not do any estimating work or financial evaluation ourselves, so this is hard to answer - I do not have the financial information of the cost of a mussel farm in these areas. - I have no insight in the business case for the mussel farming or seaweed. However the location of the project site will cause an increase of cost for vessels (higher specifications) and housing of people - I do not know yet. The calculation in the summary shows some uncertainties regarding the revenues. And, how does the 10% efficiency gain from combined use, show in the costs and revenues? Does it only lower the costs of the windpark or is it used for lowering the mussels and seaweed farming costs as well? And there are other uncertainty about subsidies, insurance costs, future market prices - I'm not yet convinced that yields will be high enough to make it profitable
Legal feasibility?	Yes	7	- See IMARES/Blueprint report but probably site specific barriers would be met - I don't see difficult problems - Yes, Dutch government is now reconsidering regulations on multi use of wind parks. - In principle this should be possible, but the permit of the windfarm has to allow this utilisation - It all depends on the political will to stimulate production in this combination - Yes, probably in the future. The Integraal Beheerplan Noordzee 2015 offers licensing room for sustainability 'experiments', although currently there are several restrictions to employ other uses in windparks
	No	3	- Safety (in particular adequate anchoring and sufficiently strong/robust constructions) needs to be guaranteed. - The interface between the 3 different functions will require legal coverage and identification between the parties. For this the effect needs to be known. For example the windfarm owner will have to ensure to the classification society the additional marine growth to the foundations

			structures as a result of the mussel farming. If this cannot be quantified, the legal framing will either not be possible or have a negative impact to the business cases of both parties. - Legislation is not far enough, there is no Regulatory Framework for MUP's, and Third Party Access to OWF's is still forbidden in NL
	Don't know	2	- Then first it has to be clarified what is the impact of large-scale seaweed farming on primary production by algae. I'm afraid that it consumes a lot of nutrients, and this should lead to a strong decrease of the growth of protozoan (single-cell) algae. This influences the entire ecosystem.
Beneficial from social-economic perspective?	Yes	8	- from the fisheries sector there is certainly interest - Yes believe it is an support for all party's - It will create a new business - It will generate more turn-over in the aquacultural business - Maybe in the far future - Yes, as long as fishers are taken into account and stakeholders who are living at the coast/ coastal regions are involved and can participate, either as employee or as entrepreneur. Fishers can plead for their historic access rights to MUP areas. - Many related activities in the region - Yes, e.g. it could support the transition to sustainable food production in the fisheries sector and to provide the sector and coastal communities in general with long-term economic perspectives
	No	2	- - Multi-use of sites could be definitely interesting from a social-economic point of view, but the risk profile for the wind farm developer will increase, meaning higher capital costs. Also the realisation of the combined windfarm / MUP will be more complicated and will delay the process of rolling out offshore wind
	Don't know	2	- Difficult question. Yes, if it all works out and is profitable without damage of the environment.
Environmental benefit?	Yes	5	- Why not? - Maybe in the far future - It contributes to the biodiversity of the area and it leads to sustainable food production. - Good for the ecology and the water quality - Yes, but that mainly depends on how closed the food production system can become to tackle the issue of nutrients and medicaments excess to the seawater

	No	1	- In general all human activities have some effect on the natural environment, it all depends on what value you consider the most precious
	Don't know	6	- IMARES expertise - I can't judge the environmental benefits or disadvantages - I do not know if the additional economic activities will be compensated by other effect. My perception would be that an area (between the WTG's) that is left untouched is in practice a (semi) sanctuary and cultivating it is in contradiction with it. - Then first it has to be clarified what is the impact of large-scale seaweed farming on primary production by algae. I'm afraid that it consumes a lot of nutrients, and this should lead to a strong decrease of the growth of protozoan (single-cell) algae. This influences the entire ecosystem.
Does our proposed MUP design meet your expectations?	Yes	6.5	- follow-up activities after the Blueprint studies (IMARES e.a.) required - Yes, your proposal comes from a theoretical excersition, and shows the opportunities for a MUP. It does not come to a realistic design, but working with the opportunities and with people with wind park design expertise you can work towards a next step. - As a proposal this will do fine to explain non-experts the basic idea of the project - More focus on mussel farming, less on seaweed - Yes (and a little no): The combination of mussels and seaweed seems to be quite obvious, although I have some concerns about the space the plan provides for maintenance lanes and safety zones.
	No	5.5	- The assumed seaweed price is too high; investment costs are high, so the investment costs are too high for current market prices - I did not have any expectations and I am not convinced that this is the way forward. Why not test it separately (not in a wind farm)? If it is successful then a careful integration in a wind farm can be considered - The proposal does not take into account sufficiently the fact that the windfarm is an industrial complex with limited possibilities for other uses. The proposal does not take into account other maritime activities. - The current design doesn't take practical activities in the region into account. e.g. the reachability of the WTGs, the subsea cables or the mussel cultures are not stated in the presentation

			- More focus on mussel farming, less on seaweed - No, it is not delineated realistically. Where can the maintenance ships pass through?
	Don't know	0	-
Has stakeholder feedback been considered properly in our proposed MUP design?	Yes	1	- Yes, to a certain extent, however, I don't know who else has been consulted
	No	5	- after the first stakeholders interviews too little (progress) feedback to stakeholders or……? - No, no realistic design from wind park owners perspective. - The proposal excludes any other co-use activities and it is not realistic as regards constraints by the windfarm operators. - The benefit for the "traditional" windfarm developer is missing. The question: why would Eneco, Vattenfall, RWE or DONG either actively get involved or at best allow it on their site is not answered in the presentation - More market research on seaweed products, and the market value
	Don't know	6	- Very important is if you design this MUPs that there are options/ possibles for all partys - I don't have sufficient information, so I am not able to judge - I doubt about the business case presented - I cannot estimate/judge this
Appropriate for reaching policy objectives on future food production?	Yes	6.5	- see the MERMAID interviews in the first year and the IMARES/Blueprint studies - It will be just a help - But not for the short term, techniques should be improved and investment costs should be lower. - As a proposal this will do fine to explain non-experts the basic idea of the project - Innovation is a key issue in our policy - It is a step in the right direction, not more, not less. - Only the objective of doubling the mussel production
	No	1.5	- Only the objective of doubling the mussel production - It is not delineated realistically. The MUP idea is good, but the design is not realistic.
	Don't know	4	- It can contribute - I have no clue what the policy objectives for future food production are - I have no knowledge of food policies and am not aware the Netherlands has set production targets

			- I do not know yet. It will surely contribute to protein production, although there seem still to be some questions about the cost efficiency of the combination of windparks and aquaculture, and the offshore location of the multiple use site
Appropriate for reaching future energy production/ provision policy objectives?	Yes	6	- see the MERMAID interviews in the first year and the IMARES/Blueprint studies - It will be just a good help. - As a proposal this will do fine to explain non-experts the basic idea of the project - Innovation is a key issue in our policy - It is a step in the right direction, not more, not less. - Yes, it is a 600 MW windpark, so it will contribute to reaching the EU 2020 and beyond objectives for renewable energy
	No	4	- It will rather increase the costs for offshore wind energy and delay the process of building new capacity - Although combining functionalities in basics appear to be attractive, it tends to lead to more complex systems, which seldomly lead to cost reduction. I am afraid I am of the opinion that cost reduction comes from simplicity. In the presentation the only potential cost saving appears to be the housing of staff. All other functions appear to be either not linked or complexing each other. - Only food production. Windfarm was already decided and contributes to our national renewable targets - It is not delineated realistically. The MUP idea is good, but the design is not realistic.
	Don't know	2	- Your proposal does not include other forms of energy production, and the benefits of your proposal are not sufficient to help the development of wind parks

4.5 Conclusions – North Sea site

The North Sea case study represents a strongly policy driven as well as science driven case. The main research questions were:

- Policy: Are incentives necessary to encourage MUPs?
- Technology: In order to get seaweed farming out of competition for space with near-shore mussel areas: Is seaweed farming feasible offshore?

- Technology: Are MUPs feasible in the North Sea?
- Technology: Are stand-alone activities such as offshore mussel and seaweed farming feasible?

Additionally, there is a market driver, since the demand for mussels is much higher than mussel supply.

The MERMAID North Sea case study turned out to be a purely Dutch case study. The Netherlands are famous for their "poldering tradition", meaning that stakeholders usually want to be involved. Moreover, parallel to the MERMAID project, several other projects/ activities have been ongoing about the feasibility of MUPs, and there was lively interaction between all of these initiatives.

The North Sea case study focused on the future wind park location Gemini. Relevant stakeholders had already been identified. Step one of the MERMAID participatory approach consisted of interviews with the most relevant stakeholders (i.e. including the mussel sector). Similar to the Baltic case study, this rather "narrow" first step of stakeholder involvement was considered very useful and efficient. However, from then on, the crucial new MUP stakeholder (i.e., the mussel sector) was and has been missing. One could speculate that this might have been a strategic decision to avoid being overruled by the mussel sector because of the "polder model". Nonetheless, MERMAID still considers offshore mussel farming in the proposed North Sea MUP design, mainly because model results suggest that offshore locations in the North Sea do offer the potential for mussel farming (Terradellas Vilella 2014). Furthermore, mussels excrete particles as well as diluted nutrients and these nutrients are food for seaweed. Hence, there is some potential for integrated multi-trophic aquaculture (IMTA).

Impact of MERMAID over the course of the project

There is now increased enthusiasm and optimism about MUPs; the various stakeholders are more aware about potential business synergies and opportunities, in particular concerning potential cost reductions. Still, comments from stakeholders indicate that those synergies and opportunities have to be shown in more detail and for cases in which multi-use can be developed in an integrated way already at the planning stage. This is important in particular for the more mature offshore wind sector.

In order to promote the opportunities of MUPs, increased MUP awareness of governmental ministries is particularly important, because regulatory/legislative government incentives are urgently needed. For example, the wind energy sector should be obliged to consider multi use

options in the planning phase. The relatively less experienced offshore aquaculture sector needs to be supported to carry out single-use pilot studies offshore. For example, mussel farming in the North Sea has traditionally been carried out in coastal areas, and the sector is hesitant to go offshore. Incentives are needed to encourage mussel farming further offshore. In particular, single-use offshore mussel farming pilot studies will help to make the sector more mature. Additionally, the seaweed sector has become interested in MUP. In contrast to the mussel sector, seaweed farming is still in its infancy in the North Sea, and actually in most parts of Europe. This sector could thus directly start offshore and thereby avoid competition for near-shore space with the already existing mussel farming areas. However, since single-use mussel or seaweed farming might not be feasible due to exploding costs. If costs can be reduced by synergies such as in operation and maintenance, multi-use might be the solution to make it feasible.

5. Atlantic site

The Cantabrian Offshore site is located in Spain, off shore the region of Cantabria. It is characterized by very rough wind and wave conditions.

5.1 The proposed final MUP design – Atlantic site

The summary presentation of the proposed design of a multi-use offshore platform (MUP), a wind-wave farm in the Cantabria Offshore Site, is included in Annex 4. It is based on a summary prepared by MERMAID site manager: Raúl Guanche, Date: 06/02/2015, and the slides present the following information:

1. Picture/figure(s) of the design; location; production estimates
2. Site characteristics; possible synergies of combined uses
3. Technical characteristics of each MUP element
4. Financial characteristics (cost & revenue estimates)
5. Legal/regulatory/institutional conditions to be met
6. Environmental effects (+/- estimates)
7. Social-economic benefits/ obstacles

5.2 The MERMAID participatory approach – Atlantic site

Stakeholders involved – Atlantic site

The marine/coastal community in Santander is small, all stakeholders seem to know each other and on occasions point towards the others for additional information. Selection of the stakeholders was done by the Environmental Hydraulics Institute of Cantabria (IH Cantabria).

Round 1, December 2012 – January 2013: The stakeholders' views were investigated by conducting individual interviews, held in Santander. An additional interview was held trough Skype. The questionnaire was used as a basis for the interviews. The interviewed stakeholders were categorized as follows:

Stakeholder group	participants
Governing bodies/regulators/policy makers as regional, national and European officers	3
End users of the MUP, e.g. energy companies and aquaculture entrepreneurs	0
Suppliers of the MUP such as cable companies and construction businesses	1
Stakeholders from other offshore activities such as fisheries, shipping & mining sectors	2
Discourse community, including e.g. (environmental) NGO's, local citizens	2
Universities and research institutes	0

In the interviews, the MERMAID team emphasized its focus on large scale development, not on test sites, which is a very clear focus in the entire MERMAID project.

Round 2, September 2013: Relevant stakeholders for the round table session were selected based on their possible interest in a MUP. 24 stakeholders were invited to participate in the roundtable; 15 stakeholders confirmed their attendance, but finally, 10 stakeholders attended the meeting in Santander, which was held in Spanish (cf. D 2.3, p.38).
The participating stakeholders are categorized as follows:

Stakeholder group	participants
Governing bodies/regulators/policy makers as regional, national and European officers	2
End users of the MUP, e.g. energy companies and aquaculture entrepreneurs	1
Suppliers of the MUP such as cable companies and construction businesses	3
Stakeholders from other offshore activities such as fisheries, shipping & mining sectors	0
Discourse community, including e.g. (environmental) NGO's, local citizens	1
Universities and research institutes	2

During the round table meeting, MERMAID presented different MUP alternatives. Criteria that affect the design of a MUP installed at this deep and high energy Atlantic Site were discussed.

Round 3, February-March 2015:
For this final evaluation of the MUP design proposed by the MERMAID Atlantic site team, emails were sent out to 10 stakeholders, of which 5 responded, i.e. 50% response rate.
The 10 stakeholders addressed are categorized as follows:

Stakeholder group	contacted	replied
Governing bodies/regulators/policy makers as regional, national and European officers	3	1
End users of the MUP, e.g. energy companies and aquaculture entrepreneurs	1	0
Suppliers of the MUP such as cable companies and construction businesses	3	2
Stakeholders from other offshore activities such as fisheries, shipping & mining sectors	0	0
Discourse community, including e.g. (environmental) NGO's, local citizens	1	1
Universities and research institutes	2	1

Has MERMAID missed any relevant stakeholder/ stakeholder group/ sector?

All relevant types of stakeholders (i.e. from all relevant sectors) were contacted and invited to the main round table session (round 2 of the MERMAID participatory approach). All but one stakeholder group participated (cf. Tables above).
In round 1, End users of the MUP, e.g. energy companies and aquaculture entrepreneurs were not interviewed.
In round 2, Stakeholders from other offshore activities such as fisheries, shipping & mining sectors were lacking. Invited stakeholders who did not attend were the following:

- The port authority
- The municipality of Santander
- A wind turbine developer
- The maritime Authority
- National sailing team
- Coastal guard
- National Government regional delegate
- National Institute of Oceanography
- Green NGO

The lack of governmental institutions, like the Port Authority, the Municipality of Santander and the Maritime Authority, is really important in the development of marine projects in Spain due to national policies. Finally, and as a conclusion, the absence of public institutions in the development of these projects in the Spanish shoreline, could generate problems to carry out any maritime projects.

5.3 Stakeholders' input and MERMAID internal evaluation – Atlantic site

The following tables (left column), summarise all comments, feedback and recommendations received from the stakeholders contacted during the MERMAID participatory process, rounds 1 and 2. All input has been clustered according to technical, financial, environmental, social-economic aspects, and one final table for general aspects.

The right columns in the tables below explain, for each issue raised by the stakeholders, how MERMAID has dealt with and responded to this input in the development and choice of the proposed MUP design.

Technical aspects – Atlantic site	
Stakeholders' concerns	**MERMAID response**
Most important: Safety and robustness of challenging technical construction in harsh offshore environmental conditions (high waves, deep sea, narrow continental shelf) ==> find multi-use combinations that can stand harsh conditions. High technical demands: Safety and robustness is very important (e.g. buoys) as well as a good signaling system for sea vessels, to avoid accidents.	The proposed MUP is considered robust and safe because the platform design allows to achieve a great stability and hydrodynamic response under the action of wind, waves and currents. The stability and the hydrodynamic response has been tested through different simulations performed with a numerical model (SESAM, the sea state of 100 return periods has been tested). Moreover, and in order to verify the resulted obtained with SESAM, laboratory test will be carried out during this month.
MUP alternatives that were considered possible: 1. Combination of offshore wind, wave and/or tidal energy 2. Combination of offshore wind energy generation with sensors to gather information on the marine environment 3. Combination of offshore wind with a temporal island for sport events	The proposed design is a combination of offshore wind with wave energy converters (Oscillating Water Column energy farm). Specifically: The final design is a semi-submersible platform (floating). Each MUP is formed by 1 NREL5 MW wind turbine and 3 oscillating water column wave energy converters.
Offshore aquaculture in this region is deemed very difficult, and there is no experience with it in this region and under these harsh conditions.	Yes, therefore offshore aquaculture has been omitted from the proposed MUP. The risk would be too high under these harsh conditions and without previous experience.
At least 5 km off the coast which means a water depth of 400 – 1,000 m.	Yes, the proposed MUP lies 10 km offshore.
High risk on geotechnical failure and failure with land connections.	Although geotechnical risks exists at the Cantabrian Offshore Site (COS) site, it is not expected that the loads transmitted from the mooring system to the anchor can generate geotechnical problems.

Financial aspects – Atlantic site	
Stakeholders' concerns	**MERMAID response**
How to attract sufficient funds?	Funds will be attracted by the collaboration between public and private companies (--> out of the scope of the design activity)
Need to find a way to provide revenues to the local community and/or the fishermen.	Revenues will be provided by creation of new employment during the construction stage and, of course, during operation stage. Moreover, fishery industries will not be involved during the COS development.
High costs expected for equipment, decommissioning, O&M.	Yes, costs will be high, but revenues are expected to cover the costs. The final economic assessment is currently ongoing.

Environmental/ ecological aspects – Atlantic site	
Stakeholders' concerns	**MERMAID response**
Questions were raised about underwater sound, sea bed disruption through mooring, and impact on bird life.	No significant negative impacts on the ecosystem are expected, in particular since aquaculture is excluded from the MUP. The site is not of special value, neither for birdlife, nor for fishermen, nor for sailing, nor does it lie within shipping routes. Also, an EIA is available.
MUP should be > ca. 5 km away from shore to reduce visual impact.	Yes, ok. The proposed site lies 10 km off the shore.
Concern about proximity to the Rio Saja River mouth with a small port.	The distance between the multi-use farm (wind-wave) to river Saja mouth and Suances port is big enough to not generate interferences between port activity (fishing activity and marina activities) and the multi-use farm activity. Also, the multi-use farm is not in front of the Saja river mouth or port (parallel shoreline distance between offshore farm and port or Saja river is about 20 km).

Social-economic aspects – Atlantic site	
Stakeholders' concerns	**MERMAID response**
The site should be selected to avoid interference with other activities, **in particular** it should not interfere with interests of the local fishing community, which is an important stakeholder.	Yes, the Cantabrian Offshore site does not interfere with the Cantabria's fishing ports nor with other marine activities. The main fishing community in Cantabria is placed in the east coast while COS is located in the middle of the Cantabria coast.
The MUP should increase temporary employment.	The proposed MUP is expected to generate 1000 extra temporary jobs.
The MUP should lead to benefits for industry and existing businesses, and revenues to local community and fishermen. In particular: Wave energy development is believed to strengthen local business.	The proposed MUP is expected to generate extra revenues to local community, industry, and existing businesses, such as fishermen and other. Exact numbers cannot be shown yet, as the final economic assessment is currently ongoing.

General comments/recommendations – Atlantic site	
Stakeholders' concerns	**MERMAID response**
Focus on potential benefits so that all stakeholders can see possibilities.	The MERMAID analyses show benefits, such as: • Increasing employment in the region • Creation and development of new industries around the site. • The multi-use farm at COS has been developed and designed, trying to avoid the interferences between other uses like fishing. • Environmental impacts are considered not important, can be neglected. • Important increase of the economics of Cantabria expected. • Important increase of the energy production in the Cantabrian region.

5.4 Stakeholders' evaluation of the proposed final design – Atlantic site

The following table summarises all answers and comments received during the round 3 consultation of stakeholders to evaluate the proposed final MUP design. Column 3 shows the number of stakeholder votes received for the three multiple-choice answers: yes, no, don't know. Column 4 lists all the comments received. Note that not each respondent provided comments.

Atlantic site: Number (#) of stakeholders who replied/total contacted: 5/10			
Consideration of:		**#**	**comments**
Feasibility in region?	Yes	4	The environmental conditions of the region are suitable for this type of platform, by winds and strong tides that often occur. In addition there is good availability of physical and water resources. In my opinion, the increase in renewable energy generation is a desirable goal and an option to explore is the offshore installation.
	No	0	-
	Don't know	1	I struggle to see the viability and profitability of such an expensive project
Technical feasibility?	Yes	4	I think that you have enough technology to create a platform that perfectly suits the environmental conditions and does not cause a high environmental impact in the coastal area in the region As set forth in meetings regarding this project, it seems technically feasible
	No	0	-
	Don't know	1	I do not have much knowledge to ensure technical feasibility
Financial feasibility?	Yes	1	-
	No	1	High costs for a market with many uncertainties and undergone many vicissitudes
	Don't know	3	Draw out a financial study and design and construction costs while energy and fisheries production once installed on the desired water area.

			I do not know the data needed to express my opinion on what asked.
Legal feasibility?	Yes	3	From the standpoint of coastal protection, in principle, yes.
	No	1	-
	Don't know	1	The coastal area of the region is well protected regarding visual and insert technologies within coastal environmental impacts, so I do not know if you can carry out the project implementation.
Beneficial from social-economic perspective?	Yes	5	Cantabria currently has an energy deficit, and these facilities can reverse the situation. I think an interesting future bet to leave our dependence on oil It will promote research, employment and regional industry.
	No	0	-
	Don't know	0	-
Environmental benefit?	Yes	3	I think so, although the environmental impact should be measured: emissions, waste , biodiversity, etc. at different levels
	No	1	This type of construction and facilities of this magnitude always cause a high environmental impact
	Don't know	1	Undoubtedly it will generate negative impacts, which must be checked to ensure they are compatible.
Does our proposed MUP design meet your expectations?	Yes	4	It combines two leading activities and necessary to investigate and implement in the region to leverage resources and promote the field of renewable energy technologies, and moreover the boom in world aquaculture fail. more or less
	No	0	-
	Don't know	1	
Has stakeholder feedback been considered properly in our proposed MUP design?	Yes	2	The draft industries and research groups from different sectors involved, so disparate knowledge and technologies are applied but necessary in platform designed
	No	0	-
	Don't know	3	I need information, I know all stakeholders consulted apart from the technical. Lack consult municipalities , fishermen, other groups The proper respondent would not answer. He had not expressed any recommendation for your design.

Appropriate for reaching policy objectives on future food production?	Yes	1	The growth in demand for fish and aquaculture sector is constantly growing, so it is necessary to expand the aquaculture industry to other locations than onshore facilities, applying new species and expand the market in the country.
	No	2	There seems to be so, at least directly , with the proposal made
	Don't know	2	It is not clear, offshore aquaculture is still little advanced and this part of the project I think is the weakest
Appropriate for reaching future energy production/ provision policy objectives?	Yes	4	Currently the sector of renewable energies is slow, but in the years of development of the country will have to produce growth, investing in energy efficient and non- wind .. In this case, yes, but it depends on the performance and durability at sea
	No	0	-
	Don't know	1	As for the promotion of renewable energies, it seems appropriate; but suitability should be ensured in the proposed location

5.5 Conclusions – Atlantic site

The Atlantic case study started with a strongly scientific and technology driven case. MERMAID identified after that all the relevant stakeholders groups and invited them, but not all of them became actively involved. Stakeholder involvement became focused mainly on a limited group of experts from the industry (civil engineering and aquaculture), science and research (technology, innovation), coastal authority and government (Department of Innovation, Industry, Tourism and Trade), and environmental NGO. This approach was considered useful and efficient; no negative experience with the MERMAID participatory approach. There have not been big conflicts with stakeholders. Similar to the Baltic case study, the chosen approach of contacting a limited group of experts instead of the entire pool of stakeholders is considered efficient as it was necessary to take decisions concerning the final choice of MUP activities.

Impact of MERMAID over the course of the project

MERMAID has identified all relevant stakeholders. However, not all of them have been actively involved in the MUP design process. Engagement of all stakeholders is difficult.

MERMAID presented different scenarios, including a “do nothing” scenario. None of the participants voted for this “do nothing” option. Hence it is obvious that MERMAID has contributed to increased motivation, openness for and interest of stakeholders in MUPs.

The Atlantic case study was mainly technology driven and focused on MUP engineering simulating scenarios (wind and wave conditions). In comparison, the analyses did not focus very much on other more practical issues such as legislation, financial aspects, business plan, and therefore, a holistic future perspective concerning realisation of a MUP project has not been analysed.

Stakeholders contributed mostly with worries about MUPs. However, despite fishers’ initial resistance to MUPs (fearing a conflict with their fishing activities), their interest in MUPs has certainly increased. MERMAID has increased their awareness of the fact that a wave farm might have a reef function, attracting additional fish. However, stakeholders’ worries and concerns might not have decreased.

6. Mediterranean Sea – Adriatic Site

The Adriatic site is a sheltered deep water site with a depth of 16 m. The suggested site for multi-use is the research platform Acqua Alta, about 12 km off the coast of Venice.

6.1 The proposed final MUP design – Adriatic site

The summary presentation of the proposed design of a multi-use offshore platform (MUP), a wind-fish farm in the Adriatic Sea, is included in Annex 5. It is based on a summary prepared by the MERMAID Adriatic team, led by site manager Barbara Zanuttigh (Uni Bologna), from May 2015. The slides present the following information:

1. Picture/figure(s) of the design; location; production estimates
2. Site characteristics; possible synergies of combined uses
3. Technical characteristics of each MUP element
4. Financial characteristics (cost & revenue estimates)
5. Legal/regulatory/institutional conditions to be met
6. Environmental effects (+/- estimates)
7. Social-economic benefits/ obstacles

6.2 The MERMAID participatory approach – Adriatic site

Stakeholders involved – Adriatic site

14 relevant stakeholders were identified and selected based on their interest and involvement in the MUP project, i.e., end-users, governmental agencies, suppliers, NGOs, discourse community. Stakeholders were invited to join an introductory round table session in November 2012, organised by UNIBO, in which the MUP concept and the site were introduced, its development discussed, and stakeholder views investigated. All relevant stakeholders were invited to this meeting, and all 14 attended the first meeting. All stakeholders were asked to fill in the MERMAID questionnaire; responses were received from all but three stakeholders.

Round 1, November 2012 – January 2013: All identified relevant stakeholders (14) were invited and attended the introductory round table meeting. The identified and selected stakeholders represent the following stakeholder categories:

Stakeholder group	participants
Governing bodies/regulators/policy makers as regional, national and European officers	6a
End users of the MUP, e.g. energy companies and aquaculture entrepreneurs	3b
Suppliers of the MUP such as cable companies and construction businesses	3c
Stakeholders from other offshore activities such as fisheries, shipping & mining sectors	0
Discourse community, including e.g. (environmental) NGO's, local citizens	2d
Universities and research institutes	0

[a] 3 national governmental bodies (1 research body, 1 energy agency, 1 environmental agency); 1 local water authority; 2 municipal authorities (1 harbour authority, 1 energy agency); [b] 2 energy companies; 1 aquaculture company: Both energy companies might be interested in investing financial and human resources, if they are properly involved. The aquaculture company that has been selected is the strongest economic and political stakeholder from the fish production sector in Venice; [c] 3 private consulting agencies: could be consulted during the design process. One of the consulting agencies might be interested in investing financial and human resources, if they are properly involved.; [d] 2 Non-Governmental Organisations (NGOs); 1 tourist operator; 1 citizens group.

Round 2, January 2014: MERMAID case study participants discussed a list of stakeholders to be invited to the second round table meeting. 18 selected stakeholders were invited to participate in the round table session; 6 stakeholders attended the meeting, which was held in Italian. The other 12 stakeholders were asked to fill in the assessment tool separately (cf. D 2.3, p.40).
The participating 6 stakeholders represent the following stakeholder categories:

Stakeholder group	participants
Governing bodies/regulators/policy makers as regional, national and European officers	2
End users of the MUP, e.g. energy companies and aquaculture entrepreneurs	1
Suppliers of the MUP such as cable companies and construction businesses	1
Stakeholders from other offshore activities such as fisheries, shipping & mining sectors	0
Discourse community, including e.g. (environmental) NGO's, local citizens	1
Universities and research institutes	1

During this second round table meeting, the discussion focused on the combination of energy production (wind and wave energy converters) in combination with research and the cultivation of microalgae or fish. MERMAID presented draft designs of possible MUPs, simulations about shore impacts of the different MUP functions, and economic procedures to be implemented to estimate social and economic impacts.

Round 3, March - April. 2015: For this final evaluation of the MUP design proposed by the MERMAID Adriatic site team, emails were sent out to 15 stakeholders, 2 responded, , i.e. a very low response rate of 13%. The 15 stakeholders addressed are categorized as follows:

Stakeholder group	contacted	replied
Governing bodies/regulators/policy makers as regional, national and European officers	6	1
End users of the MUP, e.g. energy companies and aquaculture entrepreneurs	3	1
Suppliers of the MUP such as cable companies and construction businesses	3	0
Stakeholders from other offshore activities such as fisheries, shipping & mining sectors	0	0
Discourse community, including e.g. (environmental) NGO's, local citizens	2	0
Universities and research institutes	1	0

Has MERMAID missed any relevant stakeholder/ stakeholder group/ sector?

All disciplines involved in MERMAID were represented: engineering, ecology, economics, energy, climatology, fishery. However, the first meeting in November 2012 highlighted that MERMAID was bound to be a research project, aiming at specifying a scientific methodology to be followed in designing a MUP in a very problematic study site, with low potential in terms of energy (both wind and wave), and with expected highly negative environmental impacts. Consequently, many private investors were missing, whereas many public agencies attended the second meeting in January 2013.

6.3 Stakeholders' input and MERMAID internal evaluation – Adriatic site

The following tables (left column), summarise all comments, feedback and recommendations received from the stakeholders contacted during the MERMAID participatory process, rounds 1 and 2. All input has been clustered according to technical, financial, environmental, social-economic aspects, and one final table for general aspects.
The right columns in the tables below explain, for each issue raised by the stakeholders, how MERMAID has dealt with and responded to this input in the development and choice of the proposed MUP design.

Technical aspects – Adriatic site	
Stakeholders' concerns	**MERMAID response**
Conditions at the suggested site: sheltered water, shallow, moderate wind and wave energy potential. - Design a tailored Wave Energy Converter (WEC) to be installed around the platform. - Aim: Combine research with wave and wind energy and with aquaculture (cultivation of microalgae or fish).	Several combinations were proposed and discussed. Currently, the proposed MUP is combination E: the grid connected solution of the combination aquaculture and large scale wind energy production. Due to the high costs and the immature technology, the wave energy conversion is abandoned. Synergy is induced by integrating wind energy production and fish farming.
Main concern is the exact location of the MUP: The precise site location should not be fixed in advance, but should be taken into account during the design process (as a decision variable): Disadvantages of the current location: - far away from the coast, could be costly - could be in conflict with planned offshore port and other activities (shipping, fishing)	The MUP - has to be placed on a water depth of 27 m (around 3 times the minimum submergence of the cages), i.e. 30 km off shore and therefore grid connection is a relevant cost component - has a size of about 1 km2 to avoid conflict of uses in the area
Potential problems with day/night distribution of energy production on the platform.	The solution is to include an Electric Generator to stabilize and guarantee the required power supply.
Potential conflict with the recreational navigation routes from Venice to Rovigno.	Conflicts avoided by the selected location.

Financial aspects – Adriatic site	
Stakeholders' concerns	**MERMAID response**
Need to find a new aquaculture company, as the only one interviewed cannot participate due to lack of personnel and financial resources.	Out of the scope of the design activity Note: A new aquaculture company has not been found, due to the monopolistic structure of the local fish market and to the risky investments in new activities such as offshore fish farming.

Current location (large distance from shore) is associated with high costs. Fish farming might be unprofitable.	Unprofitability of fish farming is related, to a large extent, to low water temperature, and consequently to a low productivity: distance to the market appears to be irrelevant. All single-use platforms are unprofitable in the area when considering only local-scale benefits (i.e. excluding for instance technological and non-technological advances).
Potential competition with mussel production.	Mussel production might be more profitable than fish farming and should be investigated in further studies. Fish farmers should distinguish these markets, by presenting Sea bass and Sea bream as a completely different product, although coming from nearby offshore locations.
Potential conflict when opening up a market for sea bass or sea bream - could rely on local demand.	The development of off-shore fish farms accomplishes the new EC regulations and therefore is considered as a general benefit. The new local production does not cover the whole demand while strongly increasing sustainability (zero-km production).
Lack of knowledge and experiences with offshore installations (fish and energy).	N/A

Environmental/ ecological aspects– Adriatic site	
Stakeholders' concerns	**MERMAID response**
High concern about negative environmental impact. MUP should not have any negative impacts on the ecosystem.	Modest impacts due to pile foundations and small footprint area.
Information is lacking regarding necessary amount of trips, size of aquaculture ships for daily feeding and transport of fish, size of info about other trips necessary for the MUP.	All vessels required to the MUP are of regular dimension. Maintenance is expected to take place twice per month without any significant increase of pollution.

Impact on water quality due to loss of feed: Does fish feeding for aquaculture lead to eutrophication? Do currents aggravate this potential problem?	There might be an increase of nutrients, aggravated by the vicinity to the Po Delta and by the low intensity of current speed. However, existing studies, fish farm size and off-shore location suggest that these effects would be limited.

Social-economic aspects – Adriatic site	
Stakeholders' concerns	**MERMAID response**
Potential visual problems from the center of Venice: impact on tourism and economic situation?	This problem was solved, since location is more than 12 Nautical Miles from the coast line. The MUP is too far off-shore to lead to any impact of this type.
Site selection: No interference with other activities.	ISPRA has carried out a spatial analysis to support the selection of the more promising areas leading to no conflict of uses.
Important to find new active aquaculture stakeholder.	Out of the scope of the design activity.
Important to have a participatory design process, involving multidisciplinary experts with clearly defined roles. Multidisciplinary cooperation is considered critical for the design process.	Done (by submitting structured questionnaires to stakeholders, assessment tools to experts, and taking into account the elicited suggestions in the design process) to set-up the different combinations – final selection should be based on economic feasibility and potential benefits.
What is the impact of a potential change in subsidisation policy for renewable energy by the Italian government?	N/A Out of the scope of the design activity. The importance of this feature will be assessed by performing sensitivity analysis on profitability of the MUP.

General comments/recommendations – Adriatic site	
Stakeholders' concerns	**MERMAID response**
High degree of uncertainty and concern about site location, negative environmental impact, and social-economic impacts.	Various different MUP combinations have been proposed and discussed intensively with stakeholders (see summary presentation and all of the above).

	Sensitivity analysis, a Spatial Decision Support System, an Ecosystem approach allowed us to account for uncertainty.
Focus on the site selection procedure and discuss the location with multiple stakeholders.	Not done yet. Concerns have been taken into account through the objective spatial analysis tool (ISPRA work). The chosen location is based on suggestions by stakeholders, together with technical constraints.
Focus on analysing possible environmental effects: execute an environmental impact assessment.	To be done once the final design has been selected, and included in D7.3. An environmental impact assessment will not be performed, whereas a detailed analysis of ecosystem services involved will be carried out.

6.4 Stakeholders' evaluation of the proposed final design – Adriatic site

The following table summarises all answers and comments received during the round 3 consultation of stakeholders to evaluate the proposed final MUP design. Column 3 shows the number of stakeholder votes received for the three multiple-choice answers: yes, no, don't know. Column 4 lists all the comments received. Note that not each respondent provided comments.

Mediterranean (Adriatic) site: Number (#) of stakeholders who replied/total contacted: 2/15			
Consideration of:		**#**	**Comments**
Feasibility in region?	Yes	1	-
	No	1	- No financial returns
	Don't know	0	-
Technical feasibility?	Yes	2	-
	No	0	-
	Don't know	0	-

Financial feasibility?	Yes	1	-
	No	1	- Wind energy costs very high
	Don't know	0	-
Legal feasibility?	Yes	0	-
	No	0	-
	Don't know	2	-
Beneficial from social-economic perspective?	Yes	1	- Increase in employment and decrease of CO2 emissions
	No	0	-
	Don't know	1	-
Environmental benefit?	Yes	1	- Renewable energy and local fish
	No	1	- Sea bed damages due to horizontal wind energy structures
	Don't know	0	-
Does our proposed MUP design meet your expectations?	Yes	0	-
	No	0	-
	Don't know	2	-
Has stakeholder feedback been considered properly in our proposed MUP design?	Yes	0	-
	No	0	-
	Don't know	2	-
Appropriate for reaching policy objectives on future food production?	Yes	1	- Local fish
	No	1	-
	Don't know	0	-
Appropriate for reaching future energy production/ provision policy objectives?	Yes	0	-
	No	0	-
	Don't know	2	- Large costs and fixed rather than floating structures

6.5 Conclusions – Adriatic site

The Mediterranean case study started from scratch. Hence, the identification of relevant stakeholders was a pioneering effort. The process was driven on the one hand by the question: What do stakeholders want? On the other hand, it was a science driven process: What is possible, mainly from a technological, economic and financial point of view?

Stakeholders' suggestions were partly taken into account. Stakeholders had been mostly interested in wave energy at the start. Wave energy was taken as a suggestion, but not as the general public opinion. The wave energy option had to be dismissed due to the very high financial costs of wave energy (3x costs of wind energy).

Due to the initial strong interest in wave energy, there was not any intention in the beginning to focus on wind energy. Hence, wind energy stakeholders was not involved. The change in focus towards wind energy happened in a later stage of the participatory design process. At that late stage, it proved not to be possible to involve the wind energy stakeholders.

The main reason for stakeholders to oppose wind energy was the fear of visibility issues from the coast. This concern of the stakeholders was taken into consideration during the participatory design process. The designers changed the MUP location from 12 km to ca 27 km offshore. At this distance, the wind turbines are not visible from the coast anymore.

Stakeholders also opposed a new aquaculture in the MUP, because they were afraid of competition with the already existing coastal aquaculture. Despite this fear of competition, the MERMAID design team decided not to limit the design by this argument, which is essentially a plea for keeping a monopoly of the coastal aquaculture. Therefore, new aquaculture is considered and included in the proposed MUP design, because it is an activity that can be combined with the other uses. An additional supporting argument for including aquaculture in the proposed wind-fish farm MUP design is in fact of the existence and vicinity of a market for aquaculture products nearby.

Impact of MERMAID over the course of the project

The stakeholders that got involved in the participatory design process are now more aware of the opportunities of MUPs. The future for a wind-fish MUP is, nonetheless, very uncertain,

and one reason for this is the absence of the wind stakeholders from the MERMAID participatory design process, as was explained above.

The increased awareness and knowledge of stakeholders about the MUP concept in general has stimulated stakeholders to think out of the box. A new idea for a potential MUP was raised: Mussel fisheries in gas platforms. In fact, stakeholders know that this kind of combined use is already existing. It could be studied more thoroughly and improved in the future. A challenge of such a MUP is that officially there is no permission to access the gas platforms, and what is more, the platforms increase land subsidence.

7. Lessons learned and recommendations

This report presents two different evaluations: First, an evaluation of the proposed MUP designs of the four regions, on the basis of a stakeholder evaluation of the designs. Second, an internal evaluation of how MERMAID took into account stakeholders' recommendations, based on comments received and documented in MERMAID Deliverables 2.2 and 2.3.

7.1 Evaluation of the final designs

The evaluation was sent out to 74 stakeholders in total, of which 27 replied, yieldingan overall response rate of 36%. For such type of questionnaires this response rate is in line with reported responses on average around 33% (Nulty 2008). The fact that the answers of certain stakeholder groups are lacking might cause a bias in the response rate. For example, the lack of involvement of particularly the government bodies in the Baltic case study might be a reason for the stakeholders' high uncertainty concerning the legal feasibility of a MUP (75% don't know). Note that the North Sea site has put a lot of effort in identifying a large number of relevant stakeholders (45 for round 2, 35 for round 3). Moreover, the North Sea stakeholder list has been updated, removing those from the list that changed work focus, and contacting stakeholders that had been identified as new and relevant to the field. The absolute number of North Sea stakeholders replying (12) is the highest among the four sites. The Mediterranean site, in contrast, has yielded an extremely low response rate in round 3 (only 2 of 15 contacted stakeholders replied). This introduces a bias in the analysis, and hence, the answers from the Mediterranean site should not be taken as indicative, and we exclude them from the following discussion.

In general, the 24 respondents who participated in round 3, i.e., the evaluation of the proposed final designs, were generally positive about the feasibility of a MUP in their region. More than 60% of the respondents were positive about the feasibility in general (67%), the technical feasibility (63%), and the potential for socio-economic benefits of the proposed MUP design (67%). 50% of the respondents indicated that the proposed MUP design meets their expectations.

The stakeholders' greatest concerns in all four sites relate to the financing of such a project, and this is mainly due to lack of knowledge and information to be able to evaluate the financial feasibility (42% indicating "don't know").

The respondents of the North Sea site are more sceptical about the technical feasibility of the MUP than in the other three sites. 11% disapprove the technical feasibility at the Gemini site in contrast to 0% complete disapproval in the other three sites. This North Sea scepticism relates particularly to the Gemini far offshore location.

The 25 stakeholder replies from the Baltic Sea, North Sea and Atlantic case studies confirm that in these three sites, there is now increased awareness, and even enthusiasm and optimism about MUPs, also, greater insight to the actual challenges of designing a MUP. MERMAID has helped stakeholders to understand that marine space is limited and that there are potential business synergies and opportunities when combining activities at sea. However, the MERMAID MUP designs and all related assessments remain desk studies. They cannot give any precise answers to stakeholders' main questions about technical risks and financial feasibilities. These can only be dealt with and tested once MUP designs are implemented as pilot projects.

		In % of the total replied				
Consideration of:		**Baltic (8/14 = 57%)**	**North S (12/35 = 34%)**	**Atlantic (5/10 = 50%)**	**Adriatic (2/15 = 13%)**	
Feasibility in region?	Yes	62.5	66.7	80	50	
	No	12.5	25	0	50	
	Don't know	25	8.3	20	0	
Technical feasibility?	Yes	62.5	41.7	80	100	
	No	0	41.7	0	0	
	Don't know	37.5	16.7	20	0	
Financial feasibility?	Yes	37.5	20.8	20	50	
	No	12.5	37.5	20	50	
	Don't know	50	41.7	60	0	
Legal feasibility?	Yes	12.5	58.3	60	0	
	No	12.5	25	20	0	
	Don't know	75	16.7	20	100	
Beneficial from social-economic perspective?	Yes	50	66.7	100	50	
	No	25	16.7	0	0	
	Don't know	25	16.7	0	50	

Environmental benefit?	Yes	37.5	41.7	60	50	
	No	37.5	8.3	20	50	
	Don't know	25	50	20	0	
Does our proposed MUP design meet your expectations?	Yes	37.5	54.2	80	0	
	No	12.5	45.8	0	0	
	Don't know	37.5	0	20	100	
Has stakeholder feedback been considered properly in our proposed MUP design?	Yes	37.5	8.3	40	0	
	No	0	41.7	0	0	
	Don't know	50	50	60	100	
Appropriate for reaching policy objectives on future food production?	Yes	37.5	54.2	20	50	
	No	12.5	12.5	40	50	
	Don't know	37.5	33.3	40	0	
Appropriate for reaching future energy production/ provision policy objectives?	Yes	50	50.0	80	0	
	No	12.5	33.3	0	0	
	Don't know	37.5	16.7	20	100	

7.2 The participatory process of MERMAID

MERMAID MUP designs are all desk studies. They did not coincide with real life experiments on MUPs; this was a challenging aspect of the whole project. All 4 sites followed the same MERMAID participatory approach (3 steps), despite being at different stages in real life development of MUPs when the MERMAID project started. This report shows that the MERMAID participatory approach was feasible to be carried out in all four cases, although each case was different and was in a different stage of realising a MUP in reality.

The four site specific processes can be considered efficient with respect to gathering the technical knowledge and agreeing on a final MUP design. In terms of involving the relevant stakeholders and communicating with them transparently, MERMAID has definitely succeeded in creating awareness about MUPs, increasing stakeholders' knowledge, building networks to proceed further with in order to generate pilot studies. Additionally, the following lessons and conclusions can be drawn specifically as regards the organisation of such interactive processes:

Communication

Based on our internal evaluation and the analysis that many stakeholders replied “don’t know” to the question “Has stakeholder feedback been considered properly in our proposed MUP design?”, we can conclude the following:
The communication between the MERMAID site-teams and the stakeholders in the regions was not in all cases intensive enough. One reason is that different stakeholders were involved in different rounds. Another reason is that some stakeholders were involved in MERMAID only in the sense that they were approached as a part of the work tasks in the MERMAID work package about participatory design (WP2). One exception was the involvement of stakeholders in the Baltic case. In this case, relevant experts of the relevant different fields were involved as full partners in the MERMAID project, which means that they actively collaborated regarding the design development as well as all the necessary different assessments (technical, financial, legal, environmental, social and economic).

Stakeholder representativeness

It was difficult to involve the right selection of representative stakeholders for the North Sea and Mediterranean MUP sites: two of the main sectors involved in the proposed MUP (mussel sector and wind sector, respectively) were missing. Reaching the right representatives was difficult because the MERMAID partners had to start identifying and building up this network from scratch. Contrarily, the approach in the Baltic site worked well, since there was already an existing network of interested and relevant participants involved.

Coming to a final design

Each of the four sites followed their own individual approach in terms of selecting and inviting different stakeholders at different stages. This choice for individual approaches can be considered helpful from a technical point of view, because it allowed the participants to focus on the relevant phase-specific questions. This selected involvement of stakeholders is considered efficient in terms of commenting, discussing and ultimately agreeing on a final design. In the North Sea and Baltic Sea sites, for example, an agreement on the type of MUP was found very quickly already at participatory round 1, and in consensus with all the participants. In contrast, in the Mediterranean site, the final MUP combination was agreed on only in a very late stage. This might have also been caused by the fact that the wind sector had not been involved from the beginning.

7.3 Recommendations

Based on the analysis and evaluations of the MERMAID interactive design process in the four different case studies, below we list two main recommendations in order to help increase efficiency and effectiveness of future MUP projects or initiatives. The two recommendations concern an initial assessment of the context – including identification of stakeholders, project phase and internal project developments – and transparent communication with the stakeholders.

Context assessment

It is crucial to be fully aware of the context in which a MUP initiative is developing. It is thus recommended to start with an initial assessment of the context, i.e. investigate the situation and conditions of the site under consideration, including identification of stakeholders, project phase and internal project developments (e.g. changes in project staff, time and budget constraints).
Concerning the identification of the relevant stakeholders as well as the identification of the initial project phase, the following aspects should be kept in mind:

- A stakeholder analysis for each specific stakeholder contact is recommended, meaning: Involve the relevant people for specific decisions. Do not always aim to involve all stakeholders. Focus and limit to the most relevant, who can help in initial exploring. Röckmann et al. (2015) provide a list of context specific factors and related questions that can aid in realistically assessing the context and identifying the necessary degree of interaction that would be required with stakeholders depending on the context.
- Beware that during the interactive discussions, objectives can change/be revised, so a stakeholder who was not relevant in the initial stage might become relevant at a later stage.
- In an initial technical scoping phase, it makes sense to only involve a small group of relevant experts.
- Collaborate closely with the stakeholders that are already involved in the initiative.
- Do not omit a stakeholder group representing a crucial end-user of the potential MUP.
- Regarding the project phase (the “real-life context”), it is recommended to investigate and be aware of which phase a proposed MUP initiative is in. For example, is it a real

case, such as the Baltic Sea and North Sea sites, where wind parks are being built? Or is the site in an explorative phase such as the Atlantic site? The Adriatic site is an example for an initiative that started from scratch. The MERMAID interactive design methodology can then be applied with more focus.

- Internal project developments, such as a change in team members can affect the smoothness of work flow within a project. Therefore, one should always be alert and if possible anticipate changes that could affect the project organisation.

Transparency in communication with stakeholders

Be aware that if a process is opened up for input/feedback from stakeholders, then it is crucial to also always report back to the stakeholders about what has been done with their input. If stakeholders start developing fatigue because there are too many obstacles (regulatory, institutional, financial, social and economic) as concerns implementation of MUPs in real life, then these concerns have to be jointly addressed and discussed in a transparent way. Transparent communication can then avoid stakeholder fatigue, keep up the motivation and sustain lasting interaction. It is important to communicate transparently not only once at the end of a project but at each stage. This allows stakeholders to easily trace back how their input has been used/applied or not.

Finally, in order to promote the opportunities of MUPs, increased MUP awareness of governmental ministries is particularly important, because regulatory/legislative government incentives are urgently needed. Incentives are also needed to encourage pilot studies for activities that need to be tested offshore. For the future, interdisciplinary research and collaboration needs to focus intensively on getting the financial numbers right. In all four MERMAID MUP proposals, the greatest uncertainty is about financial feasibility. If financial synergies of multi-use can be demonstrated to reduce costs, then the combination of multi-use activities offshore will have a future.

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Annex 1. Example email sent out with list of 14 evaluation questions

Dear xxx,

The attached 8 pdf slides summarise a conceptual design of a xxx MUP in the xxx Sea.
Your input (received during previous contacts with the EU MERMAID project) has helped to develop this conceptual design.

We ask you kindly to take a few minutes to reply to this email, answering our 14 evaluation questions below.

We appreciate your collaboration and thank you in advance for your help!
Your feedback will be treated anonymously. The results of all feedback received will be communicated in a MERMAID report to the European Commission.

Best regards,
the MERMAID project team

1. Please look at the attached short Summary (8 pdf slides) of the proposed multi-use offshore platform (MUP)
2. Please answer our 10 questions to evaluate this proposed MUP design.
To answer, just delete the irrelevant options. Then, please type in your explanation.

1. Do you consider MUPs to be feasible in your own region?
   Yes - No - I do not know
   Please explain, why? .....
2. Do you consider our proposed MUP design to be technically feasible in your region ?
   Yes - No - I do not know
   Please explain, why? .....
3. Do you consider our proposed MUP design to be financially feasible in your region ?
   Yes - No - I do not know
   Please explain, why? .....
4. Do you consider our proposed MUP design to be legally feasible in your region ?
   Yes - No - I do not know
   Please explain, why? .....
5. Do you consider our proposed MUP design to be beneficial from a social-economic perspective in your region ?
   Yes - No - I do not know
   Please explain, why? .....
6. Do you consider our proposed MUP design to be environmentally beneficial in your region ?
   Yes - No - I do not know
   Please explain, why? .....

7. Does our proposed MUP design meet your expectations ?
   Yes - No - I do not know
   Please explain, why? .....
8. Has stakeholder feedback been considered properly in our proposed MUP design?
   Yes - No - I do not know
   Please explain, why? .....
9. Do you consider our proposed MUP design to be appropriate for reaching policy objectives on future food production?
   Yes - No - I do not know
   Please explain, why? .....
10. Do you consider our proposed MUP design to be appropriate for reaching policy objectives on future energy production/ provision?
   Yes - No - I do not know
   Please explain, why? .....
11. What is the chance MUPs will be realized in your region within 5 years?
   Please answer in %. .....
12. When will we see MUPs in your region? .....
13. How big do you assess the chance that your organization will play a role in it?
   Please answer in %. .....
14. Will your organization play a role in MUPs?
   Yes - No - I do not know
   If so, what role? .....

End. Thank you!

Annex 2. Summary presentation of the proposed design of a multi-use offshore platform at Kriegers Flak in the Baltic Sea

Annex 3. Summary presentation of the proposed design of a multi-use offshore platform at the GEMINI site in the North Sea

Annex 4. Summary presentation of the proposed design of a multi-use offshore platform in the Cantabria Offshore Site

Annex 5. Summary presentation of the proposed design of a multi-use offshore platform in the Adriatic Sea

Annex 2. Summary presentation of the proposed design of a multi-use offshore platform at Kriegers Flak in the Baltic Sea

Summary presentation of the proposed design of a multi-use offshore platform (MUP) at Kriegers Flak in the Baltic Sea

1. Picture/figure(s) of the design; location; production estimates
2. Site characteristics; possible synergies of combined uses
3. Technical characteristics of each MUP element
4. Financial characteristics (cost & revenue estimates)
5. Legal/regulatory/institutional conditions to be met
6. Environmental effects (+/- estimates)
7. Social-economic benefits/ obstacles

MERMAID site manager: Ole Svenstrup Petersen, Date: 23.2.2015

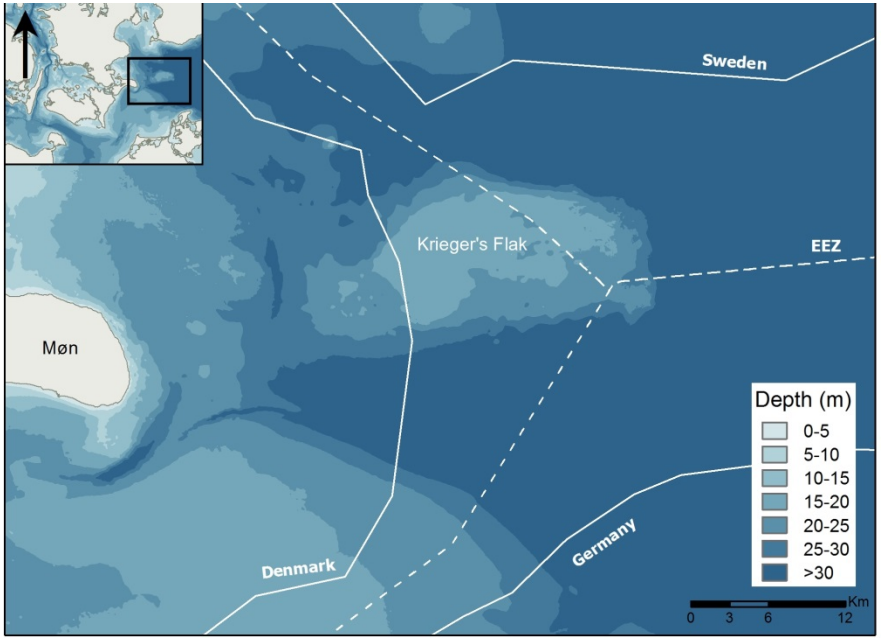
Wind-Fish-Seaweed farm in the Baltic Sea

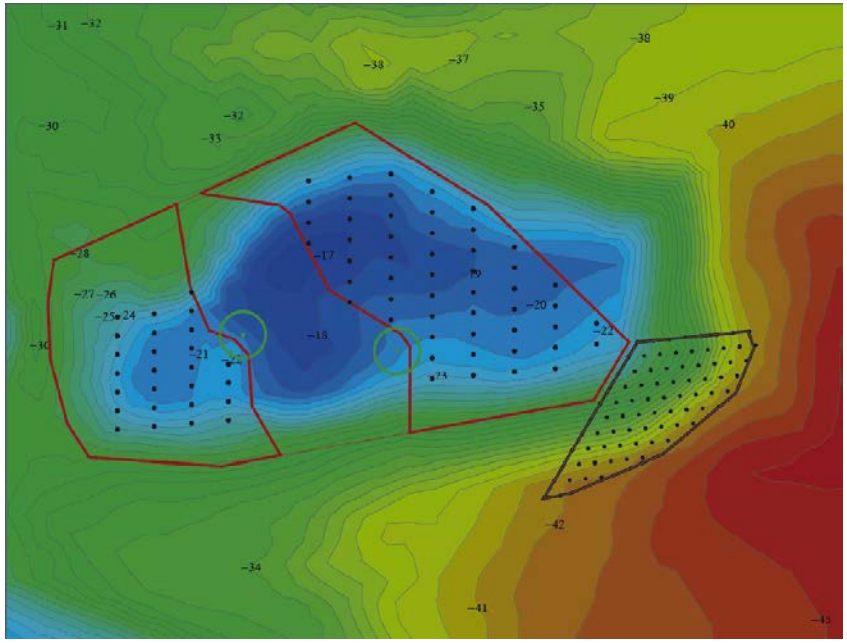
Location: Baltic Sea

- Kriegers Flak: planned offshore wind farm (OWF) site, combined with aquaculture, and possibly seaweed farming
- Total used area in DK: 180 km^2
- Distance from shore: 32 km

Annual production capacity estimates

- Offshore wind farm (OWF): 600 MW (1.600 MW planned)
- Salmonid farm: 10000 t/y (potentially higher production)
- Potential future seaweed production of Furcellaria





Wind-Fish-Seaweed farm in the Baltic Sea

Site characteristics

- Morphologic conditions: manageable water depths, not active.
- Geotechnical conditions: excellent soil conditions
- Met-ocean conditions: average wind speeds ~ 10 m/s, 10 y wave height
- Salinity and hydraulic conditions optimal for salmonid production

Possible synergies of proposed wind-fish-seaweed farm:

- Cost reduction on logistics, operation & maintenance (O&M)
  - E.g. reduction of costs for wind and fish through common O&M
- Efficient use of valuable area
- Wave sheltering inside area
- On shore grid connection in Rødvig 32 km distance

Wind-Fish-Seaweed farm in the Baltic Sea

Technical characteristics

Fish farm:

- Two sections with 12-14 round cages with a diameter of 45 m and a feeding barge
- Project time horizon: 5-10 years.
- Decommissioning: Removed and transported to shore yearly after harvest

Seaweed farm:

- Area: Future option – in best case the production potential is 6 tons dryweight/ha/y
- Project time horizon: 10-15 years.
- Decommissioning: removed and transported to shore

Wind farm:

- Area: 180 km^2
- Gravity or monopile based foundations
- Project time horizon: Construction will finish 2021. Operational for ~25 years.
- Decommissioning removed from bed level to upwards and transported to shore

Wind-Fish-Seaweed farm in the Baltic Sea

Financial characteristics

Offshore Wind: - Realization (construction costs): €1.5 billion for the project
- Planned for 25 year of production

Salmonid farming: - Realization of the project: minor
- Production: €40 million/year

Seaweed: - Future option that requires future testing and market analysis

Approximations/estimations of:

- Financial costs:
  - Capital: € 1.5 billion for wind farm + € 0.2 billion for grid connection
  - O&M: € 40 million/year
  - Administrative: € 0.1 billion
- Expected/estimated financial revenues : 0.28 billion/year
- Efficiency gains from combined use : 10 %.
- Sustainable Business Plan: yes

Wind-Fish-Seaweed farm in the Baltic Sea

Legal/ regulatory/ institutional conditions to be met

Regulatory/Institutional restrictions

- Danish marine spatial policy stresses: Lack of legal and regulatory basis for MUPs

Current strategies (Management/ planning)

- Wind energy sector committed itself to a cost reduction of 40% of the total costs/MWh → every discipline involved in offshore energy production is kept under constant review.
- Danish offshore aquaculture sector sees market opportunities for a total yearly production of 500,000 ton → new areas for fish farming production are necessary.

➔ All objectives can be met by combining offshore wind energy production with aquaculture

Current obstacles

- Spatial plans for the Baltic Sea do not designated areas for aquaculture
- Regulators lack handling practise
- Regulatory framework for MUPs (including risk assessment, insurance issues) is missing
- Third party access to OWFs is currently forbidden to avoid question on risks & responsibilities
- New renewable energy subsidy program no longer includes offshore wind developments.

Wind-Fish-Seaweed farm in the Baltic Sea

Potential environmental effects

General

- Disturbance during the construction phase, e.g. of sea mammals and birds disturbed by increased transport/ ship traffic to and from the MUP
- Emissions of nutrients, medicaments and antifouling from fish farming
- Pollution due to increased ship traffic
- Changes in hydrodynamic regime
- \+ Potential eco-facilitation: Presence of new hard substrate (piles and scouring stones) → artificial reefs → increase of amount of available habitat for some taxa

Specific for seaweed culture:
- Nutrient and light reduction (affecting local phytoplankton)
- Nutrient enrichment in case of fertilization
- Reduced phytoplankton biomass due to feeding

Specific for mussel culture:
- Increased transparency
- Accumulation of organic matter on sediment
- Stepping stone for (invasive) species

EIA available for power transmission and the Swedish part of Kriegers Flak OWF.

Input to EIA for fish farming will still be conducted by MERMAID.

Wind-Fish-Seaweed farm in the Baltic Sea

Social-economic benefits / obstacles

Employment possibilities:

- Kriegers Flak wind farm development: Hundreds of employees and companies involved indirectly: e.g. international banks, credit insurance companies, pension funds, producers of wind turbines, foundations, transition pieces, transformers and power cables.
- Construction phase: ca. 10000 people over a 3 year period
- Operation phase: first 15 years: ca. 120 people for M&O activities

Societal perceptions / objections:

- Lack of trust between offshore wind sector and fishery community
- NGOs interested in realizing ecological valuable zones within OWFs (supported by some scientists)
- Location for aquaculture is not ideal

Annex 3. Summary presentation of the proposed design of a multi-use offshore platform at the GEMINI site in the North Sea

Summary presentation of the proposed design of a *multi-use offshore platform* (MUP) in the North Sea

1. Picture/figure(s) of the design; location; production estimates
2. Site characteristics; possible synergies of combined uses
3. Technical characteristics of each MUP element
4. Financial characteristics (cost & revenue estimates)
5. Legal/regulatory/institutional conditions to be met
6. Environmental effects (+/- estimates)
7. Social-economic benefits/ obstacles

MERMAID team: JJ Schouten, C Röckmann, A Wortel, T Söderqvist, R Garcao, J Norrman et al.

May 2015

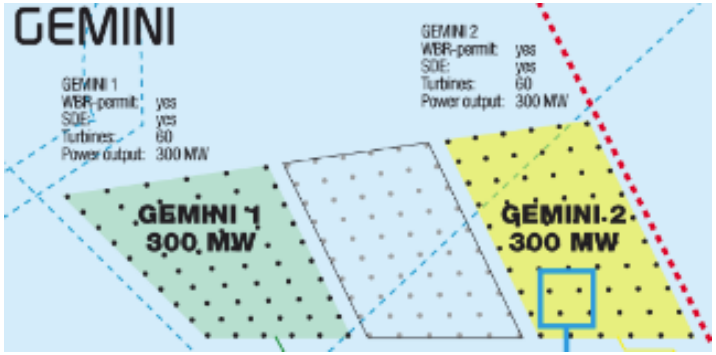
Wind-Mussel-Seaweed farm in the North Sea

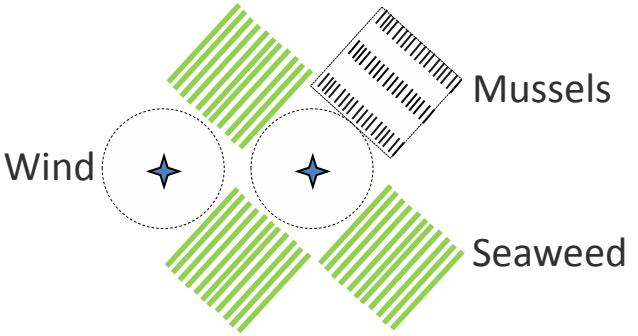
Location: Wadden Sea, Gemini
(licensed offshore wind farm sites)

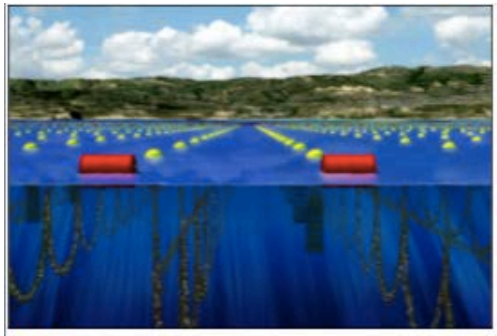
- combined with seaweed & mussel farms
- plus offshore hotel & support centre
- Total use area: 3*34km^2 = 10,2ha
- Non-wind use area: 71km^2 (55%)

Production capacity (estimates)

- Offshore wind farms: **600 MW/yr** (2,300 GWh)
- Mussel farm: ca **3 kg WW/m^2/yr**
  → **48 kton WW /yr** on 1600 ha netto
- Seaweed farm: **10 kg WW/m^2/yr**
  → **480 kton WW/yr** on 4800 ha netto

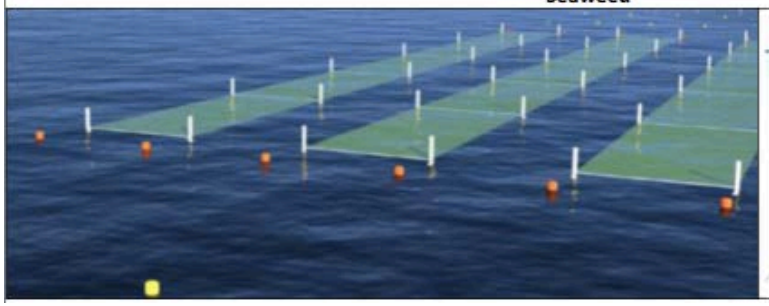


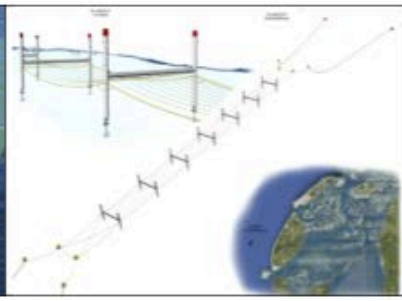



Mussels


Offshore wind turbine Siemens SWT 4.0

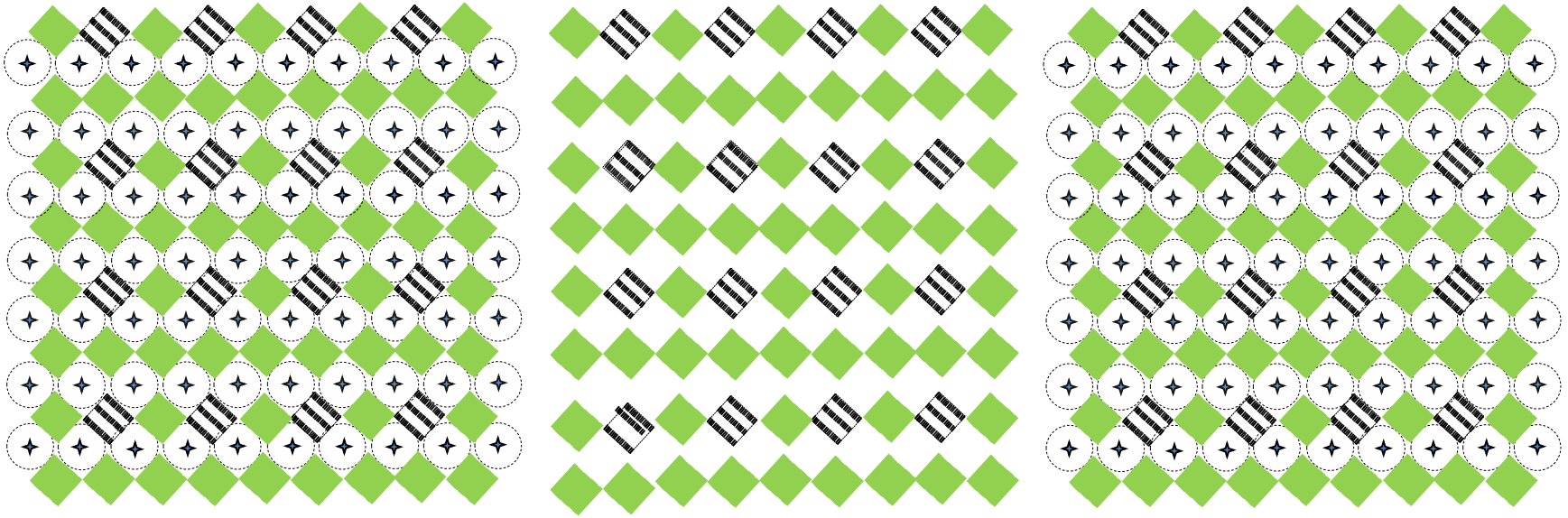
Seaweed



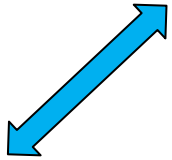


Wind-Mussel-Seaweed farm in the North Sea

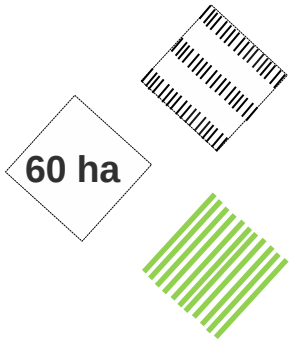
Conceptual design



"ZeeEnergie" "Clear Camp" "Buitengaats"



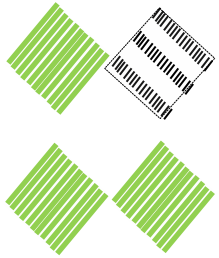
Current direction 80° / 260° Max. 1m/s



Mussels
3* (4*4) = 48 plots,
of ca 33 ha each

Seaweed
ca 48 plots *3 = ca 144 plots

Area ratio
mussels : seaweed = 1 : 3



Wind-Mussel-Seaweed farm in the North Sea

Site characteristics

- Morphologic conditions: manageable water depths, limited sand waves.
- Geotechnical conditions: excellent soil conditions; on-shore grid connection in Eemshaven (owned by Tennet)
- Metocean conditions: one of the best offshore wind locations in NL (average wind speeds of 10 m/s)

Possible synergies of proposed wind-mussel-seaweed farm:

- Cost reduction on logistics, *operation & maintenance* (O&M)
  - E.g. reduction of costs for wind and seaweed through 'Offshore hotel and support centre' (Accommodation for > 100 persons; mainly for shellfish farm, safe storage of small vessels; boat elevator)
- Wave attenuation → reduces damage & costs (fatigue); less waves inside the OWF, enhances O&M; improve longevity of material
- Mussels clean seawater → mussel farm may reduce on-growth on other structures within IMTA *(integrated multi-trophic aquaculture)*, e.g. mussels + seaweed

Wind-Mussel-Seaweed farm in the North Sea

Technical characteristics

Mussel farm: Area: 3*4*4 plots of ca. 33 ha each → ca. 1600 ha

- 120 m longlines (spacing: 20 m) at 3 m depth, buoys at ends to keep under tension;
- droplines for mussel cultivation
- Yield: 4 kg/m dropline → ca 35 ton/ha/yr = ca 3.5 kg WW/m^2/yr
- Project time horizon: 5-10 years. Decommissioning: removed and transported to shore

Seaweed farm: Area: ca 3*mussel area = 3*1600 ha = ca 4800 ha

- 3 species (*L. digitata; L. hyperborea, Saccharina*), cultivated in a row; potentially also vertically
- Preparation, seeding & harvesting of the substrate by special service vessel (navigates over substrate)
- Harvested seaweed removed by small barges, brought to transport vessel/storage
- Project time horizon: 5-10 years. Decommissioning: removed and transported to shore

Wind farm: Area: 2 x ca 34 km2 = ca 68 km2

- 750 m turbine spacing; 200 m access space around turbines for maintenance purposes
- Project time horizon: Construction will start in 2014 - 2017. Operational for ~20 years.
- Decommissioning removed from bed level to upwards and transported to shore

Wind-Mussel-Seaweed farm in the North Sea

Financial characteristics (preliminary estimates)

	Offshore wind	Mussel farming	Seaweed farming
Investment costs	2800 M€ (year 1)	3 – 7 M€ (every 5 years)	40 – 400 M€ (every 10 years)
O&M costs	60 – 140 M€ / year	3 – 57 M€ / year	62 – 68 M€ / year
Revenues	391 M€ / year	45 M€ / year	17 M€ / year
Financial profitability	Yes	Yes, probably	Very uncertain. Depends very much on the development of the price of seaweed products (210 € / ton DW assumed)

Efficiency gains from combined use:

10% has been suggested for offshore wind combined with mussel farming

(Ref: Lagerveld S., Röckmann C., Scholl M. (2014) A study on the combination of offshore wind energy with offshore aquaculture. IMARES Report C056/14. http://edepot.wur.nl/318329).

Wind-Mussel-Seaweed farm in the North Sea

Legal/ regulatory/ institutional conditions to be met

Regulatory/Institutional restrictions

- Dutch marine spatial policy stresses the need for space-efficient use, such as multiple use of offshore platforms; and the need to follow an ecosystem approach.

Current strategies (Management/ planning)

- Wind energy sector committed itself to a cost reduction of 40% of the total costs/MWh → every discipline involved in offshore energy production is kept under constant review.
- Dutch mussel sector sees market opportunities for a total yearly production of 100,000 tons of mussels (almost double of the current production) → new areas for mussel production are necessary.

➔ Objectives can be met by combining offshore wind energy production with aquaculture

Current obstacles

- Spatial plans for the North Sea do not designate areas for aquaculture
- Regulatory framework for MUPs (including risk assessment, insurance issues) is missing
- Regulators lack handling practise
- Third party access to OWFs is currently forbidden in NL, to avoid question on risks & responsibilities
- New renewable energy subsidy program no longer includes offshore wind developments.

Wind-Mussel-Seaweed farm in the North Sea

Potential environmental effects

General

- Disturbance during the construction phase, e.g. of sea mammals and birds disturbed by increased transport/ ship traffic to and from the MUP
- Emissions of nutrients, medicaments and antifouling from fish farming
- Pollution due to increased ship traffic
- Changes in hydrodynamic regime

\+ Potential eco-facilitation: Presence of new hard substrate (piles and scouring stones) → artificial reefs → increase of amount of available habitat for some taxa

Specific for seaweed culture:
- Nutrient and light reduction (affecting local phytoplankton)
- Nutrient enrichment in case of fertilization
- Reduced phytoplankton biomass due to feeding

Specific for mussel culture:
- Increased transparency
- Accumulation of organic matter on sediment
- Stepping stone for (invasive) species

EIA available for Offshore Wind Farm Egmond aan Zee.

Wind-Mussel-Seaweed farm in the North Sea

Social-economic benefits / obstacles

Employment possibilities

- Offshore wind: Once constructions starts, an average of 500 people will work to complete the project for a period of three years. During the first 15 years of its operations, 120 people are needed for maintenance activities.
- Mussel farming: About 40 people can be expected to be employed full-time or seasonal for operation and maintenance.
- Seaweed farming: About 20 people can be expected to be employed full-time or seasonal for operation and maintenance.

Societal objections

- Lack of trust between offshore wind sector and fishery community
- NGOs are interested in the potential of realizing ecological valuable zones within OWFs (supported by some scientists)
- Location for aquaculture is not ideal.

Annex 4. Summary presentation of the proposed design of a multi-use offshore platform in the Cantabria Offshore Site

Summary presentation of the proposed design of a multi-use offshore platform (MUP) in the Cantabria Offshore Site

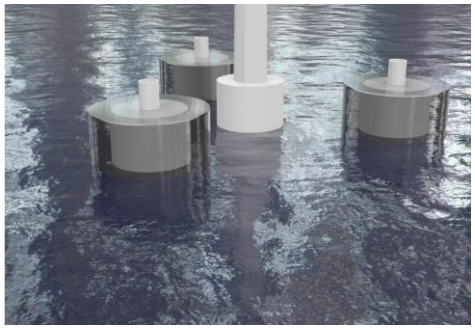
1. Picture/figure(s) of the design; location; production estimates
2. Site characteristics; possible synergies of combined uses
3. Technical characteristics of each MUP element
4. Financial characteristics (cost & revenue estimates)
5. Legal/regulatory/institutional conditions to be met
6. Environmental effects (+/- estimates)
7. Social-economic benefits/ obstacles

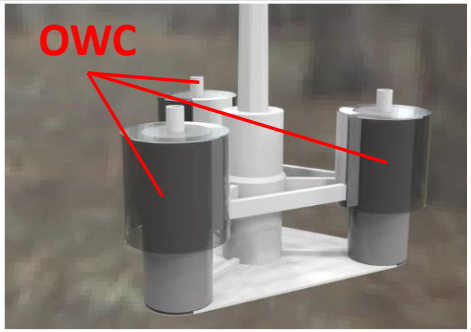
MERMAID site manager: Raúl Guanche, Date: 06/02/2015

Wind and Oscillating Water Column farm in the COS

Sharing structure concept

In the same platform – combined uses – WIND + Wave energy converters (WEC)





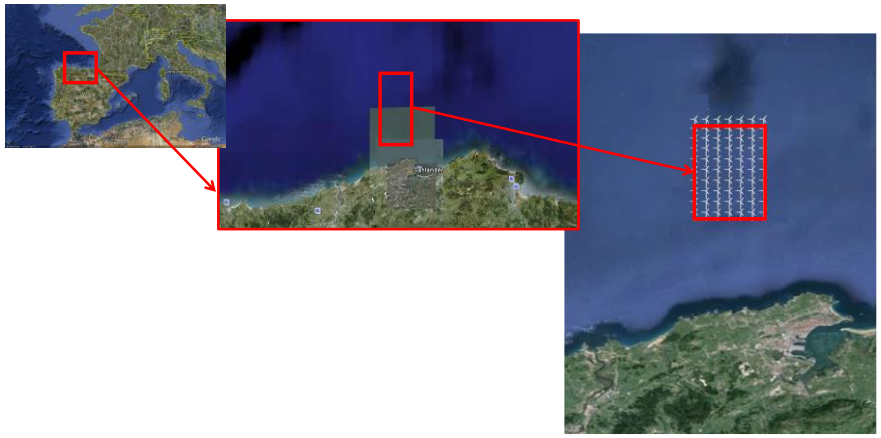
Location + Site characteristics

- Virgen del Mar, Santander-Cantabria-Spain
- Total use area = 60 Km2
- Distance from Shore = 10 Km

Annual production capacity

(estimates)

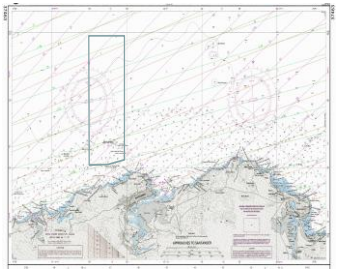
- Number of MUP = 77
- Wind Capacity (for each MUP) = NREL 5 MW
- Wave Capacity (for each MUP)= 1150 *3 Kw



Wind and Oscillating Water Column farm in the COS

Morphologic and Geotechnical Conditions

- Surface: 100 km2
- Depth range: 40-200 m
- Seabed: Sands and rock
- Distance to shore: 3-20 km



Available data information

- Idermar meteo I
- Idermar meteo III
- Red vigía
- AGL Buoy

Metocean conditions and energy resource potential

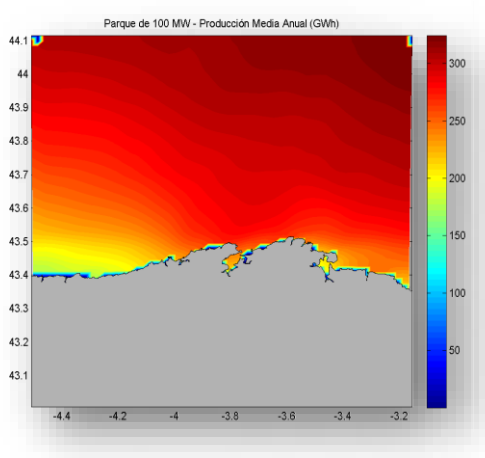
Wind energy characteristics

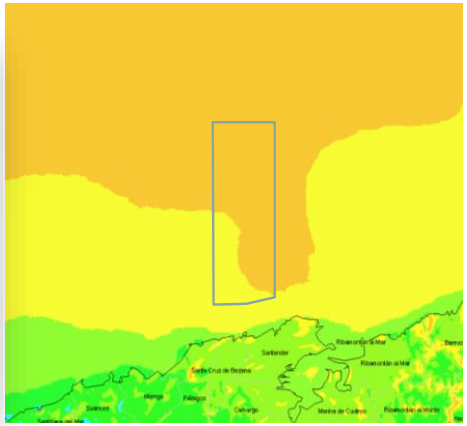
Yearly average: 80m height

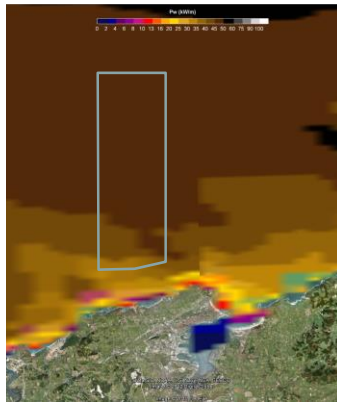
- W_{Mean} = 7 m/s
- $W_{50\text{-}yr}$ = 26,7 m/s
- Available power = 400 -600 W/m^2

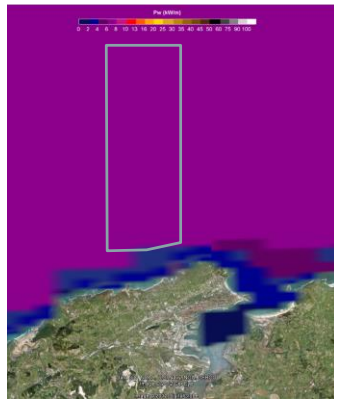
Wave energy characteristics

- Very high wave energy potential
- $H_{s\ Mean}$ = 1,5 m
- $T_{p\ Mean}$= 11 seg
- $H_{s50\text{-}yr}$ = 8,34 m
- $T_{p50\text{-}yr}$ = 15-17 seg
- Direction = NW
- F_{Mean} = 25-30 kW/m
- F_{winter} = 35 -50 kW/m
- F_{summer} = 8 kW/m









Wind and Oscillating Water Column farm in the COS

Technical characteristics

Sharing structure concept

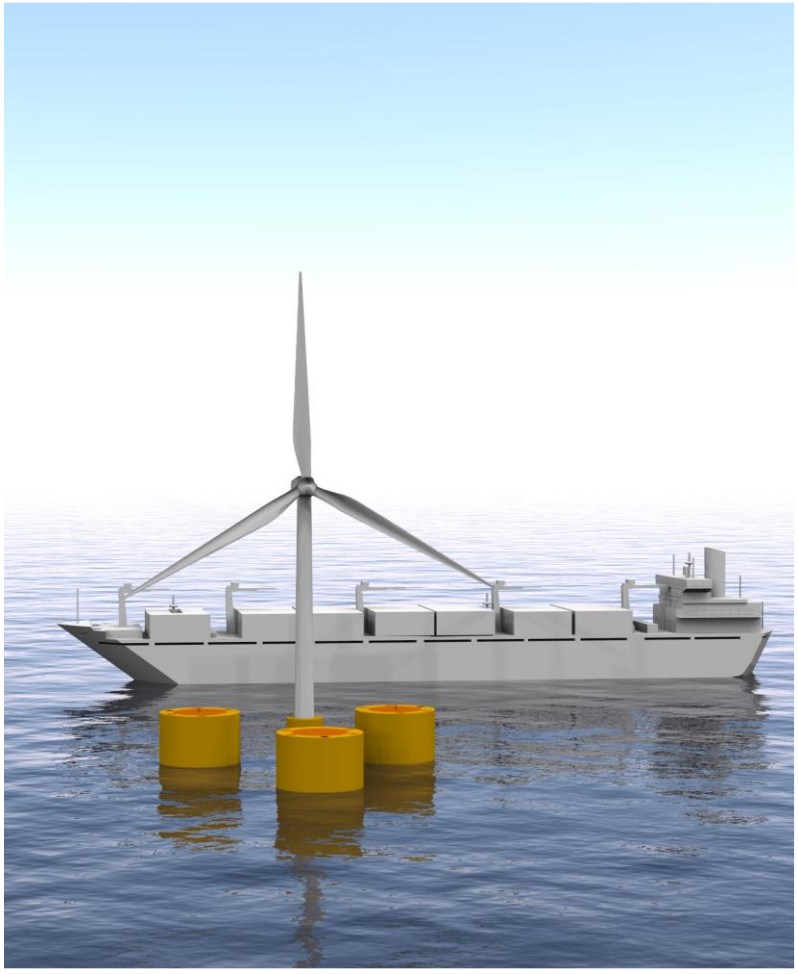
In the same platform – combined uses – WIND + Wave energy converters (WEC)

For each MUP element: Wind:

- Area: 60 km2
- Average Annual Production: 77,256 GWh
- Project time horizon: 25 year
- Decommissioning: removed and transported to shore.
- 1000 m turbine spacing; for wakes effects.

For each MUP element: Wave:

- Area: 60 km2
- Average Annual Production: 1,3 GWh
- Project time horizon: 25 year
- 1000 m OWC; for wakes effects.
- Decommissioning: removed and transported to shore



Wind and Oscillating Water Column farm in the COS

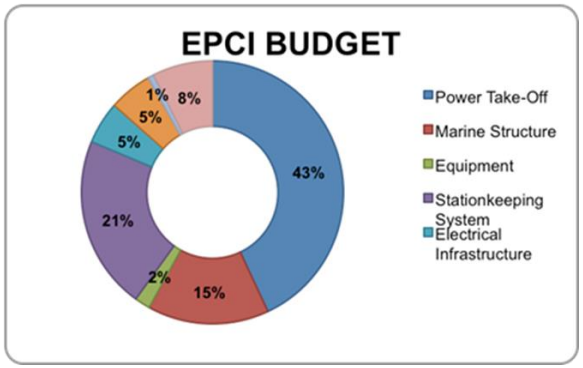
Financial characteristics

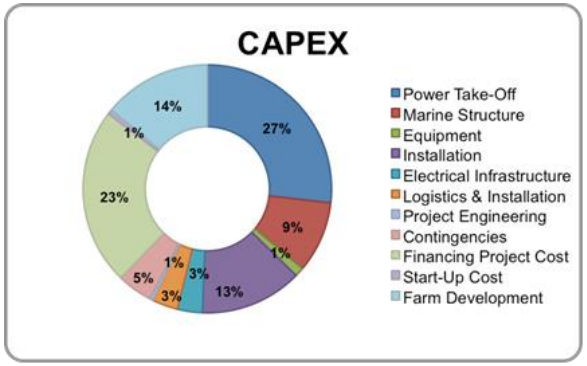
Light Concrete	500	€/m³
Passive reinforced steel	1	€/Kg
Active reinforced steel	3,67	€/kg
Equipment assembly	10%	Total manuf. costs

X

Concrete volume	4.815	m³
Passive reinforced steel	375.000	Kg
Active reinforced steel	64.050	Kg

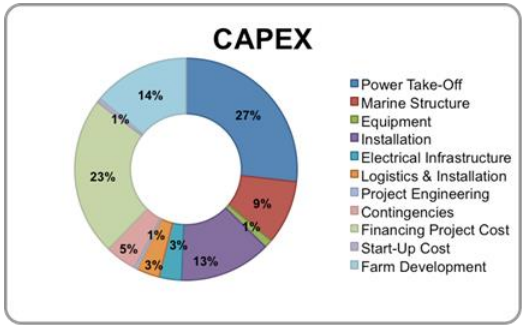
Concrete manufacturing cost	2.407.500	€
Passive reinforced steel cost	374.967	€
Active reinforced steel cost	235.030	€
Equipment assembly	301.750	€
Total manufacturing cost	3.319.247	€

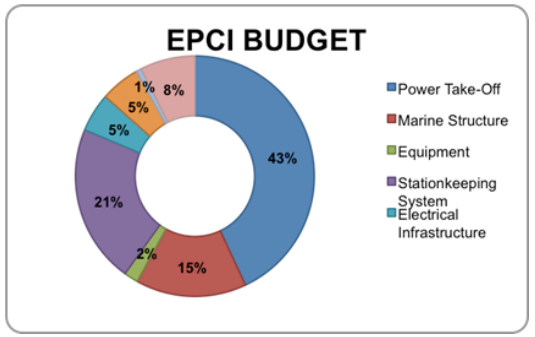


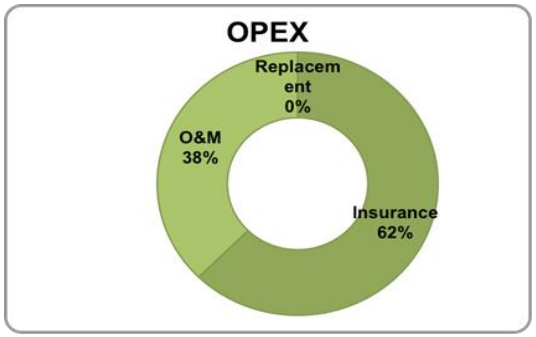


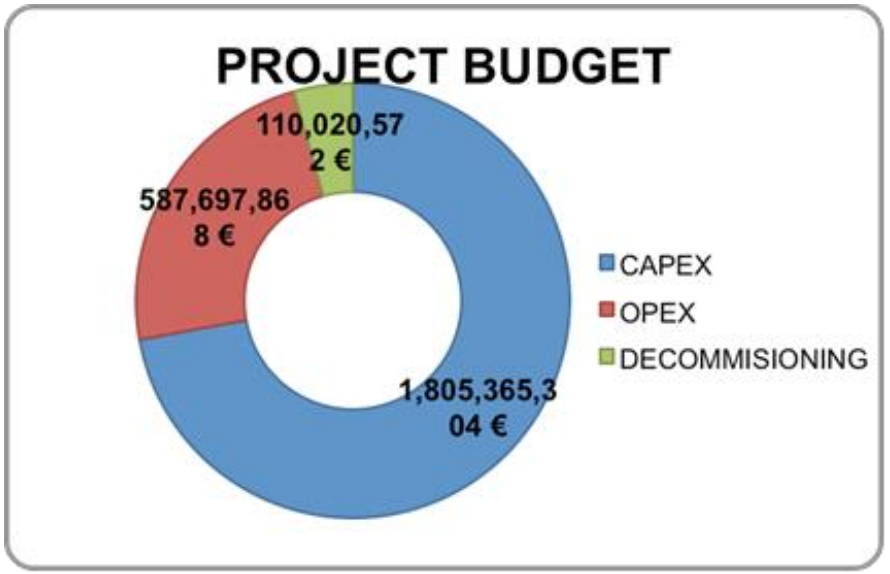
Wind and Oscillating Water Column farm in the COS

Financial characteristics









Wind and OWC farm in the COS

Legal/ regulatory/ institutional conditions to be met

Regulatory/Institutional restrictions

- Regulatory Framework for the development of Marine Energy in Spain
  1. Renewable Energies in Spain: General Framework.
  2. Royal Decree No. 661/2007
  3. Royal Decree No. 1028/2007.
  4. Administrative Procedures.

Current strategies (Management/ planning)

- Mutual restriction among users
- Availability of funding
- Intersectorial Technological transfers
- Competitive advantages for the area
- Regional Benefit Split
- Present controversies on external energy dependence

Current obstacles

Acquisition of permits:

- Lack of social consensus
- Social sensitivity towards aesthetic and functional impact of the facilities.
- Social perception on Environmental requirements

Wind and Oscillating Water Column farm in the COS

Potential environmental effects

Negative environmental impacts (local, regional, global; significant?)

- Visual impact up to 10 km offshore.
- Birdlife may be affected (Flight paths for migratory birds).
- Wind turbines makes sound that affects animal life.
- Marine life affected all along the site and radiation pollution.
- Heat, light, vibration.
- Interference with ship tracks.

Positive environmental impacts (local, regional, global, significant?) / Eco-facilitation:

- Renewable energy for all the zone (1348 GW*h/año -> 327.600 houses).
- New employment offers.
- External companies establish in the region.
- Economic impact in the community.
- Cantabria would be more known in the whole world.
- Enhance the biomass of a number of sessile and motile organisms.

EIA available for similar project(s) in the region ?

Plan Eólico de Cantabria

Wind and Oscillating Water Column farm in the COS

Social-economic benefits

Employment possibilities:

- Construction phase: ca. 1000 people over a 3 year period
- Operation phase: : ca. 500 people for M&O activities

Societal perceptions/objections; Perceived Stakeholders' Fairness of Distribution of Costs and Benefits (between income groups; spatial; intergenerational)

- …

Monetary valuations of

- environmental externalities (Ecosystem Services approach) ...
- health and other (e.g. educational) externalities ...
- local accessibility effects ....

Annex 5. Summary presentation of the proposed design of a multi-use offshore platform in the Adriatic Sea

MUP Design in the Adriatic Sea

Barbara Zanuttigh, Elisa Angelelli (UniBo)
Roberto Suffredini, Giulia Franceschi (ENEL)
Giorgio Bellotti, Alessandro Romano (UR3)
Yukiko Krontira, Dimitris Troianos (KF)

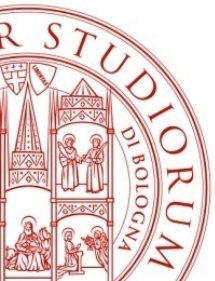
Functional and structural Design Team

Andrea Taramelli, Federico Filipponi,
Francesco M. Passarelli, Emiliana Valentini (ISPRA)

Spatial planning Team

Laura Airoldi, Stephanie Broszeit, Fabio Zagonari (UniBo)

Environmental, Social & Economic Assessment Team



Summary presentation of the proposed design of a multi-use offshore platform (MUP) in the Adriatic Sea

1. Background – various investigated combinations
2. Figures of the proposed design; location; production estimates; possible synergies of proposed MUP
3. Site characteristics
4. Technical characteristics of each MUP element
5. Financial characteristics (cost & revenue estimates)
6. Legal/regulatory/institutional conditions to be met
7. Environmental effects (+/- estimates)
8. Social-economic benefits/ obstacles

MERMAID site manager: B. Zanuttigh (UniBo), Date: 30.03.2015

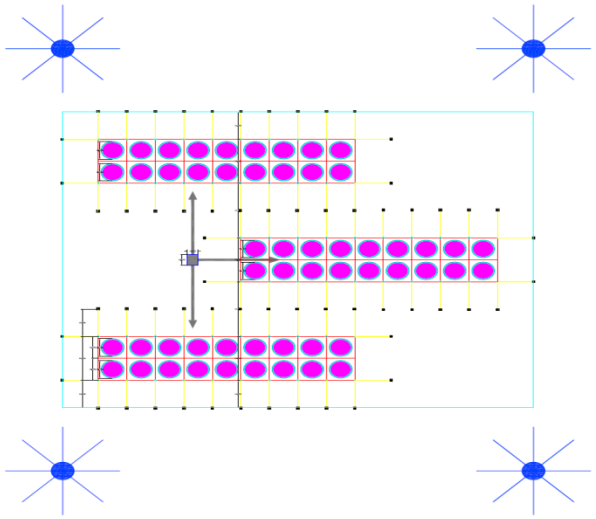
Investigated combinations in the Adriatic Sea

Several combinations have been considered!

- Starting point with end users was: WIND + WAVE + FISH
- Mild climate and long distance from the shore lead to low energy production and high costs → solution should be if yes, then the MUP should be not connected to grid
- Required energy supply for fish farm is relatively low but constant, while renewable energy production has long non-operational windows ➔ **A generator would be required also in non-connected-to-grid solutions**
- In case of connection to the grid, only large-scale wind energy production can be considered due to the mature technology on shallow depth
- In all cases, due to user conflicts, a MUP area of about 1 km^2 is assumed

➔ **Due to these considerations, the proposed MUP design is a grid-connected wind farm of 4*3.3 MW turbines (20 GWh/y) in combination with a fish farm (2000 tons/y)**

Wind-fish-farm in the Adriatic Sea



Location

- Off-shore Aqua Alta Platform
  (Latitude: 45° 18’ 51’’ N; Longitude: 12° 30’ 30’’ E)
- at least 27 m depth
- Distance from shore ≈27km
- MUP footprint: 1 km^2

Annual production capacity (estimates per module)

- Fish farm: 2000 tons/y
- Wind warm: 20 GWh/y
  (4 large wind turbines of 3.3 MW)

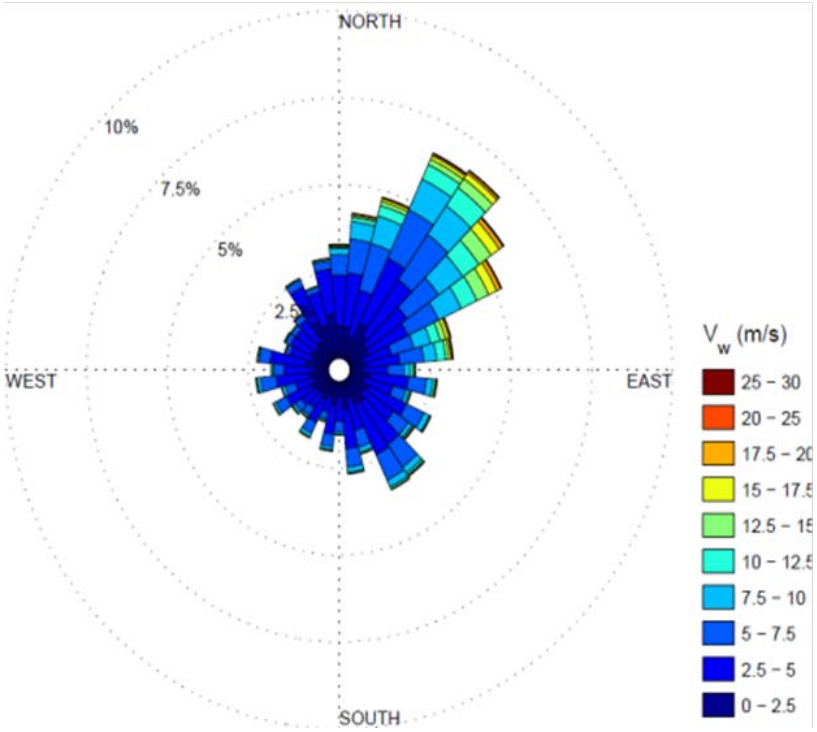
Possible synergies of a wind-fish-farm:

- power supply to the fish farm
- share of the electrical infrastructures
- production of wind energy for an off-shore terminal or for grid connection

Wind-fish-farm in the Adriatic Sea

Site characteristics

- Morphologic and geotechnical conditions: bottom is a mixture of sand and muds → liquefaction
- Met-ocean conditions:
  - very low wave energy climate.
  - Mean annual wind conditions:



Wind climate	
Typical range (mean and std) V, MWD	4.54 m/s, 40°(+/-20°) and 120° (+/-20°)
Extreme conditions (Tr=100 years) V, MWD	28.08 m/s, 40°(+/-20°)
Expected annual wind power	Large wind: 12.7 GWh/y / 4 turbines Vestas V112
Wave climate	
Typical range (mean and std) Hs, Tp, MWD	1.25 m, 5.5 s, 45°(+/-30°) and 130° (+/-30°)
Extreme conditions (Tr=100 years) Hs, Tp, MWD	3.99 m, 8.5 s, 70°(+/-20°)
Expected annual wave power	3 kW/m
Tidal range	
Typical range (mean and std) Z, V	0.5 m (+/-0.15 m)
Exceptional annual Z, V	0.85 m
Other	
Salinity, typical range (mean and std)	27.5 psu (+/-1.5 psu)
Temperature, typical range (mean and std)	14°C(+/-6°C)
Nutrients, typical range (mean and std)	2 mmol l^{-1}(+/-1 mmol l^{-1})

Wind-fish-farm in the Adriatic Sea

Technical characteristics

Fish farm

- Area: 0.4 km^2
- 2'000 tons of Sea bass (*Dicentrarchus labrax*) and Sea bream (*Sparus auratus*)
- Local platform for fish feeding, maintenance twice a month with regular barges/vessels
- Power generator for assuring constant power supply
- Project time horizon: 20 years
- Decommissioning: removed and transported to shore

Wind farm (4*3.3 MW)

- Area: 0.8 km^2
- Energy production: 5.6 GWh/y per turbine ➔ ca. 20 GWh/y
- Data for 4 wind turbines
- Transportation off-shore of the wind structures by means of regular vessels
- Project time horizon: 30 year
- Decommissioning: rotor removed and transported to shore, pile lowered and left in the bottom

Wind-fish-farm in the Adriatic Sea

Financial characteristics

Wind farm:
- Realization (construction) costs: € 44 Million
- Expected revenues: ca. € 1 Million/year from 20 GWh/y
→ Internal Rate of Return: -7% over 22 years
- Decomissioning costs excluded

Fish farm:
- Realization costs: € 3.7 Million
- Expected revenues: ca € 16 Million/year from 2000 tons/y
→ Internal Rate of Return: +10% over 20 years
- Decomissioning costs excluded

No synergy assumed concerning costs.

Wind-fish-farm in the Adriatic Sea

Legal/ regulatory/ institutional conditions to be met

Regulatory/Institutional restrictions

- Legislative Decree No.11954 of 2010, Art. 4 (1) on the Production of marine animals and algae by biological aquaculture states that “in order to reduce impacts on the sea bed and on rounding sea water, current must be greater than 0.02 m/s on average per year, and sea depth must be greater than 20 m”

Current strategies (Management/ planning)

- Regulatory framework for MUPs (including risk assessment, insurance issues) is missing
- The renewable energy subsidy program does not include offshore developments

Current obstacles

- High costs of the offshore installations due to immature technologies
- Mild climate conditions for renewable energy conversion
- Potential cumulative impact of nutrients (Po Delta area) induced by the fish farming
- High distance from shore and therefore high costs for connection to grid
- Renewable energy availability and discontinuity do not allow for an efficient non-connected to grid solution for fish farm energy supply

Wind-fish-farm in the Adriatic Sea

Potential environmental effects

Negative Impacts

- Increase of nutrients induced by the presence of the fish farm
- Effects on soft bottom assemblages (disruption) in the areas covered by the piles
- Disturbance of the area in the construction phase, e.g. increased transport from and towards the MUP

Potentially positive = Eco-facilitation

+ Non significant changes in hydrodynamic regime (piles, (floaters), high distance from shore)
+ Presence of new hard substrate: piles and scouring stones ➔ increase of biodiversity

EIA available for similar project(s) in the region ?

- No

Wind-fish-farm in the Adriatic Sea

Social-economic benefits

Employment possibilities:

- New positions for the renewable energy sector

Societal perceptions/objections

- Potential benefits to enterprises induced by the development of new technologies (renewable energy)
- Potential benefits due to reduced environmental impacts (off-shore rather than near-shore fish farms)
- Potential benefits induced by the km-0 production of fishes
- Environmental externalities (Ecosystem Services approach)
- Benefits induced by additional local energy production
- Benefits induced by increasing technical skills and capacities