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The Governance of Multi-Use Platforms at Sea for Energy Production and Aquaculture: Challenges for Policy Makers in European Seas

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Academic Editor: Phoebe Koundouri
Received: 31 December 2015; Accepted: 29 March 2016; Published: 6 April 2016

Abstract: European seas are encountering an upsurge in competing marine activities and infrastructures. Traditional exploitation such as fisheries, tourism, transportation, and oil production are accompanied by new sustainable economic activities such as offshore windfarms, aquaculture, and tidal and wave energy. One proposed solution to overcome possible competing claims at sea lies in combining these economic activities as part of Multi-Use Platforms at Sea (MUPS). MUPS can be understood as areas at sea, designated for a combination of activities, either completely integrated in a platform or in shared marine space. MUPS can potentially benefit from each other in terms of infrastructure, maintenance, *etc*. Developing MUPS in the marine environment demands adequate governance. In this article, we investigate four European sites to find out how governance arrangements may facilitate or complicate MUPs. In particular, we apply a framework specifying policy, economic, social, technical, environmental, and legal (PESTEL) factors to explore governance arrangements in four case study sites in different sea basins around Europe (the Mediterranean Sea, the Atlantic Ocean, the North Sea, and the Baltic Sea). The article concludes with policy recommendations on a governance regime for facilitating the development of MUPS in the future.

Keywords: multi-use platforms; offshore; governance; PESTEL; energy production; aquaculture

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1. Introduction

European seas will undergo massive developments of marine infrastructure and face an increase in competing spatial claims in the marine environment. This is due to an increase in offshore activities such as ocean energy, aquaculture, tourism, biotechnology, and mining. These developments are stimulated by the Blue Growth strategy initiated by the European Commission. It is the EU's long-term strategy to support sustainable growth in the marine and maritime sectors. Competition for marine space will become a delicate issue when negotiating future Blue Growth plans in European seas, and will demand creative and innovative solutions of co-location of offshore windfarms and marine protected areas [1,2].

One creative and innovative solution to competing claims in European seas lies in the development of Multi-Use Platforms at Sea (MUPS) that combine different activities within a specific marine area, for instance energy production and aquaculture [2]. MUPS can be understood as areas at sea, designated for a combination of activities, either completely integrated or next to each other, that benefit from each other in terms of e.g., infrastructure and maintenance. MUPS make use of marine space in a more effective way to solve problems related to competing claims on space. Combining activities in an area as such is not new, as we used to combine, for instance, shipping and fishing. However, the approach is now covering typical Blue Growth sectors, such as ocean energy, tourism, biotechnology, mining, and/or aquaculture combinations. MUPS or co-location of activities as an idea is increasingly known across Europe [1,2]. Because of practical obstacles for fishermen and developers of windfarms, as well as socioeconomic and ecological challenges [3–5], it is not yet clear how to implement MUPS in European seas.

To increase insight into the practical implementation possibilities of MUPS, a European FP7 project called MERMAID developed concepts for multi-purpose use, including energy extraction, aquaculture, and transport. MERMAID has examined multi-use offshore by means of a participatory design process [6]. The participatory design approach emphasized the inclusion of multiple stakeholders in workshop discussions (including policy makers, businesses, sector representatives, NGOs, local citizens, and research institutes) to identify possible combinations feasible to specific contexts. MERMAID holds both technical and visionary perspectives when theoretically examining new concepts, such as new combinations of structures or completely new structures. The technical perspective focuses on possible physical combination of different activities, and the visionary perspective attempts to facilitate social acceptance of MUPS developments to support future sustainability in European waters. Based on the idea that different conditions should be represented in the north, northwest, southwest, and south of Europe, a total of four offshore case study sites were selected. In all four sites, the MUPS designs combined wind turbines with aquaculture or wave energy generators:

(1) The Baltic Sea—a typical estuarine area with fresh water from rivers and salt water. The design discussed is a combination of wind turbines and offshore aquaculture using floating fish cages with trout/salmon production [6].
(2) The North Sea–Wadden Sea—a typical active morphology site. The design discussed is offshore wind including an offshore hotel and support center, combined with seaweed and mussel farming [6].

(3) The Atlantic Ocean—a typical deep water site. The design discussed included a combination of floating offshore wind turbines and wave energy generators [6].
(4) The Mediterranean Sea—a typical, sheltered deep water site. The design discussed included grid-connected wind turbines combined with fish farming [6].

Against this background, this paper aims at contributing to the discussion on the development of MUPS for energy production and aquaculture from a governance perspective. To explore the contours of appropriate governance for MUPS developments, the underlying logic behind the policies and interventions—or, in the words of Lascoumes and Le Gall [7], "the sociology of policy instrumentation"—is unraveled. Specifically, the different modes of governance that are present in the different sites are analyzed and, according to specific policy, economic, social, technical, environmental and legal (PESTEL) factors, the core obstacles to MUPS are identified.

The methodological approach is presented in Section 2, including explanations of modes of governance, the PESTEL framework, the participatory design, and case study descriptions. This is followed by presentations of core case study findings (Sections 4–7). Main conclusions are presented in Section 7.

2. Methodological Approach

2.1. Modes of Governance

Governance concerns all processes of governing, whether undertaken by a government, market, or network; whether over a family, tribe, formal or informal organization, or territory; and whether through laws, norms, power, or language [8]. A "mode of governance" refers to the underlying logic and coordinative principles that can be recognized in governance processes. In this paper we distinguish between five modes of governance: *hierarchy, network, market* [9–11], *self-governance* [12], and *knowledge* [13,14]. These modes of governance are ideal types for analytical purposes only, whereas real life is a lot fuzzier. The understanding of the coordinative principles can clarify why governance processes stagnate or how they can be strengthened.

Over the years, new forms of governance have emerged in addition to the classical hierarchical notion of governance. The hierarchical notion of governance belongs to the nation state, which uses authority, a clear division of tasks, rules, rationality, and objectivity [11] to intervene in society and markets. Regulations, spatial planning, and national policy and plans are examples of this hierarchic governance. In other modes of governance, the government is not solely responsible for the provision of collective goods [15,16]. In market governance, societal change is realized by the powers of the market, where competition and pricing decide what path is selected and where financial incentives are an important instrument [9,17]. Network governance makes use of the potentials of actor networks and their ability to combine multiple agendas and responsibilities, and to distribute gains, in order to arrive at policy outcomes. Reciprocity, collaboration, interdependency, trust, and empathy are coordinative principles in network governance [18–20]. Self-governance relies on "the capacity of societal entities to govern themselves autonomously" [12]. Self-governance is based on a shared identity and a common interest, for instance in the usage of natural resources by local communities [21–23]. Knowledge governance is understood as "purposefully organizing the development of knowledge in order to deal with societal problems. Knowledge governance is aimed at creating new insights, and innovative solutions which tempt actors to leave traditional insights and practices and get away from inert interaction patterns, stalemate negotiations, and interest conflicts" [14].

2.2. PESTEL Framework

In realizing combinations of energy and aquaculture in MUPS, specific policy, economic, social, technical, environmental, and legal (PESTEL) factors will become influential in some way. Recognizing these external factors to a business environment can assist in understanding the "big picture" in which businesses need to operate [24]. The intention when applying a so-called PESTEL framework is to assist business innovation to take advantages of opportunities, while minimizing risks and threats [24].

The PESTEL framework is an analytical tool used to identify key drivers of change in the strategic environment. Other variants of PESTEL include ETPS (including economic, technical, political, and social factors), STEPE (adding an ecological factor to the four in ETPS), PEST, PESTLE (including international and demographic factors), and STEEPLE (including ethical factors) [25].

When taking account of external key drivers to change, the idea is that the PESTEL framework may encourage firms to think more long term and to choose for sustainable business innovation and investment strategies [26,27]. In MERMAID, the PESTEL framework was applied to explore case study specific opportunities and possible obstacles for MUPS. In particular, questions were asked about whether policy, economic, social, technical, environmental, and/or legal obstacles exist in the specific case study.

2.3. Methods

The information has mainly been collected by the so-called site managers during the participatory design process within the MERMAID project. Each site had a site manager: a local process facilitator responsible for carrying out the participatory design process. The participatory design process aimed at developing MUPS by a group of relevant stakeholders for each site. The stakeholders were selected on the basis of relevance and interest in each case study. They were invited to a total of three workshops that included relevant policy makers, businesses, sector representatives, NGOs, local citizens, and research institutes [28]. More specifically, the three rounds consisted of:

i Collecting perceived stakeholder views about potential needs, benefits, and obstacles for MUPS in future. This information was applied to shape a preliminary MUPS design for each case study [29]

ii Reviewing the preliminary MUPS design by the stakeholders. This information was used to adapt and re-design the MUPS to a final design in each case study [6]

iii Evaluating the final MUPS designs in each case study by the stakeholders [28]. This evaluation was published for the MERMAID project [28] and used for the end conference of MERMAID in a booklet and diverse publications [30–32]

Modes of governance. The site managers explored opportunities for MUPS by means of the five modes of governance, in consultation with a range of stakeholders:

(1) Hierarchical mode of governance:

- Is there a public authority who already has promoted MUPS in this case?
- Are there plans or rules or visions to realize a MUPS by a particular public authority that are shared with others?

(2) Market mode of governance:

- Are companies investing in MUPS (in cash or in kind?)
- Is there competition in developing MUPS and, if so, among whom?

(3) Network mode of governance:

- Is there cooperation between stakeholders in the area who aim to develop a MUPS?
- Is there a collective effort that makes decisions on developing MUPS in the area?

(4) Self-governance mode:

- Are there spontaneous initiatives to develop MUPS by stakeholders?
- Does the government give space to develop these initiatives?

(5) Knowledge governance mode:

- Is there knowledge development on MUPS in the area?
- Is there reflexive social learning among the stakeholders involved?

Obstacles. In order to examine the potential perceived and real obstacles to MUPS, covering risks, lack of social acceptance, and legal obstacles, among others, the site managers analyzed the main political, economic, social, technical, environmental, and legal factors that were raised by the participants during the three rounds of participatory design of the MUPS [6,28,29]. The PESTEL framework was thus applied for MUPS at a case study level in consultation with a range of different stakeholders.

2.4. Case Study Descriptions (Sites and Stakeholders)

The case study sites are illustrated in Figure 1, including the Mediterranean Site, the Atlantic Site, the Baltic site and the Southern North Sea. They are further described in the following.

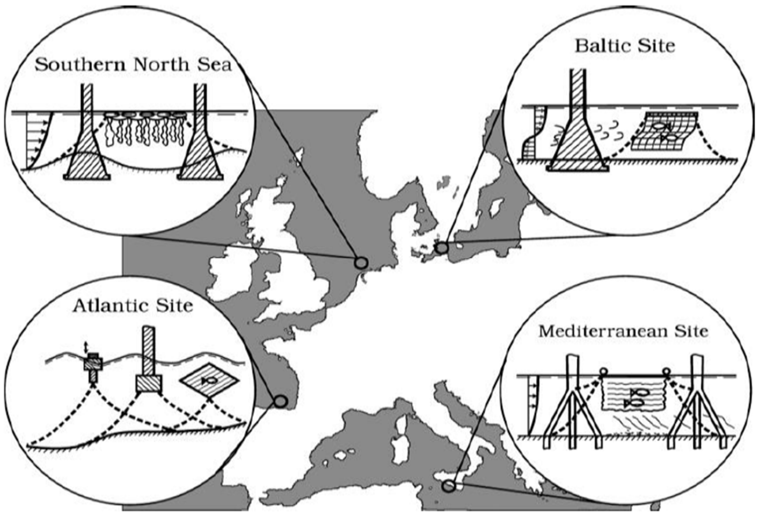

Figure 1. Map of case studies.

The Mediterranean Site. The analysis focused on Greece and Italy, more specifically the Adriatic Ionian Macro region and the area located in Crete, Greece. References to Cyprus, Spain, France, Algeria, Egypt, Israel, Jordan, Lebanon, Libya, Morocco, the occupied Palestinian territory, Syria, and Tunisia were also included in order to capture issues from the rest of the Mediterranean region. The PESTEL framework analysis was particularly conducted in the northern Adriatic Sea, off the Venice coast. Stakeholders involved in the analysis were governing bodies and policy makers from different authority levels (regional, national, and European), end users and suppliers of the MUPS (e.g., energy, aquaculture, cable and construction industries, and SMEs), representatives of offshore maritime activities, locals and NGOs, universities, and research institutes.

The Atlantic Site. The analysis was carried out in the Cantabrian offshore area, in the Spanish area of Bay of Biscay. The ocean conditions in this site are typical for an exposed area: harsh conditions leading to high technical demands. Offshore wind development is not foreseen in the area but there is experimentation on wave energy generation. The invited stakeholders included representatives of the offshore energy sector and aquaculture, suppliers to the offshore industry, and NGOs and scientists [6].

The Southern North Sea. The analysis focused on the Dutch part of the North Sea, 55 km north of the Wadden Sea Island called Schiermonnikoog, in an already licensed site called Gemini that is developing an offshore windfarm. At this location, an offshore wind energy farm is being built that is planned to be fully operational by 2017 with a total capacity of 600 MW [33]. Stakeholders were selected on the basis of interest in discussions about multi-use activities in the North Sea. They included market actors representing the following sectors: offshore wind, offshore aquaculture, fisheries and tourism; governing bodies/regulators/policy makers such as regional, national, and European officers; stakeholders from other offshore activities like shipping; and mining; as well as NGOs and local citizens [28].

The Baltic Site. The findings are based on a case study site called Kriegers Flak in the Baltic Sea that is situated on Danish territory. Offshore wind energy is already an established business in this area; further development of the Kriegers Flak area is foreseen and gives potential for multi-use with aquaculture. Stakeholders involved are businesses that expressed interest in the development of a MUPS, policy makers, and shipping authorities. Furthermore, NGOs and scientists participated. The findings in this chapter are primarily based on the existing governance in Denmark as the site Kriegers Flak in the Baltic Sea is situated on Danish territory. Thus, there may be other findings that are relevant to governance in the Baltic Sea that are not covered here, e.g., relating to governance in Sweden, Germany, Poland, Russia, Lithuania, Latvia, Estonia, and Finland.

3. The Mediterranean Site

3.1. Modes of Governance—Opportunities for MUPS

In the Mediterranean Sea no public authorities at national or regional level have decided to realize MUPS to date. Even so, in a series of research projects (including ADRIPLAN [34], TROPOS [35], IMP-MED [36], SEANERGY2020 [37], ADRICOSM [38], and RITMARE [39]) it is documented that visions for future multiple use appear in national plans for ocean space and Marine Spatial Planning (MSP).

Nonetheless, the main initiatives are mainly European driven, involving funding opportunities for MUPS development and efficient multi-use of ocean space. The EC intends to improve coordination and increase common understanding between different stakeholders [36]. For instance, in support of Integrated Maritime Policy in the Mediterranean, the Commission seeks to provide opportunities for nine southern neighborhood states in the Mediterranean to engage in and obtain assistance for developing integrated approaches to maritime affairs [36]. In this way the Commission aims at improved maritime governance in the Mediterranean by raising awareness across countries about potential sustainable maritime growth and jobs, environmental sustainability, and safer maritime use of space.

In research projects it has been argued that MUPS could solve some of the competing claims for space that exist among companies in the Mediterranean Sea. The core competing economic activities include aquaculture and petroleum tankers, as well as aquaculture and tourism in the region of the Ionian islands and Igoumenitsa [34]. The aquaculture sector in particular has limited availability of space, due to near-shore competition from other uses essential to the local economy and deep waters with harsh conditions [35]. Notwithstanding, companies invest in MUPS mainly by participating in research projects (such as TROPOS [35], MERMAID, H2OCEAN [40], MARIBE [41], ORECCA [42], MARINA [43], and IONAS [44]) with a vision to develop or participate in future developments of MUPS and other multi-use solutions of ocean space. For instance, an existing partnership between European ports and cities from neighboring countries in the Adriatic and Ionian area involved companies that could be interested in the future development of multi-use activities in the ocean [44]. Still, no companies have obtained permissions and licenses to proceed with multi-use, mainly due to policies and regulations taking account of environmental and social concerns [35].

While it is too early to judge the cooperation between stakeholders aiming at developing a MUPS, networks are emerging within MSP initiatives. These networks include working groups in all the countries bordering the Mediterranean. Potential support to development of MUPS exists, such as the Mediterranean Sea Innovation & Business Cluster [45], which supports investment in research and development of innovative future technologies. Furthermore, energy networks are emerging that consider the establishment of a hub between Europe and other countries, such as between Cyprus and Israel. The networks for offshore energy production are located in Greece (CRES—Center for Renewable Energy Sources), Italy (APER—Associazione Produttori Energie Rinnouabily; an association for renewable energy production, Spain, and Portugal (LNEG—Laboratorio Nacional de Energia e Geologia; a national laboratory of energy and geology; there is also an international team for renewable energy (3E) [46]. Related to self-regulation and knowledge governance, the potential benefits from closer interaction with and learning from other activities/sectors were observed by stakeholders on a series of research occasions [6,34].

3.2. PESTEL Obstacles for MUPS

Based on the stakeholder dialogues in the workshops, a series of obstacles for the development of maritime activities in MUPS have been identified in the Mediterranean Sea. The core PESTEL factors playing a role in this case study are: (1) legal and policy obstacles, (2) social obstacles, and (3) environmental obstacles.

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

The energy sector is operationalized at a national level by involvement of three ministries [47]. While energy policies that apply to Europe under European Directives or international agreements apply to the Mediterranean area as well, new energy sectors are not covered by these regulations. For instance, wave energy generation is in an early stage of development and there is no established industry consensus on codes and standards. No regional or national legislation specifically addresses wave energy [47].

Furthermore, bureaucratic complications refer to local commissions that are assigned to improve the management and modernization of the aquaculture sector. At present, regional governments are in charge of authorization for aquaculture activities, setting fines and possibly withdrawals of concessions in order to preserve marine biological resources, and to preventing, discouraging, and eliminating illegal, undeclared, or unregulated fishing. At the same time, companies with permits are obliged to conduct regular checks and tests that ensure the proper operation of fish farms.

Second, social obstacles were identified in this case study. For instance, MUPS may conflict with near-shore and offshore fishery and tourism activities, and with trade and tourist maritime routes, as well as shipping. There are also conflicts between long-distance offshore fish farming and sustainability, because of high transportation costs [47]. Conflicts have also been appearing in the management of natural protected areas and in the implementation of marine plans. A characteristic example is the landscape in Venice, which is regarded as an area under protection. The development of maritime activities that change the landscape of the area is therefore not socially acceptable. In the case of wave energy production, it mainly conflicts with energy suppliers and the equipment and machinery sector, as well as marine transport activities [47]. As for conflicts with shipping, other ship routes can be assigned [48]. Observed perceived social obstacles relate to a lack of knowledge and experiences with offshore energy installations. For instance, they are concerned about possible anchoring problems near the platform, and also potential problems with the day/night distribution of energy production on the platform.

Sometimes social and environmental obstacles are interrelated. On the one hand, MUPS could contribute to job creation and research potential in support of local and regional economic development; on the other hand, there is often a lack of political willingness due to environmental and social concerns [35].

Third, the highest concern in the Mediterranean Site relates to possible negative environmental impacts of MUPS, especially in the case of aquaculture and the risk of eutrophication and pollution. According to EU legislation, each plan and program requires the judgment of an Environmental Impact Assessment or Strategic Impact Assessment Commission. Permits for new aquaculture activities are only given after this environmental assessment states that the environmental requirements are met. The environmental concerns are higher in cases when information is lacking about the needed frequency of trips offshore, back and forth to the MUPS, and the size of aquaculture ships for daily feeding and transport of fish, due to increased use of fuel. [6,28]. In addition, the risks of natural disturbance and possibility of harm to biodiversity due to human maritime activities are an issue for public authorities [34].The effects on biodiversity depend on the actual construction and operation of MUPS [47].

4. The Atlantic Site

4.1. Modes of Governance—Opportunities for MUPS

At this stage there are no plans by the national Spanish government to realize MUPS in the Atlantic Ocean. MUPS development is not promoted by local, regional, or national governments. MUPS is at this stage solely driven by European Union-funded research projects such as MERMAID and MARIBE.

Still, MSP is currently being implemented in Spain. For instance, the 2008–2011 Spanish maritime Cluster Strategic Plan [49] stresses the importance of facilitating maritime sub-sectors such as ship-building, fisheries, ports, and coastal and cruise tourism. While this could have boosted the Spanish maritime economy, little is expected in terms of growth of value added.

In particular, the development of future renewable energy is a priority for some public authorities in Northern Spain, and as a consequence this sector has gained a growing market share [50]. Among the different renewable energy technologies, offshore wind is considered most important for future energy supply. This does not imply any immediate interest in MUPS, because in Spain most of the potential areas to be exploited are in deep or very deep waters. Given the local ocean conditions, governmental agencies are more focused on floating offshore wind solutions. Consequentially, companies are also increasingly getting involved in floating offshore wind developments as well as wave energy. At this stage, they are not investing—cash or in kind—in the development of MUPS, but they are interested in taking part in ongoing MUPS research projects (MERMAID, PLOCAN, TROPOS) in order to contribute with specific knowledge. In particular, five companies in Spain have been involved: Abengoa sea power, Acciano Infrastructures, Ener Ocean, and Advance Intelligent Developments. These companies are likely to have interest in or to be involved in future MUPS developments.

While research projects (e.g., MERMAID, TROPOS, and MESMA) have encouraged cooperation and knowledge among stakeholders, this has not resulted in MUPS developments in this region. There are no spontaneous initiatives from stakeholders to develop MUPS, and no space is demanded for MUPS as such. Network initiatives include the Spanish national government, which has shown great interest in a Canary Islands Oceanic Platform (PLOCAN) [51], with the purposes of designing, constructing, and operating an oceanic platform. In this platform, participants take part in research and technology development [52].

The MERMAID project has brought together marine sectors such as aquaculture, wind energy, wave energy, mooring and offshore engineering, and other blue economy activities to learn and discuss MUPS. Various governmental agencies have been involved in the process as well. The interaction contributed to social learning. In particular, it was found that MUPS is of particular interest to the Cantabria region due to the new possibilities for companies and labor force [6], and that the harsh ocean condition can be a core problem to MUPS developments [6,29].

4.2. PESTEL Obstacles for MUPS

Based on the stakeholder dialogues in the workshops, a series of obstacles to the development of maritime activities in MUPS have been identified in the Atlantic Site. Most PESTEL factors have been addressed in this case study: (1) legal and policy obstacles, (2) social obstacles, (3) technical and economic obstacles, and (4) environmental obstacles.

First, legal and policy obstacles appear when developments in the Atlantic Sea affect other regions and different exclusive economic zones (EEZ). Lack of cross-border cooperation on MSP is complicating projects crossing several EEZ such as large-scale offshore wind projects. Also, the current permitting procedure is complex. Insufficient coordination between different administration levels and complex permitting procedures are pinpointed as obstacles to offshore grid development. The length of time it takes to get permission varies greatly depending on the type of administration. The administrative procedure is not flexible to keep up with new technologies and maritime uses. This was shown in the case of Santoña, a wave energy test site set up as a joint venture production plant. It took six years to obtain the environmental permits [53]. Five different administrative levels were involved and more than 33 communications between the administration and the promoter were carried out. Consequentially, long delays as well as budget overruns can become a reality to new marine developments such as MUPS.

Second, different social obstacles have been identified. The local fishing community is an important stakeholder in the marine context and if MUPS developments interfere with their interests, there will be conflicts. While the development of MUPS can provide new jobs to the fishing community, it is not clear that these benefits will be clear to the local community and/or the fishermen.

Third, technical and economic obstacles have been regarded as the most important ones to this case study. The technical ones include challenges related to extensive waves and depth. For instance, the Bea of Biscay is known for large waves (up to 20 m high). At the Bay of Biscay 1 km off the coast, water depths are about 100 m, while at 5 km off the coast this has already increased to 400–1000 m depth. The combination of deep water and large waves makes it difficult to design and build secure systems that can withstand these conditions. Also, given negative experience with buoys (some got loose), it is important to design robust and safe systems [6,29].

Even though the development of MUPS in the Spanish Atlantic region is in its experimental phase, stakeholders see clear socioeconomic benefits. This development can be relevant for the maritime sector in Cantabria because it offers new jobs and revenues. Also, the Basque coast was found to be vulnerable to demographic pressure, overexploitation of resources, and intensive human use of marine space. In this case MUPS can be an option because it "makes it necessary to approach the marine energy production development planning in an integrated way" [54].

Fourth, environmental obstacles have been observed as restrictions to multi-use. While the existing environmental legislation does not explicitly exclude offshore renewable energy installations/infrastructure, it may slow down or hamper these developments. This is because interpretations of the legislation differ; for instance, some countries consider protected areas as "NO-GO-areas" for ocean energy whereas others are more open to new developments. There is also a lack of clarity related to the grid capacity reinforcements at the international level. It is important to choose a site where interference with other uses are minimal. Other uses include e.g., fishing, tourism, transport, entrance to ports, and bird and wildlife protection [29].

5. The Southern North Sea

5.1. Modes of Governance—Opportunities for MUPS

In the Netherlands, efforts aiming towards realizing MUPS have taken place among public authorities and market actors. The Dutch government has the ambition to realize multi-use offshore windfarms in the near future. This can be concluded from recent stakeholder meetings, processes, and projects initiated as well as facilitated by the Dutch Ministry of Economic Affairs and Ministry of Infrastructure and the Environment. There is a political will to promote MUPS but the government's approach is to leave initiatives to the market. The market, however, has not reacted yet. In particular, the offshore wind sector has been very hesitant or even opposed to participation in the development of MUPS because of the possibility of increased risks such as collision [55–57] and corrosion [58,59]. Moreover, the multi-user(s), for instance seaweed and mussel aquaculture, are currently not yet in a state to (co-)exist offshore and, therefore, synergies of potential MUPS cannot yet be guaranteed.

Due to the hesitance of the offshore wind sector to invest in MUPS and the financial limitations to doing so in other marine sectors, the Dutch government is exploring risks and opportunities as preparation for potential legal adjustments, *i.e.*, opening up windfarm areas for co-use [60]. Various workshops have been commissioned and funded by the government to discuss multi-use at sea [61], in which different MUPS designs have been presented and discussed [62]. Because Dutch law at present does not allow shared use and free passage through windfarms, the Dutch government is also currently investigating the risks of allowing free passage and shared use [60].

In the Netherlands there are already several examples of market parties taking initiatives towards the development of MUPS. For example, the Dutch offshore aquaculture sector is in the beginning of a new development. While Dutch blue mussel cultivation is likely to remain inshore in the Wadden Sea and Easter Scheldt because mussel farmers are hesitant to go offshore [55], a transition phase to more offshore culturing has started [29], probably triggered by indications that the market potential for mussels might be twice the current market [59,61]. The potential for seaweed cultivation, not only for food and health care products, but also for plastic products, indicates an increasing need for large quantities [59]. However, the financial and economic feasibility of large-scale Dutch offshore seaweed production is unclear and is dependent on the future development of demand and the potential of co-use synergies [59].

The offshore wind sector has taken collective action by editing a "Common Position Paper & QRA regarding Open Offshore Wind Park Access" in response to a ministry report on the risks of multi-use of windfarms [63]. Simultaneously, the Dutch fisheries "Knowledge Circles" is a project carried out by the industry to investigate the possibilities for MUPS with passive fisheries in windfarms [57,61,64]. They have lobbied to convince the ministries to move forward with their ideas [62]. The knowledge circles serve as platforms for stakeholders to share knowledge and also to involve researchers for scientific assistance. Other examples of networks relate to fisheries and MUPS, and include the "Fishers club" and the "Vissen voor de Wind" projects. Another networking initiative related to offshore seaweed production potential is the Stichting Noordzeeboerderij project, which is explicitly aimed at offshore cultivation tests and at connecting with entrepreneurs. The government provides funds for research, innovations, and facilitation of the workshops to encourage such self-regulation and learning initiatives, with the idea that sharing knowledge and discussions is necessary for development and to move forward. According to these principles, knowledge of MUPS is further developed in research projects [57,59] and workshops [62] at a national level, as well as in EU-FP7 projects (MERMAID, H2OCEAN, TROPOS).

5.2. PESTEL Obstacles for MUPS

Based on the stakeholder dialogues in the workshops, a series of obstacles to the development of maritime activities in MUPS have been identified in the North Sea. All PESTEL factors have been addressed in this case study: (1) legal and policy obstacles, (2) social obstacles, (3) economic obstacles, (4) technical obstacles, and (5) environmental obstacles.

First, policy and legal obstacles refer to the lack of a MUPS regulatory framework in the Netherlands, and the fact that third party access to offshore windfarms is not allowed [55]. However, a reconsideration of regulations is probable, and the government has begun to take steps towards reducing the obstacles [65]. Moreover, in Dutch policies, MUPS are mentioned as a promising way to make the most out of scarce available space [66]. However, currently there is no demand for MUPS. Energy companies have and will build various offshore windfarms but an offshore aquaculture sector is still in its infancy. Consequently, policy-makers and regulators have not yet been substantially challenged to handle requests for MUPS permits, and subsidies and a regulatory framework for MUPS are missing [55]. Also, there is no area designated for aquaculture in the Dutch spatial plans for the North Sea. Current practice for offshore windfarms is to forbid other vessels to enter the designated parks, thereby avoiding questions about risks and responsibilities, though the Dutch government is currently investigating the risks of opening up the windfarms to free passage and shared use [67].

Second, the economic obstacles were discussed for the North Sea case. Although wind energy is currently a profitable business case, it depends on governmental subsidies [65]. Stakeholders express skepticism about the financial feasibility of combining offshore mussel and seaweed farming with wind energy [55], in particular because wind energy operators are presently reluctant to share their allotted space with other operators due to the risks associated with multiple use, which could have an influence on insurance premiums. What impact MUPS will have on insurance premiums is unknown, and stakeholders perceive that it might be very difficult to insure MUPS [6]. The uncertainty of a business case for MUPS is illustrated by the negative profitability of seaweed cultivation and the uncertain profitability of mussel farming in the North Sea case study [65]. However, mussels, especially, could become financially feasible if reductions on operational and maintenance expenditures can be obtained, e.g., through substantial synergies with other uses.

Third, the social obstacles include matters of trust. Trust among potential users in MUPS would facilitate future MUPS realization. The discussions between fisheries organizations and wind power companies illustrate some difficulties in the case of offshore activities. The energy companies disagree when the fishermen organizations argue that there is a need for compensation fees for lost fishing grounds and/or additional employment for fishing vessels, e.g., sightseeing trips to the windfarms for tourists. There have also been drafts for new fishing vessel designs, which could make the vessels suitable for service and maintenance work in windfarms. The Dutch "poldering tradition" of involving stakeholders could play a more important role in establishing trust [55]. Handling uncertainty is key. It is therefore crucial that potential business synergies and opportunities are clarified and that risks are reduced through a transition process towards implementation of MUPS that preferably starts in a testing format with pilot projects [55].

Fourth, stakeholders discussed the need to handle technical obstacles, because the North Sea case study site is characterized by harsh conditions, which requires reliable anchoring and sufficiently robust constructions [55]. Also, maintenance of the windfarm and cables must always be feasible, which requires a MUPS design where there are satisfactory maintenance lanes through which wind turbines are accessible [55]. There is also a lack of experience in offshore aquaculture, but particularly for mussel farming there are incentives for testing offshore cultivation because the traditional coastal areas for shellfish culture are reaching their carrying capacity, setting limits on the further growth of production in those areas [58].

Fifth, with reference to the environmental obstacles, in the stakeholders' opinions, MUPS must not have a detrimental effect on the existing ecosystem, which makes environmental impact assessments crucial [55]. Some stakeholders are interested in the potential of realizing ecological valuable zones within windfarms, which is also supported by some scientists [68,69]. However, a potential problem is that hard structures in an otherwise sandy environment might form "stepping stones" for invasive species [69]. This illustrates that it is at present not clear what the environmental risks might be [55]. For example, while mussel and seaweed farming might improve water quality through their need for nutrients, ecosystem effects could arise as fewer nutrients could become available for single-cell algae [55]. While the offshore wind sector intends to avoid a bad reputation in the media if environmental qualities decrease, MUPS can also provide an opportunity to enhance the sustainability image of the offshore wind sector as well as for other MUPS actors.

6. The Baltic Site

6.1. Modes of Governance—Opportunities for MUPS

The idea of MUPS is mainly supported at the European level by the European Commission, while no public stakeholders in the Baltic site have decided to realize MUPS at local or regional levels. Instead, different uses of the Baltic Sea Region are emphasized in MSP [70], which has been a transnational issue since 2001.

There are also no official plans or visions yet to have MUPS realized by the public sector in the Baltic Sea, apart from a vision developed in a project called BaltSeaPLan [71], which mentions the need for spatial efficiency and the need to promote co-use, synergies, and multiple spatial use.

In Denmark there is a core political goal to become completely independent of fossil fuels by the year 2050. Thus, there is a lot of focus on renewable energy sources, with offshore windfarms of high interest, especially since land-based windfarms are increasingly perceived as negative. Linked with energy production, the authorities are quite open to discuss new initiatives, although MUPS has not yet been set on the agenda.

Furthermore, while in Denmark there is a political vision to increase the total aquaculture production in 2014–2020 with 25% before 2020 [72], the public is still skeptical due to possible medicine residues in the fish and marine environmental impacts [73]. At the same time Denmark aims at increasing ecological production, complying with existing environmental legislation and decreasing 20% nitrogen per ton of produced fish. This may contradict the aim to increase the export of fish and shellfish by 25% and of feed and technology by 200%. However, in order to comply with these environmental and production challenges at once, plans clearly designate offshore areas for fish and shellfish production in combination with constructions for seaweed and mussels that can compensate for nutrient release, *i.e.*, so-called integrated multi-trophic aquaculture (IMTA). Thus, there are already motions to establish IMTA, which can be seen as a MUPS although the primary purpose is nutrient-neutrality rather than efficient use of marine space. However, the legislation for establishing IMTA is not yet in place, and they have not proved to be economically viable. Still, due to current regulation on N-release from fish farming, aquaculture companies are more or less forced to implement IMTA as a remedial activity. It is at the moment very difficult to get new licenses for establishing any new fish farms to implement IMTA at sea in Denmark. Correspondingly, an initiative was taken by the Danish AgriFish Agency, referred to as "cross-boundary cooperation," in support of IMTA-related initiatives. In particular, Kriegers Flak is suggested as a case study site (in a project called BalticSCOPE) suitable for energy, sand and gravel, cable and pipelines, fishing, environment, and shipping.

There is currently no competition in Denmark for developing MUPS as the risks are still too high and synergies too few to invest in a combination of wind and aquaculture. Still, companies involved in research projects on MUPS (MERMAID, TROPOS, and H2OCEAN) have invested by means of in-kind contributions. Moreover, aquaculture companies have been investing (primarily by cash (millions), in kind, and by getting external funding) in exploring the possibilities for IMTAs. IMTAs provide the possibility of increasing the production of aquaculture in the Baltic; they are hindered by a modest aquaculture strategy and strict regulations on N-release in Denmark. The aquaculture industry would therefore benefit if it had the option of joining a MUPS combining wind energy production and fish farming since this would expand production [28].

Danish companies have also invested in the combined use of wind and wave energy. One example is the Floating Power Plant A/S (FPP), which combines innovative wave energy conversion with floating wind turbines [74]. The company runs an EU-funded project, POSEIDON, and has a test platform in the Baltic Sea. Further, the company Hexicon AB, situated in Stockholm, Sweden, has developed an offshore solution primarily for wind energy production but states that it is possible to integrate complementary technologies to use the platform for multi-purpose: e.g., wave power, tidal power, solar power, desalination, fish farming, and oxygenation [75].

Cooperation between and learning among stakeholders have been observed in research projects (MERMAID, TROPOS, and H2OCEAN). The stakeholders have become more realistic about synergies and costs. Also, small spontaneous initiatives to develop MUPS have been observed among stakeholders who took part in research projects (e.g., SUBMARINER), such as looking for possibilities to grow mussels in windfarms.

Baltic actors take part in a network called the SUBMARINER (2010–2013). This project aimed at testing and evaluating new and innovative uses and technologies, and is still a platform for multiple actors. Testing and developing of MUPS has not been a primary objective, but could become so in the future. Also, several transnational network initiatives exist around MSP in the Baltic Sea Region [68], such as ocean-based energy production in Sweden (e.g., VINNOVA, OffshoreVäst). A pre-study on establishing a test-bed for ocean-based energy production of the west coast of Sweden has been carried out, acknowledging the possibility of the combination of offshore wind and wave energy [76,77].

6.2. PESTEL Obstacles for MUPS

Based on the stakeholder dialogues in the workshops, a series of obstacles to the development of maritime activities in MUPS have been identified in the Baltic Sea. In particular, the PESTEL factors addressed in this case study involve: (1) legal and policy obstacles, (2) technical and economic obstacles, and (3) environmental obstacles.

First, the legal and policy obstacles in Denmark include the fact that spatial planning of the sea areas with a focus on the different interests and stakeholders has only just started. The area around Denmark, including the Danish part of Kriegers Flak, is thus not yet a regulated area [78].

Still, Danish aquaculture is strictly regulated by national, international, and regional environmental, planning, and nature rules and directives. Before establishing or extending a fish farm in Denmark an EIA (Environment Impact Assessment), HIA (Habitat Impact Assessments), permission for water use and for placement in land or sea must be obtained. The process includes several public hearings, and the experience is that the process takes more than one year. At the moment, it is a challenge for fish farm companies to get permits [23]. For development and establishment of offshore windfarm projects in Denmark, three licenses are required, which are granted by the Danish Energy Agency [79]: (1) license to carry out preliminary investigations, (2) license to establish the offshore wind turbines, (3) license to exploit wind power for a given number of years, and—in the case of windfarms of more than 25 MW—an approval is needed for electricity production. There are also noise and spacing rules, and an EIA (Environment Impact Assessment) has to be carried out including e.g., visual impact, noise, shadows, and impacts on nature. While the regulations for windfarms originate from those of oil- and gas offshore platforms and reflect a high concern about safety issues, the regulations for aquaculture reflect a different mindset. The two sectors are governed by different sets of authorities and regulations, and thus it is a challenge to get these working together towards a common goal.

Second, there were no direct technical obstacles identified for implementing windfarms or aquaculture in the Baltic site; on the contrary, conditions are judged favorable [6]. However, there is a potential risk of internal damage, e.g., anchors of the fish farm drifting into the power supply cables, or fish cages damaged by the wind turbine construction [29]. In order to reduce the risks, technical monitoring equipment must be installed in the MUPS, and risk assessments are needed. Good guidelines and rules are needed for technical equipment to ensure safety of the people, vessels, cages, and wind turbines involved. An economic obstacle refers to the non-existence of insurance that will cover the excess of risks that a combination of aquaculture and wind energy would incur. As for interference with shipping, it is possible to just change fishing routes, (for instance, the two shipping routes that pass Kriegers Flak can be replaced by the Ferry to Travemünde).

Third, the stakeholders identified a number of environmental obstacles to MUPS [29]. For instance, as parts of the sea bed area will be occupied by the foundations of the wind turbines and parts of the sea by the fish cages, this will have an effect on habitats and living marine environment. The foundation and scour protection of wind turbines have proved to become an artificial reef in which algae and invertebrates appear to do well and the fish cages should be positioned such that those artificial reefs and their habitats are not disturbed.

Moreover, although aquaculture provides great opportunities in remote areas in Denmark in terms of growth and jobs [28], there is opposition from NGOs especially about emissions of nutrients and interaction with habitats and species. Primary focus areas from the NGOs are the discharge of nutrients and the use of antifouling to the nets. Thus, although the renewable energy sector offshore gains a lot of goodwill, the aquaculture industry struggles with social acceptance due to eutrophication and release of antibiotics. Moreover, it was stated that a MUPS will potentially affect the marine landscape, and preferably not affect the views from shore [29]. In order to deal with the different effects of MUPS, the stakeholders expressed an urgent need to develop clear procedures for stakeholder involvement (for instance, among the countries involved in Kriegers Flak: Denmark, Germany, and Sweden) [29].

7. Conclusions and Implications for Policy-Makers

This paper contributes to the discussion on MUPS in European seas by exploring governance conditions for co-location of energy production and aquaculture. This was studied in four case studies: the Mediterranean Site, the Atlantic Site, the Southern North Sea, and the Baltic Site. In each case study, the different modes of governance, with reference to hierarchical, market, and network governance, as well as self-governance and knowledge governance, were examined. Moreover, specific policy, economic, social, technical, environmental, and legal (PESTEL) obstacles that stakeholders face were identified.

Comparing the case study findings with respect to governance conditions, we see that the ambitions for MUPS are highest in the Southern North Sea, where aquaculture developments in windfarms are explored intensively. In Denmark MUPS as such have not been discussed by public authorities, but arrangements that come very close in terms of, for instance, integrated multi-trophic aquaculture (IMTA) and "cross-boundary cooperation" gained attention, and may pave the road for MUPS in the future. In the Mediterranean as well as the Atlantic Sites, interest from public authorities and market actors was confined to research projects. Still, companies as well as public authorities are encouraging developments, mostly in terms of research and support to workshops. The European Commission puts substantial effort into encouraging coordinated activities in the Mediterranean [36]. As for the applicability of the five modes of governance categories, it was at this stage not possible to fully distinguish between market governance and self-governance, on the one hand, and between knowledge and network governance on the other hand, because these efforts in real cases seem to be interwoven.

With reference to the PESTEL factors, at this early stage of MUPS developments, the laws and policy obstacles seem to be the most visible ones, together with the environmental obstacles, as we see supported by Wright and others [4,5]. While there is a need to synergize laws, regulations, and policies across sectors, it is also necessary to coordinate across nations when transboundary MUPS are to be installed, as well as across governance levels. For instance, the United Nations Convention on the Law of the Sea (UNCLOS) needs to develop regional regulations with different governing bodies across nations. The environmental impacts are highly context dependent, and depending on the exact ecological context and the design of the MUPS, they can be positive.

Technological obstacles were seen a major challenge to MUPS in the Atlantic Site but not in the Baltic Site, where the technical issues seemed to be less of a challenge. This can be explained by differences in the natural physical conditions such as weather and depth. Of the social obstacles, the issues of trust and conflicts were addressed foremost in the Mediterranean Site and the Southern North Sea. Extensive stakeholder consultations were recommended as an important strategy to encourage trust and reduce conflict, which also is supported by the literature [80,81]. In addition, it appears from the Baltic Site and the Southern North Sea cases that economic obstacles, in terms of insurance in case of accidents, can become core obstacles in the future. This is because risks and uncertainties are high at the moment, and when it becomes clearer what accidents insurance companies actually have to cover, the prices may become very high.

Because MUPS provide opportunities for more effective use of marine space in the future (such as combinations of energy and aquaculture), as well as for providing more environmentally friendly solutions (such as IMTAS, which are extending aquaculture production while reducing nitrogen release), it is regarded a possibility for future sustainability of economic developments at sea, and thus also to Blue Growth. A PESTEL framework in combination with stakeholder consultations is recommended to gather a complete picture of external factors that matter to MUPS developments in future. Research on future governance arrangements for MUPS can also benefit from evaluating their schemes according to an improved understanding of how self-governance, network governance, and knowledge governance arrangements can be implemented in a strategic and responsible manner. This will be critical to future MUPS developments.

Based on this research, four recommendations for governance of MUPS are formulated:

- Develop a clear policy frameworks at all levels to guide offshore MUPS development, including a clear licensing procedure that adheres to the principles of MSP to foster sustainable use of marine space [82].
- Create mechanisms for financial support to make the investments attractive to developers because the start-up of MUPS comes with substantially high investment costs and risks compared with business-as-usual projects.
- Protect the marine ecosystem through licensing procedures based on site-specific environmental studies that guarantee the implementation of an environmental monitoring system in the designated marine areas for MUPS development.
- Involve different stakeholders who can share and improve their knowledge as well as influence MUPS developments with their views, and together search for creative solutions to solve difficulties with the development and implementation of MUPS.

Acknowledgments: This research was funded under the Seventh Framework Program, Theme (OCEAN.2011-1). "Innovative Multi-purpose offshore platforms: planning, design and operation" Grant Agreement No.: 288710.

Author Contributions: This paper was compiled by Marian Stuiver and Katrine Soma, with inputs from all co-authors. All authors were involved in preparation of the round-tables and interviews. All authors read and approved the final manuscript.

Conflicts of Interest: The authors declare no conflict of interest.

Abbreviations

The following abbreviations are used in this manuscript:

NGO	non-governmental organization
MUPS	Multi-Use Platform at Sea
MSP	Marine Spatial Planning

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