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The Effects of Time and Exposure on Coastal Community Opinions on Multi-Use Offshore Installations Combining Fish Farms with Renewable Energy Generation

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Abstract

Multi-use of sea space is increasingly seen as a tool for efficient marine resource management, renewable energy utilisation, and sustainable food production. Multi-use Offshore Installations combine two or more production technologies on a single platform at sea. However, achieving commercial viability faces several challenges: social, technical, environmental, and economic. This research focuses on the social aspect, investigating community perceptions of a multi-use offshore installations over three years from 2019 to 2021. Our research was conducted in Reggio Calabria, Italy, where a prototype was deployed in 2021, and Islay, Scotland, suitable for a full-scale multi-use offshore installation but with no deployment, using community surveys. We used the theories of Social License to Operate and Institutional Analysis and Development to frame our analysis. Our findings indicate that coastal communities prefer wind turbines over fish farming, have low trust in public officials to regulate environmental impacts of a multi-use offshore installation, and that short-term deployment of a prototype does not significantly change opinions. We reflect on the challenges of understanding societal opinions of a multi-use offshore installation, given complex boundary conditions, and that multi-use offshore installations combine familiar technologies into a new and unknown form. We suggest that future research should explore the scale of deployment needed to crystallise community opinions, and the role of regulators in developing social license to operate for multi-use offshore installations.

Keywords: social license to operate; socio-technical change; community perceptions; multi-use offshore installations; offshore wind energy; fish farming

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1. Introduction

The sharing of space and infrastructure on offshore platforms is increasingly being researched and tested as a solution to competition for marine space and as a route to more sustainable production of food by use of renewable energy [1]. The concept of co-location encompasses a spectrum of models and names for multi-use of an area in the sea and its resources [2]. Within this manuscript, we use the term 'Multi-use Offshore Installation'

(MOI) for combined technologies on a purpose-built floating platform moored at sea (see Table 1 for key terms). There are several hurdles to combining food and energy production at sea such as through an MOI [1–6]. These relate to different requirements for aquaculture and energy generation in respect of engineering; economics; environmental constraints on structures and processes; livestock welfare; workforce training, health and safety; and legal conformity, risk assessment and insurance. In addition, the industries end-products differ in respect of their societal governance and public policy; their consumer, stakeholder, and developer relations; and the acceptance by coastal communities, and wider society.

Social acceptability is important in the context of participatory marine spatial planning policies and the drive towards equitable use of marine resources [5,7]. There have been a number of studies on the social acceptability of each industry, considered in isolation [8–12]. In their review paper on multi-use platforms, van den Burg et al. [13] identify social acceptability, visual impact, lack of trust in governing and development agents, and conflict around navigation and use of space (e.g., fisheries) as predicted barriers to deployment. Further, the concept of Social License to Operate (from here on referred to as 'social license' or 'social license to operate'), is increasingly being used by marine industries and researchers [14–17] to describe the conditions under which there is informal acceptance of a specific activity by communities (of place, practice, and interest), where legitimacy, trust and community engagement are central themes. In this paper we distinguish on-going situations, such as those conceptualised as social license, from decisive-change situations, which we understand as Action Situations [18], defined in Table 1.

Table 1. Key terms defined, adapted from [6].

Term	Definition Used Here	Other Definitions
AS: Action Situation	Finite collective and communicative process, centring on an Issue; outcomes may be physical actions, communicative signals, or new/revised institutions/norms/plans [6].	Situations *"in which individuals (acting on their own or as agents of organisations) observe information, select actions, engage in patterns of interaction, and realise outcomes from their interaction"* [18]; see also [19].
MOI: Multi-use Offshore Installation	Platform designed for use in open waters, combining several technologies and business types.	MUP: Multi-Use platforms [13]
SLO: Social License to Operate	*"an on-going active relationship between a host community and a development organisation, wherein the development organisation is held to certain standards set by the community, in exchange for community acceptance or support of the organisation and its local activity"* [6].	Active fostering of the growth of host community trust in an operator, and of the community's perception of an activity as legitimate, leading to its consent to the activity [20,21].

This paper follows on from a 2019 study [6], where we aimed to anticipate the characteristics of social license to operate for an MOI deployment. To do this, we surveyed two local communities for their opinions on an MOI. The case study sites were Reggio Calabria, Italy where the EU Horizon 2020 Blue Growth Farm (BGF) project prototype MOI was due to be deployed (without fish), and Islay, Scotland, where the biophysical conditions would be appropriate for the deployment of a full-scale MOI at some point in the future. The main findings of the 2019 study, set out within an Action Situation framework, are:

- Opinions on MOI: Coastal community opinions of the concept of an MOI sat in between opinions of offshore wind energy and fish farming, with opinions on offshore wind energy being very positive, MOI being positive, and fish farming being less positive.

- Community attributes: Prior experience of both types of production technologies were likely to inform opinions on MOI and their products. The 'fit' of the MOI technology within the local context may influence social license for it.
- Actors and local governance system: Trust in local regulators to manage environmental impacts of an MOI was low in both case studies, but more so in Reggio Calabria. Trust in local regulators has been identified in other studies as a key factor for social license [22].
- Developer characteristics and access/use rights: The amount and quality of information provided to a host community by the developer may influence opinions of the technology and the likelihood of developing social license.

We concluded the 2019 study with the hypothesis that community opinions might 'crystallise' [23] around a proposed MOI deployment, to an extent influenced by the relationship between the developer and the community. By crystallisation, we were envisioning a polar-type view, of acceptance or rejection, as these are the types of views we have read in studies on aquaculture [14,16,17,24] and renewable energy [25,26].

With this background, we deployed the same survey in the same case studies in 2021. The aim was to:

(1) Investigate whether the deployment of the BGF projects' 1:15 scale protype MOI, which did not contain fish [27,28], in Reggio Calabria waters, resulted in crystallisation of community opinion and social license, and if so, under what conditions.
(2) Compare the results from the Reggio Calabria case study with those of the Islay case study, where no prototype was deployed.

As the deployed MOI was a prototype, did not include fish, and was in the water for only 10 months, we recognise that this study is limited in its ability to answer these questions to their full extent. However, as social license is a challenge to many marine resource uses, we reason that this study is useful as an exploration of the potential social interactions of MOI using a prototype (there is only one full-scale MOI deployed, in China). Our findings contribute to the limited literature on social perceptions of MOI, provide a first attempt at exploring how these perceptions may change over time, and add to knowledge needed to understand the characteristics of social license to operate for MOI.

2. Theoretical Framework and Research Strategy

2.1. Communities and Social License to Operate

Communities are communicative networks that have grown up because of physical proximity of actors (communities of place) or because of actors' common interests or practices. Social license is a partial description of the state of a community, and of the attitudes of its members, with respect to a developer and a proposed or existing plant and its operation. Insofar as it harmonises relations within the community, social license is part of bonding social capital. In most cases, it is also a bridging capital, linking the community with an external organisation. As with other social capitals, it (when positive) facilitates communication, reduces cognitive overheads and the physical, financial, and psychosomatic consequences of sustained hostility [21].

Social license is a predictive attribute, allowing developers to estimate the social component of development or operational costs; positive social license reduces costs and delays in licensing developments, improves plant security and aids staff recruitment [19]. Investment in generating social license, following established procedures, is prudent business behaviour [29]. It is also ethical, and can contribute to the components (redistribution, recognition, and participation) of visions of social justice [30].

Conceptually, social license can be positive, neutral, or negative. In the case of a new technology and industry, we suppose the initial state of social license to be roughly neutral, perhaps tending slightly positive or negative depending on narratives prevailing in broader society as filtered by the worldviews of community members. However, we hypothesise that a proposal to install a prototype of the new technology at a local site will crystallise vague opinions into strong views and, in some cases, strong opposition, unless steps are taken by the developer to establish community trust. Enquiries into opinions provide the main method used here for exploring and testing this hypothesis: the opinions are considered as indicators of community opinion, rather than individual opinion as found in, for example, [31,32].

2.2. Action Situations

Such step changes as the deployment of an MOI can be understood as outcomes of an Action Situation within the Institutional Analysis and Development (IAD) Framework of Ostrom and McGinnis [18,19,33]. The concept of an Action Situation provides a model for discrete changes in society, and the IAD framework provides a set of analytical categories with which to describe an Action Situation and its context. The IAD has been widely used, and to some extent modified, by social scientists, for example in researching energy transitions [34], and there has been interest in networks of action situations [19,35,36].

The SPICOSA (Science and Policy Integration for Coastal System Assessment) project's Systems Approach Framework (SAF) [37–39] introduced the idea of an *Issue* that generated an Action Situation aimed at resolving the Issue. Action Situation results from an *Issue* and ends when the issue is resolved. It involves structure—in the form of formal and informal rules and local communicative networks—and agency—in the form of actors and their organisations. It is bounded, and has inputs of information, filtered by process rules and an output in the form of decisions leading to action in the social or the biophysical world. In systems terms, the communicative network part of an Action Situation may be understood as a subsystem within a more general societal network, one that is excited by the issue, and which is temporarily distinct from the larger network, which provides its *boundary conditions* in the external socio-economic context. Table 2 lists the information needed to describe an Action Situation.

Using a model of society as a communicative network [39] we understand an *Issue* as something that excites a part of the network in a way that can be conceptualised as an Action Situation because of the potential for action—i.e., some change in the network or in the physical world. In simple cases, such as an application to a licensing authority for a development permission, the Action Situation's operational rules mostly pre-exist, and the Situation is ended when the licence is either issued or refused. If the application is uncontroversial, only a few actors take part in the Action Situation, typically the applicants and some officers of the licensing authority, and the influence of wider society is minimal. We call this a *Focused Action Situation*. In contrast, a controversial application creates what we call a *Diffuse Action Situation*, in which a wider and less clearly bounded part of the network attempts to influence the Situation's outcome. The Diffuse Situations involve more actors and more information, and less obvious and less formal rules. Our interest here is in what triggers a Diffuse Action Situation and leads to a process of crystallisation of weak community opinion into strongly positive or negative social license to operate. We are considering such Action Situations as, primarily, social (i.e., communicative) processes, and only secondarily as shifts in actors' mental states; although, one way of recognising an outcome from an Action Situation is from changes in people's expressed opinions.

Table 2. Information needed to contextualise an Action Situation in the present context, mostly, from [6]. Quoted definitions from [33] are in italics.

Issue	The Stimulus That Generates an Action Situation
Actors	Those who have agency in initiating the Action Situation or determining its outcome; they include stakeholders; the relevant actor characteristics are those of position (in relation to the Action Situation and to organisations and communities) and opinion (in relation to the *Issue*)
Local governance system	The *"set of processes or institutions through which the rules shaping the behaviour of the users are set and revised"* including formal rules and regulations and the informal *"repertoire of strategies, norms, rules being used on a regular basis by participants".*
Community attributes	The relevant communicative networks (or place and interest) relevant to the issue; within-group attributes include mutual trust, common understanding, and cultural repertoire; attributes relating to other groups or organisations include tendency to reciprocity and perception of legitimacy
Market characteristics	Those determining the relationships between producers and consumers (of energy and farmed fish in the present case): these can be direct, small-scale, and local, based on acquaintance and personal trust, or components of large-scale or global economies, disconnecting consumer from producer, and relying on brand as a basis for trust
Developer characteristics	Developer organisations, or individual entrepreneurs, are relevant actors but are singled out because of the importance of their intent and motivation towards the resource, natural environment and affected communities, their interactions with local people and organisations
Social-economic system's boundary conditions	The social, economic, and political settings, are the *"broader context within which the governance system per se is located, including the effects of market dynamics and cultural change"*, and are understood as the institutional outcomes of higher-level Action Situations in a polycentric diversity of political, social, and economic domains

3. Context

In this section we provide information on two changes between 2019 and 2021, to the boundary conditions of the Action Situation for deployment of an MOI (the factors that sit outside of the Action Situation but may influence the Action Situation). The first change was the declaration of a Climate Emergency by the European Parliament on 28 November 2019, on behalf of the member states [40]. The second was the global COVID-19 pandemic, with policy reactions and economic implications across Europe starting in January 2020, and Italy declaring the first EU member state lockdown on 3 March 2020, [41]. The climate emergency increased the political urgency of the transition to a lower carbon economy [42–44]. The pandemic influenced which actors were willing and able to participate in the Action Situation. The United Kingdom's exit from the European Union (Brexit) in 2020 will have impacted the boundary conditions of the Islay case study, shifting the dynamics of trade and investment in Scottish businesses [45].

3.1. Reggio Calabria, Italy

Reggio Calabria is a coastal city and municipality off the southwestern tip of the Italian mainland. In the BGF project, the Strait of Messina, which runs between Sicily and Reggio Calabria, was chosen as the MOI prototype testing site. Further information on the site choice can be found in [6]. The main change in the Action Situation from 2019 was that in 2021, the Natural Ocean Engineering Laboratory deployed a 1:15 scale prototype MOI for 10 months, which did not contain any fish. This prototype was visible from the city of Reggio Calabria's beaches and waterfront promenade as seen in Figure 1. Full details on the prototype are available in, and depictions can be seen in Figure 2 [27].

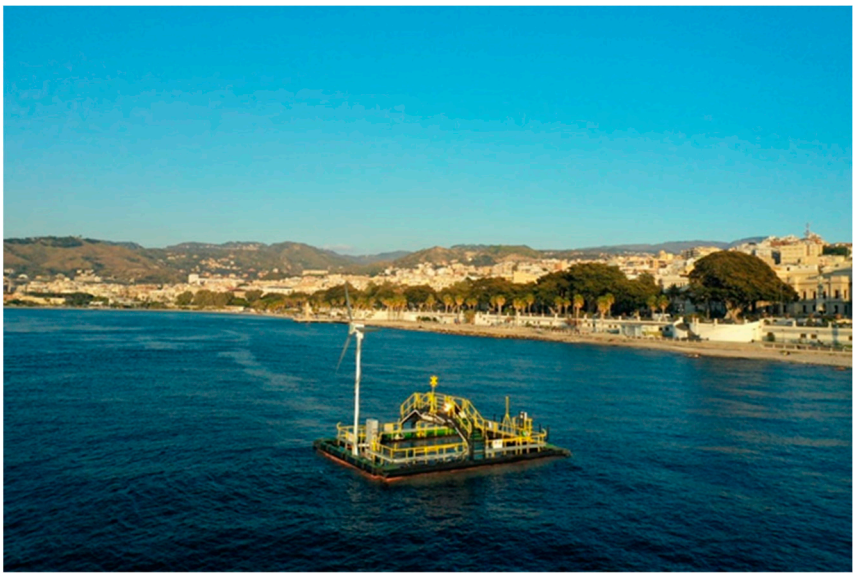

Figure 1. Air-drone photo of the BGF platform prototype, deployed on the seafront of the city of Reggio Calabria in 2021. Water depth, 35 m, hull footprint 14: 10.8 m, with a maximum blade tip of 10.5 m above sea level [27].

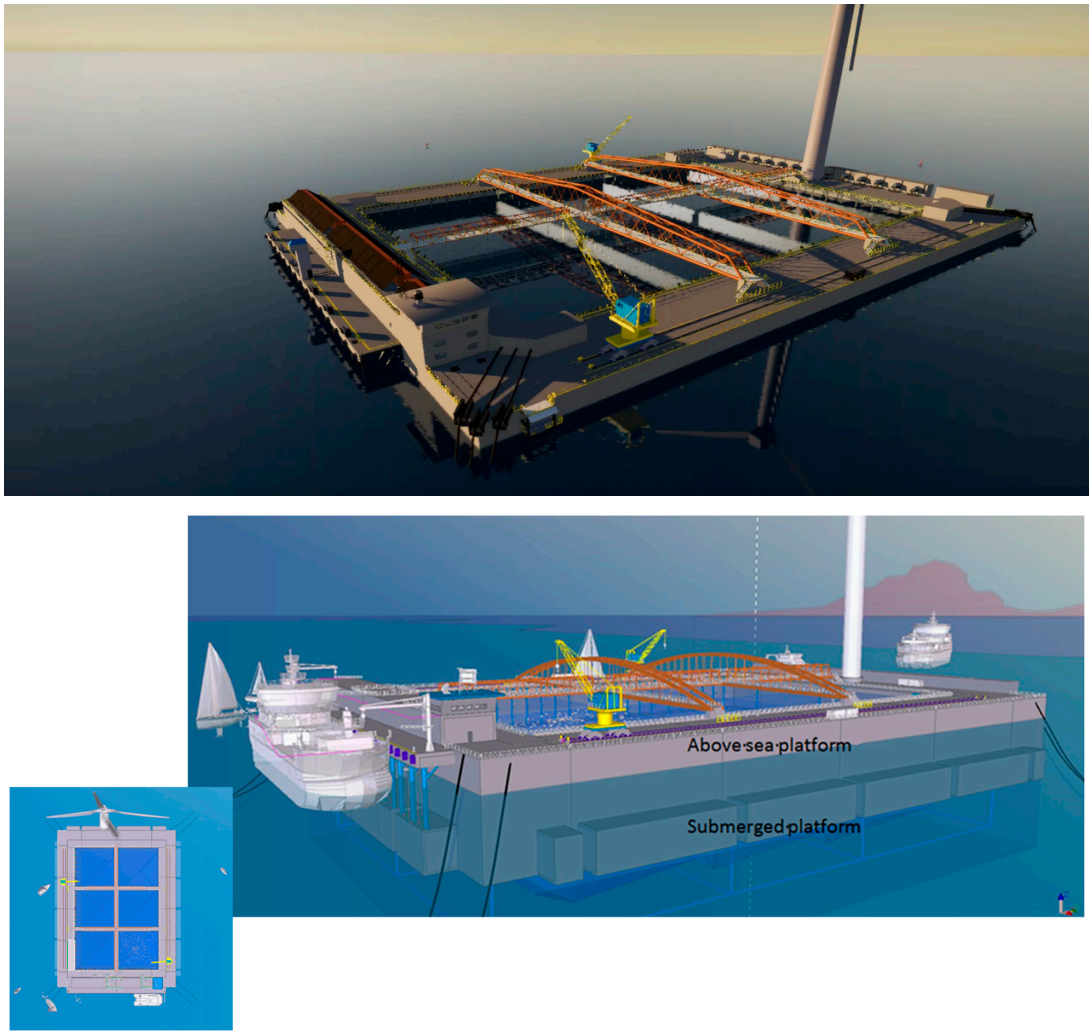

Figure 2. Blue Growth Farm model render view of the MOI full-scale platform.

3.2. Islay, Scotland

Islay sits off the West Coast of Scotland, with unobstructed experience of the North Atlantic and its weather systems. It was chosen as a hypothetical MOI deployment site for the BGF project due to optimal biophysical conditions for the technology. The main local change in this case study from 2019 was that in 2021, there was a UK-wide leasing round for offshore wind, with sites up for lease off the northwest coast of Islay. Scottish Power Renewables was successful in their bid for a 2GW fixed offshore wind site in July 2021 [46] before the survey on Islay was conducted. Brexit had a national effect, which is likely to have influenced the socio-economic and socio-political environment on Islay (for example directly through export/import challenges for agricultural, fisheries, and whisky products).

4. Methods

We used a quantitative approach to this study that involved collection of data through use of survey questionnaires in both case studies [47]. Questionnaires are reproduced in the Supplemental Materials and included questions about demographics, together with Likert-type items to gauge strength of opinion. Data can be made available upon request. Both surveys follow the same design as described in Billing et al. [6], except for some additional questions to further explore public opinions regarding trust in public officials, following Moffat and Zhang's survey items on trust [20]. The main questions were designed to collect opinions on each of the component parts of an MOI before asking about opinions on the integrated platform and its location. The questionnaires, adapted to language and place names at each study site as shown in the Supplemental Material, were split into the following sections: (1) wind turbines at sea; (2) fish farms at sea; (3) the concept of combining both of these activities in the BGF MOI as presented to the participants in illustrations seen in the Supplemental Materials; (4) opinions about deployment, ownership, and regulation of MOI and; (5) participant demographics. This enabled us to assess the differences between opinions of wind turbines and opinions of fish farming, before asking about them in combination. We also wanted to know if respondents reported different opinions about turbines, farms, and MOI when asked about them in general and when asked about local deployment. Section 3 included a question on willingness to eat fish farmed in an MOI. Section 4 included one question on MOI ownership and two on trust in public regulation in relation to acting in the interest of the local community, and regulating the environmental impacts of a platform, to explore some of the factors behind potential support of, or opposition to, MOI deployment.

A non-probability convenience sampling strategy was used for the survey distribution. There are limitations to this sampling strategy, in that the results are not generalisable [48]. However, as this was an exploratory small-scale study, conducted as part of a large research project focused on engineering, convenience sampling was chosen as practical within the timeframe and resources available. The survey in Reggio Calabria was conducted on the sea front on the 14 December 2021 close to where the BGF prototype was situated. Passers-by were intercepted and asked if they would consent to an interview. BGF personnel then read the questions to each participant and noted their responses. This differed from the 2019 survey, which was conducted in September, coincided with a local holiday, and where an ice cream voucher was offered as an incentive. The survey on Islay was carried out by interviewing passers-by in the streets of two main settlements from 5–8 November 2021, a little later than the 2019 survey (18–20 October). The questions were loaded onto a tablet computer, and participants were talked through the questions while the surveyor inserted the responses. Before the in-person surveys, the survey was shared across local forums through social media and email to those on Islay and other surrounding islands, including

Jura, Colonsay, and Gigha. The survey also remained available online for eight weeks until the 31 December 2021 to coincide with an article shared in the local Islay paper, The Ileach, released on the 11 December that shared the details of the BGF project and survey. The online survey was required to supplement the street surveys as the population base of Islay is dispersed in comparison to Reggio Calabria.

Survey Analysis

The Likert-type responses to the opinions survey were analysed by categorising the response options into codes from one to four following the procedures set out in [48]. For example, question 1.1 was 'What is your opinion of wind turbines that are at sea and used for electricity generation?' and the responses were counted as 'positive' (code 1), 'mostly positive' (code 2), 'mostly negative' (code 3) or 'negative' (code 4). In some cases, categories (such as 'mostly positive' and 'positive') were combined to dichotomise data for further analysis.

Three non-parametric tests were used with the aid of the R Studio 4.1.3 statistical software package [49]. The chi-square test for difference and the chi-square test for correlation used the frequency of responses in different categories. Fisher's exact test was used when there were frequencies < 6 in a category [50]. The Wilcoxon matched-pairs signed-rank test was used to test the significance of the shift in each participant's response between pairs of questions. For example, a participant who answered, "mostly positive" to the wind-farm question 1.1 and 'negative' to question 2.1, 'What is your opinion of the farming of fish in the sea?', would have the change scored as +2. This pattern of change was compared with an expectation based on a null hypothesis of no change. Although the Wilcoxon test could only be used for pair-wise comparisons, it is more powerful than a chi-square test as it retains information about individual participants.

Statistical outcomes have mostly been reported as probabilities for the observed data on null hypotheses of no difference, or no correlation (as appropriate), with $p > 0.05$ given as 'not significant'. $p < 0.05$ has been taken as significant where the analysis was used to answer a specific research question. The difficulty arising in the case of multiple comparisons, when investigatory tests were used, was resolved by a Bonferroni correction, i.e., dividing the probability level of 0.05 by the number of comparisons. Values of the effect size parameter φ [51] were calculated from the following:

$$\sqrt{\frac{\chi^2}{(df \times n)}}$$

5. Results

The focus of this section is on the community opinions between the survey conducted in 2019 (already reported in [6]) and the one conducted for this study in 2021. Table 3 provides information on the 2021 survey participants and the differences from 2019. The important 2021 results are provided in Tables 4 and 5; however, more detailed analysis can be found in the Supplemental Materials. For the 2021 survey, 10% and 30% fewer individuals took part in the Reggio Calabria and Islay 2021 surveys, respectively. Similar numbers for residency and gender were seen, with higher numbers of visitors seen in the 2019 survey. This was expected as the 2019 survey coincided with the Patron Feast in Reggio Calabria. Age ranges were more spread out in the 2021 surveys, particularly in Reggio Calabria, where there was a lesser skew towards a younger audience (21% compared to 44% 15–24-year-olds). Because there were almost no significant associations by chi-square (Tables S3 and S4) between response and either age, gender, or domicile, responses were pooled.

Table 3. Information on 2021 survey participants and changes from the 2019 survey demographics. Changes are indicated as '↓' for a decrease and '↑' for an increase.

Case study	Reggio Calabria		Islay	
Year	2021	Change from 2019	2021	Change from 2019
Number of respondents who answered all questions	98	↓10% (108)	89	↓38% (122)
Number responding online	0	-	16	↓9%
Where do you live? (implying primary habitation)				
Locally (province or county)	85%	↑8%	69%	↑13%
Nationally (Italy or Scotland) but outside local area	13%	↑1%	28%	↑4%
Internationally	2%	↓9%	2%	↓18%
How would you identify yourself?				
Female	44%	↓7%	42%	↓10%
Male	56%	↑8%	58%	↑9%
Which range includes your age?				
15–24	21%	↓23%	5%	↓1%
25–49	49%	↑24%	44%	↑2%
50–64	20%	↑1%	38%	↑12%
65–79	9%	↓2%	14%	↓9%
80+	1%	↑1%	0	↓3%

Table 4. Summary of opinion questions and responses from the 2021 and 2019 surveys. 'Positive, here, includes 'somewhat positive. Response change, assessed by χ^2, is shown by arrows: one arrow indicates significance at $p \leq 0.05$, two arrows indicate significance at $p \leq 0.0625$ (i.e., with Bonferoni correction). Additionally, a measure of effect (φ) is given when $\varphi \geq 0.1$. The boundary between a small and a medium effect was set by [51] Cohen (1988) at $\varphi = 0.3$.

		2019 Reggio Calabria Positive	2021 Reggio Calabria Positive	Reggio change between '19–'21 (φ)	2019 Islay Positive	2021 Islay Positive	Islay, change between '19–'21 (φ)
Q1.1	What is your opinion of wind turbines that are at sea and used for electricity generation?	76%	96%	↑↑ (0.29)	88%	97%	↑ (0.15)
Q1.2	What is your response to a proposal to install wind turbines in the sea (near here)?	63%	88%	↑↑ (0.28)	79%	97%	↑↑ (0.25)
Q2.1	What is your opinion of the farming of fish in the sea?	63%	78%	↑ (0.16)	48%	48%	
Q2.2	What would your response be, to a proposal to place a fish farm in the sea (near here)?	57%	70%	↑ (0.13)	46%	51%	
Q3.3b	(Having been shown a picture) What is your first reaction to (MOI)?	85%	91%		68%	79%	
Q3.4	How likely are you to eat fish produced in one of these installations?	65%	71%		56%	62%	
Q4.1	What would be your response to a hypothetical proposal to place an. . . MOI in the sea near (here)?	70%	76%		61%	75%	↑ (0.14)
Q4.2	Suppose that this hypothetical MOI was going to be installed near (here). Would you prefer that it was owned. . .						
	locally;	43%	48%		76%	69%	
	by a large national company;	30%	34%		21%	28%	
	by an international company?	27%	18%		3%	2%	
Q4.3a	. . . how likely are you to trust public officials to act in the interests of the local area?	n/a	20%	n/a	n/a	61%	n/a
Q4.3b	. . . how likely are you to trust public officials to regulate the environmental impacts of this MOI?	37%	22%	↓ (0.16)	39%	59%	↑↑ (0.20)
	Sample size (number of responses to questions)	106–108	96–98		120–127	85–89	

Table 5. Important comparative findings from the 2021 surveys, restated as question and answer. OWE = Offshore Wind Energy (harvesting device), FF = fish farm(ing); IL = Islay, RC = Reggio Calabria. 'Yes' answers are deduced from statistically significant pair-wise W. 'MIXED' means that the findings of change differed between Reggio and Islay.

Survey questions compared	Comparison as question	Finding (as answer to comparison question)	Change from 2019
Binary comparisons (details in Table S1)			
Q1.1 and Q2.1	Did respondents think better of global OWE than of global FF?	YES: respondents expressed more strongly positive opinions of OWE (in general) than of FF (in general), although the difference was less strong in RC.	No change.
Q1.1 and Q1.2	Did respondents think less well of local OWE than of global OWE?	MIXED: RC respondents expressed less strong positive opinions of potential OWE in their locality than of OWE in principle; no significant differences in the case of IL participants' responses.	YES in 2019 to MIXED in 2021. Difference between positive opinions about local OWE and OWE in general was larger in 2021 than 2019. It remains strongly positive.
Q2.1 and Q2.2.	Did respondents think less well of local FF than of global FF?	NO: there was no significant difference between respondents' opinions of potential FF in their locality than of FF in general.	No change.
Q1.2 and Q2.2	Did respondents think less well of local FF than of local OWE?	YES: participants' responses to potential local FF significantly more negative than to potential local OWE, although the difference was stronger in IL.	MIXED in 2019 to YES in 2021. Increase in negative opinions about potential local FF in comparison to OWE in RC. The 2019 responses in RC showed no significant differences.
Three-way comparisons (details in Table S2)			
Q1.2, Q2.2, Q4.1	Were respondents' opinions about potential local deployments of MOI intermediate between those for OWE and those for FF?	YES: participants' responses for local MOI were significantly less positive than those for local OWE but significantly more positive than those for local FF; the difference was stronger in IL than RC.	MIXED in 2019 to YES in 2021. Responses for local MOI remain in between OWE and FF. The 2019 responses were less polarised in both RC and IL.
Q1.1/2, Q2.1/2, Q3.4	Were respondents' opinions about eating farmed fish improved by associating FF with OWE in MOI?	YES: respondents' opinions about eating fish from MOI were significantly more positive than opinions about OWE and FF, whether local or global; the difference was twice as strong in IL than RC.	NO in 2019 to YES in 2021. Increase in positive opinions about eating fish from and MOI when compared to opinions about OWE and FF. The 2019 responses showed no significant difference.

Most responses to the opinion survey in 2021 did not significantly differ from 2019 (Table 4). They were found in responses to questions 1.1 and 1.2, about offshore wind energy in general and offshore wind energy installed locally, and 4.3b, about levels of trust in local officials to regulate the environmental impacts of an MOI. In Reggio Calabria there was a 20% increase in positive responses to offshore wind energy in general between 2019 and 2021. There was also an increase in positive responses to local offshore wind energy, although this was not found to be a significant increase. In Islay there was an 18% increase in the positive responses to locally installed offshore wind energy between 2019 and 2021. There was also an increase in positive responses to offshore wind energy in general, although this was not found to be significant. In Islay, there was a 20% increase in positive responses about trust in regulators between 2019 and 2021. However, in Reggio Calabria responses were less positive in 2021 than in 2019, although this was not found to be a significant change.

Further analysis showed that this lack of trust was independent of place of residence, although there was some evidence of dependence on gender and age (Supplementary Materials Table S4). Respondents in Islay had a strong preference for local ownership of the hypothetical MOI (69%), whereas opinion was more divided in Reggio Calabria (48%) (Table 4, Q4.2).

The results of a Wilcoxon analysis of Likert-scale opinions are summarised in Table 5. Before these surveys, we hypothesised that opinions about MOI would be somewhere between those for fish farming and for offshore wind energy. We used three-way comparisons to investigate this. Below are the main findings from these two types of comparisons, and the changes from the comparisons of responses to the same questions in 2019.

- Respondents in both sites in 2021 had more positive opinions about offshore wind energy in general than about fish farming in general, which is a pattern unchanged from 2019. The same is true for opinions about these production technologies on a local scale. However, in 2021, respondents in Reggio Calabria were significantly more negative about local fish farming than they were about local offshore wind energy, compared with the 2019 survey.
- Respondents in Reggio Calabria were less positive about the prospect of local offshore wind energy than offshore wind energy in the abstract in 2021 than they were in 2019. However, opinions were still positive overall.
- Respondents in both locations in 2021 were more favourable towards local offshore wind energy than towards a local MOI, but they viewed the MOI more positively than local fish farming. This pattern strengthened from 2019 to 2021.
- Respondents' willingness to eat fish from an MOI was more positive than their opinions about fish farming by itself in both case studies. This was unchanged from 2019.
- The difference in opinions between offshore wind energy and fish farming as separate activities and the combination of both on an MOI was stronger in Islay than Reggio Calabria, a pattern unchanged since 2019.

6. Discussion

Through our survey in Reggio Calabria, we have attempted to explore how a coastal community's perceptions might change between being asked about a "hypothetical" MOI to being asked about an MOI that they experienced, albeit in prototype and without fish. The surveys on Islay allowed for a comparison of what happens to opinions over time, when there are no MOI-specific changes. The focus of this discussion is on the changes in perspectives that were significant; in situating the findings within our theoretical framework; and the implications for the deployment of a full-scale MOI.

6.1. The Positivity Gap

The surveys in both Reggio Calabria and Islay showed that there was an increase in positive perceptions of wind turbines at sea in general, and a slight reduction in positive opinions of wind turbines at sea in their local areas between 2019 and 2021. As the surveys were quantitative only, we do not have the data to comment on exactly why there is this positivity gap between local and general perceptions. However, this pattern has been identified in studies exploring the social acceptability of specific renewable energy projects, where local communities are accepting of the technology in principle but have concerns when developments are proposed in their local area (see for example [52,53]). Research into the cause of these concerns ranges from superficial explanations such as Not In My Back Yard (NIMBY) descriptions, to narratives dealing with social change, psychological characteristics [31,32], participation processes, perceptions of fairness, local power dynamics [54], and collective action, that are more compassionate and cognisant of human emotion and human relationships [25].

Understanding the connections that coastal communities have with offshore wind farms is not limited to perceptions about site-scale economic or environmental impacts but is inclusive of the complexities of broader socio-technical change [55]. In other words, the change to the energy system that an offshore wind farm brings about, impacts more than just local jobs and the local natural environment. Using our IAD framework, it fundamentally changes all *Issues*; the Governance system such as processes around the local planning and politics; market characteristics, developer characteristics and actors such as energy networks and distribution of the energy; ownership of complex resources such as sea space, seabed, vistas [25]; community attributes such as social-psychological

and cultural aspects such relationships with space and place [53,54], perspectives on use, distributional equality [56]; and social economic systems such as the broader shift to a lower-carbon economy [57]. Within the context of MOI, the "positivity gap" is a topic that requires further exploration, specifically the ways in which fish farming within an MOI influences this gap.

6.2. The Role of Exposure in Acceptability of Offshore Wind Turbines

In addition to the extensive societal changes that low-carbon energy production produces, the boundary conditions of our Action Situation means that populations in Reggio Calabria have no local exposure to offshore wind turbines, and relatively little exposure at a national level. (As of 2024, Italy has a total of 30MW (10 turbines) installed offshore wind capacity sited at the Beleolico Park, Taranto, operated by Renexia [58]. It is the first offshore wind installation in the Mediterranean. Taranto is approximately 400km northeast of Reggio Calabria). Populations on Islay have no local exposure to wind turbines at sea, but at a national level, the UK is a global leader in installed offshore wind power [59]. The authors propose that this lack of local experience of the technology and the processes involved in planning and operation of such technologies in both case studies (quite understandably) incite a cautious opinion of developing local offshore wind. A recent study on Belgian offshore wind farms found that exposure to offshore wind energy technology over time increased acceptability of the technology by coastal communities [60]. The same has been found in the USA with communities neighbouring onshore wind developments [61].

Our survey shows there was an increase in positive opinions on offshore wind in both case studies, with a more positive opinion of offshore wind in general, than on a local scale. This is likely a mix of extended exposure to the technology through the increasing offshore wind development pipeline globally (and urgency of deployment of solutions to the climate emergency), a change to the boundary conditions, and a feature of the phenomenon that opinions improve about a wind farm in the pre-development phase [25,62]. We postulate that in the case of Reggio Calabria, the prototype may have created excitement similar to a pre-development phase as evidenced by Wolsink [62]. This could be because of the scale and the time limited nature of the deployment—a phenomenon that could be targeted for investigation in future opinion studies. On Islay, the ScotWind leasing round allocation was pre-development. Our study adds to the extensive body of literature showing that there are nuances to opinions of offshore wind farms at a local level (Action Situation level), despite general support for the technology.

6.3. Opinions on Farming Fish

The coastal communities, in both case study sites, were less positive towards fish farming, in general and locally, than towards offshore wind energy. The difference in opinions about these two industries was significant across both 2019 and 2021 surveys and Reggio Calabria and Islay. Our findings are reflected in current literature, media, and policy discussions, where fish farming is coming under increasing scrutiny for issues related to environmental practices and fish welfare (see for example [63]). There is increasing awareness and evidence that farming of high-value fish in developed nations (such salmon) has seen a reduction in its social acceptability over the past decade [64]. Within our theoretical framework, developer characteristics and local governance systems seem to be at the forefront of this reduction in acceptability. The former associated to lack of trust which links with poor transparency and communication around operations in general and more specifically, environmental impact management and 'fit' to place/context [16,17]. The latter is linked with regulatory processes for environmental management of fish farms, and

the perception that these largely do not meet expectations by communities of interest in particular [64]. It is likely that these underlying factors meant that our participants already had a crystallised opinion about fish farming, and the deployment of the MOI prototype did not influence these significantly. However, these suggestions should be interpreted cautiously as respondents had no exposure to fish farming within the prototype MOI.

Farming of fish and other low trophic species [aquaculture] can support solutions to challenges in the food-health-water-biodiversity nexus. However, aquaculture currently faces numerous social (and biological) challenges [64]. Our study shows that respondents from both case studies felt they were likely to eat fish from a fish farm within an MOI, 71% in Reggio Calabria and 62% in Islay in 2021. More research is required to understand the factors involved in these opinions, including comparisons between likelihood of eating fish grown through different farming techniques/technologies (e.g., in an MOI vs. traditional farming methods), cultural contexts (e.g., culinary culture, where fish providence may/may not significantly influence decisions), and socio-economic contexts (e.g., price of fish grown in different farming technologies).

6.4. Trust and the Governance Challenge of MOI Deployment

Trust is either an outcome [65] or a part of social capital, defined as "the networks, norms, values and understandings that facilitate co-operation within or among groups" [66]. What is assessed by the questionnaire is clearly an individual attribute, but one that is shaped by interactions within communities, and we use survey data about trust in regulators as a proxy for the part of social capital that bonds citizens with governance [67]. Studies of both renewable energy and aquaculture have shown that the social acceptability of the industry is linked to trust and procedural fairness within governance systems [12,61,62,64]. Social license and social acceptability studies more broadly have linked trust and effective communication with acceptance and reduced perception of environmental risk [15,68–72].

Low trust in public officials to regulate the environmental impacts of an MOI was a main feature in the Reggio Calabria case study across the surveys, with a drop in positive responses between the years (37% in 2019 and 22% in 2021). It is likely that the boundary conditions of our action situation were influencing our participant responses. Both the global pandemic in 2020, and Italy starting the first restrictive lockdown in Europe [73], are likely to have had an impact on the sense of trust in the governing regime [74].

On Islay, the level of trust was higher across both surveys, and there was a significant increase in trust between 2019 and 2021 (39% and 59%, respectively). The global pandemic is likely to have influenced trust in government overall [74]. In the 2021 survey of Scottish attitudes, 66% of those surveyed trusted the Scottish Government to work in Scotland's interest [75]. This proportion might have been particularly high in 2021 compared with 2019 because of the way the Scottish Government engaged with its citizens over COVID-19. At a local scale, there was a change of local representative to the Scottish government in 2021, following the Scottish elections. As Islay is a small, island community it is also likely that changes in opinion are related to the activities of local community networks (and agents), of organisations (e.g., Royal Society for Protection of Birds), and planning/land allocation decisions (e.g., allocation of land for regeneration projects by NatureScot) (These postulations are based on personal communications with Euan Patterson, who is from an Islay family, and who has first-hand knowledge of the local way of life and communication networks). Thus, there may have been relevant Diffuse Action Situations of which we were unaware.

In our study it is likely that there is an interplay between community opinions, local (where our Action Situation takes place), and global environmental governance (the boundary conditions). Current global governance and economic systems have failed and continue

to fail to adequately protect the natural environment [76]. The climate emergency and rapid loss of biodiversity has become a persistent and increasingly loud noise in international politics, with environmental NGOs playing a substantial role in disseminating lack of action and its consequences to the general public. Under the IAD model, these boundary conditions will influence the opinion of the actors (local coastal communities) within our Action Situation, in addition to the direct experiences of these communities in exposure to the types of decisions that local officials have previously made and their effects (good or bad, intended or not).

The trust and governance challenge here is that, despite MOIs potential to contribute to the transformation to lower-carbon food-energy production systems, they combine proven and institutionalised technologies—wind turbines and farming of fish, which most people have an opinion on, to create a technology that is currently experimental. The implication is that an MOI represents more than simply a change in energy and food production, it is a change across many systems and perhaps importantly, a change to known opinions on technology, which brings with it uncertainty and unintended consequences (positive and negative) [77]. Lack of exposure to and understanding of technologies can incite perceptions of caution and risk [60]. There are mechanisms that may reduce these types of negative perceptions and in turn may increase social license to operate, such as time and exposure to the technology [60].

6.5. The Resolution of the Action Situation—Coastal Community Perspectives on MOI Deployment

Ontologically, an Action Situation is a finite intensification of communicative networks around an issue, which is resolved by an output that brings about or constrains action in the communicative (social) world and/or the biophysical world. Epistemologically, an Action Situation is constructed, as defined by [18] in Table 1, as a system with an outcome that can be related to evidence about actors and their motivations and behaviours, formal and informal institutional structures, and boundary conditions. It is this evidence that we have presented here for both Reggio Calabria and Islay, using it to contextualise the potential Action Situation in both places and to test the crystallisation hypothesis for Reggio Calabria. According to our theoretical framework, the Focused Action Situation generated by the application for permission to deploy a prototype MOI, was resolved in February 2021 when the BGF platform was installed off the coast of Reggio Calabria, Italy. Although not without issue (there were setbacks related to bureaucracy within the formal consenting process, a fire in the facility building the steel frame for the platform (not located in Reggio), and the COVID-19 global pandemic), the formal procedures (or 'rules in use' as described by the IAD) for licensing were complete. We hypothesised that awareness of the application, or the deployment itself, might generate a Diffuse Action Situation, and opinion crystallisation about MOI, in the coastal community in Reggio Calabria. Our survey found an increase in positive opinions about MOI between 2019 and 2021 in Reggio Calabria (of 6% from 85% to 91%); however, (a) it was not statistically significant, and (b) the increase in positive opinions could not be directly linked to exposure to the prototype (a limitation future studies should seek to address).

We propose two scenarios that feed into the consistency of opinions; the first is that a small-scale prototype, deployed for a short period of time, is not enough to sway coastal community opinions, particularly within the context of continual background noise of other local resource, infrastructure, and global changes. The second is that this technology is new, it is untested at scale, and the general public know very little about MOIs and multi-use [78] and are generally supportive of renewable energy [25], but are more skeptical of aquaculture [79].

6.6. Study Limitations

We conceptualised relevant events in Reggio Calabria in terms of Focused and Diffused Action Situations. Our hypothesis was that the deployment of the BGF prototype in Reggio Calabria waters in 2021 would generate a Diffuse Action Situation and crystallisation of community opinions on MOI, whereas there was no relevant Action Situation in Islay during this period. Testing this hypothesis involved comparison of survey findings in 2021 with those in 2019, and the assumption that we were sampling the same communities in both years. However, the strongest finding from these surveys was not of a growing difference between Reggio Calabria and Islay but that opinion tilted further in favour of offshore wind energy in both locations. It is important to reiterate here that a limitation of this study is that the MOI was a 1:15 prototype and did not contain any fish.

We must first consider the possibility that our findings about change are artefactual, the consequence of differences in the demographics of people interviewed. In both Islay and Reggio Calabria there were fewer internationals in 2021, and fewer students in the Italian survey in that year (Table 3), perhaps the result of restrictions on travel imposed during the COVID-19 pandemic. However, there were few significant correlations (and only one significant after Bonferoni correction) between demographic contrasts (national/non-national, male/female, young/old) and opinions (Tables S3 and S4 in Supplemental Material), although this finding might have been the result of small sizes in the case of some of the subgroups. There were also changes in trust in regulators, which decreased in Reggio Calabria and increased in Islay, and which cannot be explained by the different demographics in 2021. As our survey methods were largely unchanged between 2019 and 2021, we conclude that the samples were drawn approximately from the same populations and communities in each year. However, we cannot claim that they were exactly representative of the sampled communities, and we have no information with which to assess the possibility that the 2021 respondents in Reggio Calabria were influenced by seasonal differences (September 2019; December 2021) in the time of the survey.

7. Conclusions

Multi-use of marine space is being actively pursued as a solution to food, energy, and spatial issues [2,80]. However, multi-use offshore installations combining fish farming with marine renewable energy is still at an early technology readiness level. Hence, our study was exploring opinions of coastal communities at this stage. We hypothesised that coastal community opinions might crystallise, in support or rejection of a multi-use offshore installation, in Reggio Calabria, where the Blue Growth Farm project prototype was deployed, without fish. This crystallisation would result in the resolution, or end of the *Diffuse* (informal) Action Situation. We found that the prototype deployment did not appear to generate such a Situation, perhaps because of the small scale of the prototype and the short length of deployment. Nevertheless, we found in both case studies and across time, that there is a positivity gap in perceptions between the concept of a multi-use offshore installation and its components in general, versus if one were deployed locally. Further, we found fish farming to be less acceptable than offshore wind in both case studies.

Trust in public officials to regulate the environmental impacts of a multi-use offshore installation varied across the case studies and over the years, with lower levels in Reggio Calabria than on Islay. This is a key finding, as trust is one of the foundations of social license to operate [20]. If public officials are not trusted, then by default the onus is on MOI developers to ensure that they can effectively convince communities that they are operating within socially acceptable environmental parameters. Further work is required to understand whether established industry-based methods for garnering social license to operate, and social acceptability, (such as effective stakeholder and community engagement,

voluntary standards, certification, procedural fairness, and community benefits mechanisms), are nuanced enough to support coastal communities' choice to grant/not grant social license to operate for multi-use offshore installations.

In the framework of the Institutional Analysis and Development, there is more to explore and explain in this multi-use offshore installation *research puzzle* [81]; (A *research puzzle* is seen as distinct from policy analysis in that a puzzle requires the search for an explanation for a question or phenomenon, whereas policy analysis seeks to understand the outcomes of different policies and their implementation [81]) (a) investigate if there is a degradation of perceptions of offshore wind energy if it is associated with "controversial" food production such as farming fish (and why); (b) if positive associations with offshore wind is the case for other food products (e.g., low trophic species such as seaweed and mussels) and other value chains from the same production methods (e.g., chemicals, nutraceuticals, pharmaceuticals, biofuels etc.); and (c) how these associations interact with social license to operate for multi-use offshore installations.

Despite the limitations of an opinion study based on a multi-use offshore installation prototype without fish, our results provide insight into the difficulty of exploring community perspectives on new technologies and re-confirm the plethora of evidence showing that the context of the deployment of low-carbon technologies matters. We can thus point to the following considerations needed to gain positive Social License to Operate for multi-use offshore installations:

- Actors: Within coastal communities, it is unlikely that people can form solid opinions on multi-use offshore installations without increased exposure to the technology and how its impacts are managed and by whom. Exposure could be at a local, national, or international scale, so long as it is covered by relevant media sources.
- Market characteristics: There is a preference for local ownership of multi-use offshore installations, challenging current market characteristics where large-scale energy and fish production systems are mostly internationally owned.
- Developer characteristics: As multi-use offshore installation technology is in its infancy and people have limited or no knowledge of it [78], communication and engagement with the actors and the communities involved is critical. Information could include technological outlay, production strategies, economics, environmental impacts, and day-to-day running in accessible language [6].
- Social-economic system's boundary conditions: The social, economic, and political settings of higher-level Action Situations (i.e., the system is polycentric) can directly or indirectly influence the opinions of the actors in an Action Situation for a multi-use offshore installation. For example, the positive opinions of offshore wind in this study are likely to be as a result of increasing exposure to the technology (from the 1990s), and the intensifying concern that we (as a collective human race) are not doing enough to combat climate change. These factors are not those which a developer could influence but are likely to influence people's opinions of multi-use offshore installation technologies.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/su18020874/s1, Table S1: Pair-wise Wilcoxon tests for differences amongst individual respondent's Likert-scale opinions about FF and OWE. Table S2: Matrices of pair-wise Wilcoxon tests for differences amongst individual respondent's Likert-scale opinions about OWE, FF and MOI. Table S3: Chi-square or exact Fisher test (2×2) correlations of opinions with demographics. Table S4: Chi-square or Fisher test (2×2) for correlations of trust with demographics.

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Data Availability Statement: The full results of the statistical analyses are available in the Supplementary Materials. The raw datasets are not readily available because the data were collected under the Blue Growth Farm project, which was completed in 2022 and included a time limitation on data storage. Requests to access the raw data should be directed to suzi.billing@sams.ac.uk.

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Abbreviations

The following abbreviations are used in this manuscript:

AS	Action Situation
BGF	Blue Growth Farm project
EU	European Union
FF	Fish Farming
GW	Gigawatts
IAD	Institutional Analysis and Development
IL	Islay
MOI	Multi-use Offshore Installation
MUP	Multi-use Platform
NGO	Non-governmental Organisation
NIMBY	Not In My Back Yard
OWE	Offshore Wind Energy
Q	Question
RC	Reggio Calabria
SAF	Systems Approach Framework
SLO	Social License to Operate
SM	Supplementary Materials
SPICOSA	Science and Policy Integration for Coastal System Assessment
UK	United Kingdom

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