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Combining wind power and farmed fish: Coastal community perceptions of multi-use offshore renewable energy installations in Europe

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ABSTRACT

There is increasing competition for space in coastal seas as new industrial sectors, such as Marine Renewable Energy (MRE) and Aquaculture, seek to expand. Multi-Use - involving sharing of space and, in some cases, facilities - can lessen competition and reduce industry costs if societal and economic challenges can be overcome. An example societal challenge is that of gaining Social Licence to Operate (SLO) for 'Multifunctional Offshore Installations' (MOI) combining fish farming with MRE (from wind and waves) in a large floating structure. This article reports a mixed-methods study at two potential MOI deployment sites in 2019, aiming to understand the local context for SLO. A survey was carried out in Reggio Calabria, Italy, with 108 respondents, and in Islay, Scotland, with 127 respondents. Questions concerned opinions about MRE and fish-farming, separately and combined. A facilitated workshop in Reggio Calabria provided additional qualitative data. Most findings were the same in both places. Respondents thought better of MRE than fish-farming but remained moderately likely to eat fish produced in MOI. The majority distrusted regulators to control environmental impacts of the technology. The main differences were that respondents in Reggio Calabria anticipated local benefits from MOI industrial activity, and were more likely to accept development by non-local owners than were people on Islay. We interpreted the findings in a conceptual framework that combines theory for SLO with theory for Action Situations, hypothesising that a community's diffuse and perhaps heterogenous opinions might 'crystalise' around an issue during an Action Situation. The hypothesis will be tested when a prototype MOI is deployed near Reggio Calabria in 2021.

1. Introduction

As human populations increase, so does the requirement to meet the need for sustainable energy and food production whilst tackling global challenges such as poverty, inequality and climate change [1–4]. Two industries which have been identified as contributing to solving these complex issues are the Marine Renewable Energy (MRE) and aquaculture sectors [5]. The MRE industry is made up of wind, wave, and tidal electricity generators, with wind technologies currently the most developed. In recent years, the offshore wind sector has experienced high levels of growth, with many countries looking to it as a significant contributor to their energy mixes [6]. In general, public attitudes also support a movement away from fossil fuels for energy production [7,8]. The aquaculture industry has also experienced large levels of growth in the past three decades [9], with annual production overtaking capture fisheries [10].

A consequence of such growth is increasing competition for space in coastal seas. Multi-use of sea-space, it has been argued, can ameliorate some of this competition and reduce industry costs [11–17]. Multi-use ranges from simple sharing of the same marine space to joint activities on board a single installation [18]. An example of the latter type of multi-use is the 'Multifunctional Offshore Installation' (MOI, Fig. 1),

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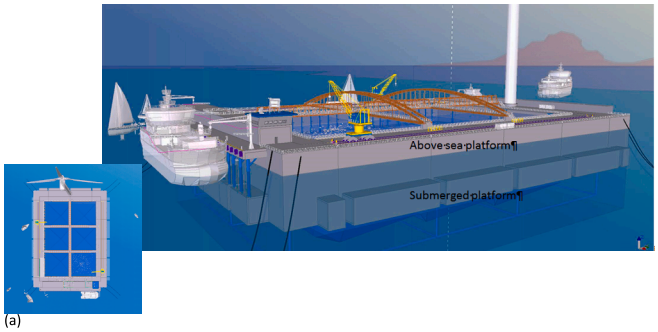

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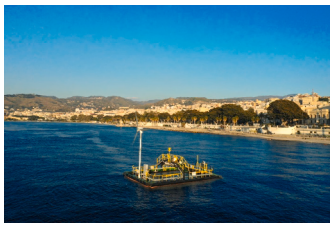

(b)

Fig. 1. Visualisation of the Blue Growth Farm project Multifunctional Offshore Installation (MOI): a) full scale and b) impression of the prototype at the NOEL site. The full-scale MOI will be a floating concrete construction, of dimensions 210 by 162 m, and will be moored at each corner in water depths up to 200 m. It will support a 10 MW wind-turbine, a wave-energy converter (in side-wall), and suspended nets able to hold at least 2000 tonnes of farmed salmon (North Atlantic sites) or sea-bass and sea-bream (Mediterranean sites). The 1/15 scale 'aero-hydro prototype' has a smaller turbine and wave energy converter, and scaled net pens without fish.

designed by the EU H2020 funded project 'The BlueGrowthFarm' (BGF). This MOI is a large floating platform supporting a fish farm alongside renewable energy generation from wind and waves. Our research question concerns the societal challenges to the deployment of such a MOI, and, more generally, what determines the acceptance and use of new technology [19].

Some of these challenges to MOI deployment are formal and exist at the policy level [12,20]. Other challenges are informal and concern local acceptance of a new activity, such acceptance theorised here as Social Licence to Operate (SLO). Our research objectives for the work described in this paper related to SLO and were to determine local community opinions about hypothetical deployment of MOI at two realistic coastal sites, and to assemble a stakeholder group at one of these sites. A growing body of research has explored the perspectives of stakeholders on multi-use in general and shared facilities in particular [16,21], and public attitudes to the separate activities of MRE [22–26] and fish farming [27–31] are well understood. SLO is more than passive acceptance of a development; it is a term developed by the mining industry to refer to active fostering of the growth of host community trust in a development organisation, and of the community's perception of an activity as legitimate, leading to its consent to the activity [32,33]. Its application to fish-farming [34,35] is new, and, with the exception of [36] (which does not use the SLO label), its use with MRE appears scant. Thus, research was needed to explore conditions for the development of SLO for MOI and to provide commercial developers with guidance in order to reduce investment risk from the societal challenges to MOI. In the next section we provide the theoretical framework and strategy for this research.

2. Theoretical framework and research strategy

Sociotechnical change has been theorized in a number of ways [19], each using terms with different shades of meaning. Here we focus on the social dynamics that determine whether a new technology, in particular that externally generated and embodied in the large structure of a MOI, will be able to take root and flourish in a specific locality and host community. We combine the concepts of Social Licence to Operate (SLO) and Action Situations to conceptualise these dynamics (Fig. 2). Table 1 defines key terms as used in the present article.

The Institutional Analysis and Development (IAD) Framework of Ostrom and McGinnis [37,48,49] defines an Action Situation as one *"in which individuals (acting on their own or as agents of organisations) observe information, select actions, engage in pattern of interaction, and realise outcomes from their interaction."* Adapting one part of the SPICOSA project's Systems Approach Framework [50–52], we place an *issue* at the centre of an Action Situation and resolution of that issue as the completion of the Situation. In the present case the issues concern the deployment of MOI, which will take place within jurisdictions that are multi-level/ multi-scalar (i.e., EU laws, national laws, local enforcement regimes and local opinion), and multi-sectoral (i.e. varying policy and planning regimes, marine industries, and stakeholders). This article focusses on situations at the operational level of analysis or arena of choice [37], which is the lowest level in the IAD hierarchy.

Although the terms 'Social Licence to Operate' and 'social acceptability' have been seen as similar [35,46,45], we distinguish them (Table 1) as, respectively, active and passive features. Social Licence to Operate (SLO) is an on-going relationship between a host community and a development organisation, where the development organisation is held to certain standards set by the community, in exchange for their acceptance or support of the organisation or activity; it results from the growth of community trust in an organisation, the community's perception of an activity as legitimate, and its consent to the activity [32,35]. This is a sociological view which maps to the 'community characteristics' component of the IAD/SES framework; also relevant is a psychological perspective on the external factors and personal psychodynamics that lead individuals to a general opinion about an industry and a specific opinion about its development locally [53]. We expect some people to have pre-existing opinions garnered from experience, their networks, or the media, while other people might have an unformed part of their worldview that could crystalise to an opinion in reaction to a suitable stimulus (such as a realistic proposal to introduce a MOI).

In contrast to an Action Situation, which is finite, SLO is an ongoing characteristic of a community (with respect to a developer and activity), albeit something that a developer can cultivate. SLO is an important part of the context for two kinds of operational Action Situations: those involving an informal collective decision for or against a specific local development; and those involving a formal, legally defined process

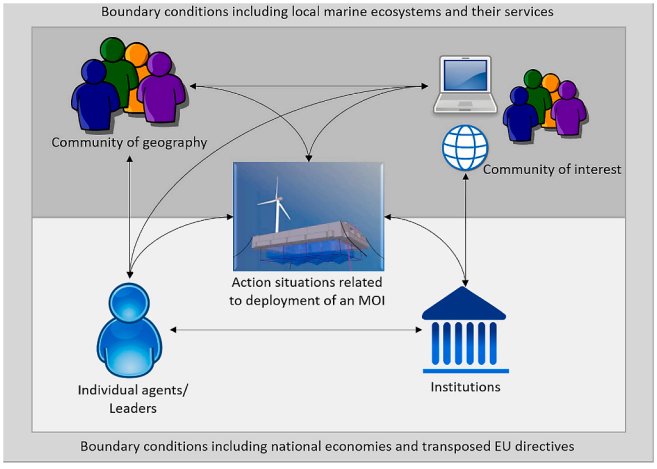

Fig. 2. Conceptual diagram for an operational-level Action Situation in which the issue is the deployment of an MOI.

Table 1
Definitions, as used in the context of the study described in this article.

ACTION SITUATION	a finite collective and communicative process, centering on an Issue, and "in which individuals (acting on their own or as agents of organisations) observe information, select actions, engage in pattern of interaction, and realise outcomes from their interaction" [37]. Outcomes may be physical actions, communicative signals, or new/revised institutions/norms/plans.
COMMUNITY	a group of people with shared norms forming a bounded communicative network or system that reproduces itself through its members' behaviours [38] and which contributes to their identity [39]; community properties may be described in terms of social capital(s) [40–42]; typology includes *communities of place or geography* and *communities of interest or choice* [43,44].
MOI	MULTI-FUNCTIONAL OFFSHORE INSTALLATION (this paper) also called Multi-Use platforms at Sea (MUPS) [13].
MULTI-USE	intentional joint use of resources in close geographic proximity [18] which can range from sharing maritime space to sharing infrastructure and activities.
OPERATIONAL LEVEL	the level of POLYCENTRIC GOVERNANCE at which practical decisions are taken and implemented [37] under constraints resulting from higher-level decisions.
POLICY	a set of rules, norms and strategies that empower or constrain behaviour at a given level of governance [37], typically the outcome of higher-level ACTION SITUATIONS; for example, planning laws and codes that constrain operational decisions to licence deployment of a MOI.
POLYCENTRIC GOVERNANCE	A system of governance with multiple levels (e.g. national, local) and multiple agencies [37].
SOCIAL ACCEPTANCE	(of an activity, organisation or technology) has been seen as roughly equivalent to SLO, [35,45,46] but we use it here as a more general term for a societal state in which a technology or activity is seen as normal (even if a local application may be opposed [47]).
SLO	SOCIAL LICENCE 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 [32,35].
STAKEHOLDER	A person or organisation having a recognised legitimate interest in the outcomes of an ACTION SITUATION, i.e. is admitted to the situation under its Boundary and Position rules [37].

leading to the granting or withholding of development permissions. SLO might directly influence formal processes or might informally influence a development through campaigns and negative media and market methods such as unwillingness to work for the developer or consume its products. We hypothesize, influenced by Wildavsky's cultural theory of preference formation [54], that a community's diffuse and perhaps heterogenous opinions might 'crystalise' around an issue such as the proposal for a MOI in their waters. This leads to the idea that a community's granting of consent can be understood as the outcome of an Action Situation, and that such crystallisation can be influenced by the suitable engagement of developer with community, following assessment of context and societal concerns.

Thus, our strategy for the work reported here was to investigate the context for MOI deployment at two sites in European waters where there is a realistic potential for such deployment, plus a preliminary engagement with local people and authorities at the one of these sites where a small-scale MOI prototype was to be deployed. Table 2 lists information needed to characterise the 'potential Action Situation' and to inform the preparatory phase of SLO cultivation.

Table 2
Information needed to contextualize an Action Situation and for the initial stages of gaining SLO. Quoted definitions from [37].

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*
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. Case study contexts

3.1. Choice of site

The BGF project had identified three sites that would be representative of the climatic condition encountered during MOI deployment and operation. The site selection was based on data for sea state, wind conditions, and water temperatures, in order to provide an optimal farming environment and at the same time maximize the wind/wave energy exploitation. Sites were identified in the Mediterranean near Marseille in France, the North Atlantic near Port Ellen on the island of Islay in Western Scotland, and in the sub-tropic North Atlantic near Arinaga in Gran Canaria [55].

Additionally, although no full-scale MOI could be built within the budget of our research project, a 1/15 scale 'aero-hydro prototype' (Fig. 1b), with wind turbine, wave energy converter and scaled net-pens, was in construction for deployment without fish in March 2021 in the authorised sea area of the Mediterranean University (Natural Laboratory of Maritime Engineering - NOEL) concession close to the shore of Reggio Calabria.

Based on this, we chose the Italian city of Reggio Calabria and the Scottish island of Islay as sociological study sites, providing urban–rural and northern-southern-European comparisons, plus an incipient Action Situation in the Italian case. The contextual information required to characterise each site according to Table 2, was obtained by document analysis [56]. Table 3 compares governance arrangements and Fig. 3 shows the positions of the sites.

Table 3
Governance arrangements at the two sites [56].

	Islay	Reggio Calabria
National Polity	**United Kingdom**; the devolved administration and parliament of Scotland has responsibilities for MRE, marine planning and environment	**Italy**, divided into regions (e.g. Calabria) which can make laws for planning and environment; the Italian state is responsible for marine planning and energy.
Local polity	The 'unitary (local) authority' (LA) of Argyll and Bute, with elected Council, provides services and Town & Country (policy and operational) planning; Islay has an elected Community Council which is consulted on planning issues.	Provinces, and within these, municipalities, administer planning laws. The 'metropolitan city of Reggio Calabria' has provincial powers, and includes the municipality of Reggio Calabria. The Port of Reggio Calabria is a separate entity, under the authority of the Italian Coast Guard.
Marine Planning	Scotland National Marine Plan (SNMP) but no local marine plan for this area	No National Marine Plan; substituted inefficiently by coastal marine plans, managed by municipalities
MRE licensing	SNMP designates zones for MRE; Crown Estate Scotland auctions leases for new developments, which must be consented by Scottish public agencies	Draft Integrated National Energy and Climate Plan sets growth targets for offshore wind generation, but few wind-farms have so far been consented.
Fish-farm licensing	Operational planning permission for farms granted by LA subject to consultation with (Scottish) public agencies	Municipalities authorise aquacultural development within 1 km from the coast; development further offshore must be authorised nationally; other public bodies must be consulted

3.2. Reggio Calabria – Italy

The municipality of Reggio Calabria is a coastal city off the south-western tip of Italy, nestled in between rugged hills and the Straits of Messina, overlooking the island of Sicily. The 2020 census determined that the population of the city is 180,000 [57]. The metropolitan city of Reggio Calabria is becoming an increasingly popular Mediterranean destination for both domestic and extra-national tourism [58]. However, it also relies on agriculture, infrastructural industries (railways, mechanics, construction), some chemical production and it is host to the largest container port in the Mediterranean (Gioia Tauro). Unemployment in the metropolitan city is relatively high at 18.9% overall and is particularly acute among younger demographics [57]. According to Panuccio et al [59], the economic development of the metropolitan city can no longer rely on land expansion, as there are few areas left to build on and many built areas are in a state of decline. Instead, the authors advised a regeneration approach with a focus on the sustainable use of natural resources, social cohesion and stakeholder collaboration and engagement.

Central to research and development in the area, is the Mediterranean University of Reggio Calabria and its associated Natural Ocean Engineering Laboratory (NOEL). The sea state in the Straits of Messina provides small-scale models of ocean storms, and NOEL makes use of this to operate a test facility for ocean energy technologies in waters that are part of the Port of Reggio Calabria and in front of the city's main beach.

Aquaculture in Italy is dominated by the cultivation of mussels and freshwater fish, together with a limited number of seawater farms for sea-bass and sea-bream [60]. There is currently no aquaculture in the coastal waters of Reggio Calabria. Nor is there MREG except for project-

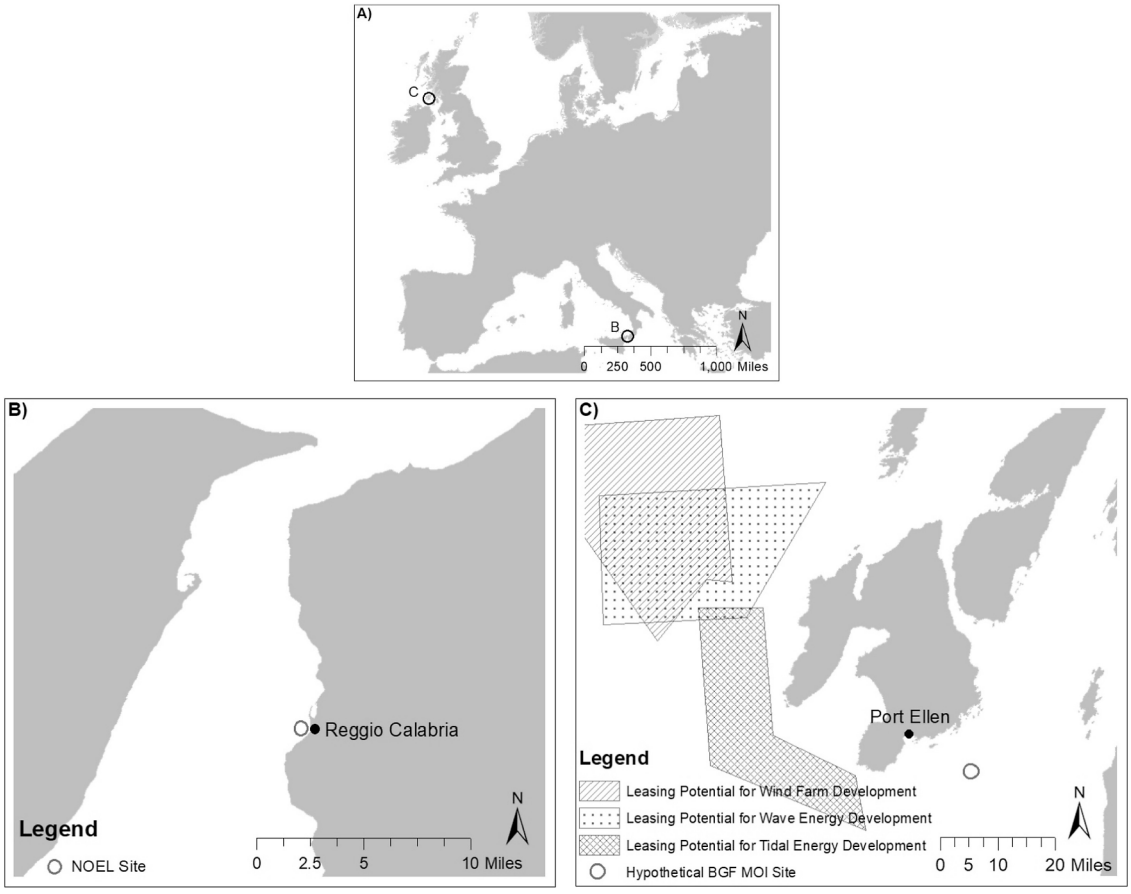

Fig. 3. Composed of a) a map of Europe, indicating study sites and b) and c) local maps of the case study sites, with c) showing areas that have been nationally identified as potential leasing sites for wind, wave, and tidal developments.

based testing at the NOEL facility. The main uses for the sea space adjacent to Reggio Calabria are small-scale fisheries and shipping.

3.3. Islay – Scotland

Islay, which is part of the Argyll & Bute local authority area, is Scotland's fifth largest island. Its population of 3,228 residents (2011 census), more than half of which live in the villages of Bowmore and Port Ellen, is considered as below the threshold for long-term sustainability [61]. Agriculture constitutes the largest single economic activity on the island [62]. However, the importance of Islay's whisky industry is reflected in the relatively high proportion of people employed in the 'manufacturing' sector, 14% [63]. Islay also relies on the fisheries and tourism industries as an important source of income [62]. In Argyll & Bute as a whole, unemployment was<2% (in 2018), but average pay was only 85% of the Scottish mean.

Currently, there is a single aquaculture site in operation off the north of Islay, an oyster shellfishery, and no plans to develop more farms [64,65]. In this, Islay differs from most of the west and north of Scotland, where salmon farms are common features. A proposal in 2011 for two salmon farms was withdrawn following community consultation and opposition from the commercial and recreational fishing sectors [66]. In terms of marine renewables, the waters off the west coast of the island are within the Scottish National Marine Plan development zones for offshore wind, wave, and tidal energy [67,68]. Leases have already been granted to two small-scale wave and tidal developments close to the island, these being the Land Installed Marine Power Energy Transmitter (LIMPET) and the Sound of Islay Demonstration Tidal Array [69,70], with a third, the West Islay Tidal Farm, currently under development [71,72]. The potential MOI site in Fig. 3 was chosen to provide moderate shelter for the fish farm and is outside the currently designated MRE lease areas.

3.4. Comparison of sites

Both Italy and the UK are complex polycentric polities with different regulatory regimes for MRE and fish-farming. Both countries are strongly globalised market economies, and in these circumstances, it is likely that the large capital investments required for MOI construction will come from non-local finance, as is currently the predominant situation in Scotland, where ultimate owners of fish-farms are to be found in Norway and Canada [73,74]. Islay and Reggio Calabria are alike in that they are distant from markets, central government, and power centres, and for much of their recorded histories have been included in different polities from those of which they are now part [75,76]. In addition to the long-term cultural effects of repeated external interventions, what the communities in Islay and Reggio Calabria have in common are maritime traditions and concern about emigration by young people seeking education and work in metropolitan centres. What distinguishes them is population density, language, culture, and settlement tradition, plus, in Islay, prior exposure to MRE and successful opposition to a fish-farming proposal.

4. Methods

We used a mixed methods approach [77] that involved collection of quantitative data through use of survey questionnaires in both case studies, and collection of contextually rich qualitative data from a facilitated workshop in Reggio Calabria. The workshop was also intended to aid the gaining of SLO by setting up a semi-permanent Stakeholder Reference Group. The workshop and survey in Reggio Calabria were conducted in Italian before being translated into English for analysis and the survey on Islay was conducted in English.

4.1. Survey

Questionnaires are reproduced in the Supplemental Material and included some questions about demographics, together with Likert-type items to gauge strength of opinion. 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 such as those of Fig. 1a; and 4) opinions about deployment, ownership and regulation of MOI. 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 to think about local deployment. In order to test whether opinions on MRE, fish-farming, and their combination, influenced purchasing decisions, Section 3 included a question on willingness to eat fish farmed in an MOI. Section 4 included a question on MOI ownership and one on trust in public regulation, in order to discover some of the factors behind potential support of, or opposition to, MOI deployment. Although the BGF MOI includes energy generation from waves, we identified MRE with generation from wind, because the wind turbine will be a highly visible part of the MOI and reactions to turbine visibility are an important planning constraint [78,79]. Thus we refer to OWE (Offshore Wind Energy) in analysing responses.

The survey in Reggio Calabria was conducted on the sea front on the 19th September 2019, taking advantage of the city's Patronal Feast, a public holiday during which many citizens and visitors were promenading past a staffed gazebo advertising the BGF project and the survey, and close to the NOEL concession where the small-scale prototype would be sited in 2021 A voucher for an ice-cream was offered to each respondent. BGF personnel read the questions to each participant and noted their responses. The survey on Islay was carried out by interviewing passers-by in the streets of the three main settlements from 18th-20th October 2019. The questions had been loaded onto a tablet computer, and participants given the choice of being talked through the items or themselves reading questions and inputting responses. The survey was also made available online for five weeks from the 9th October – 16th November 2019 and was shared across local forums through social media and email. The online survey was required to supplement the street surveys as the population base of Islay is dispersed, particularly in comparison to Reggio Calabria.

4.2. Survey analysis

The Likert-type items in the survey had four options for the participants to choose: 'positive', 'mostly positive', 'mostly negative', and 'negative' or, 'very likely', 'likely', 'unlikely', 'very unlikely'. The responses were categorised into codes from one to four following the procedures set out in [80]. 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 statistical software package [81]. 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 [82]. 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.

4.3. Facilitated workshop

The BGF project aimed to set up a 'Stakeholder Reference Group' in Reggio Calabria, as part of the process of getting SLO for the prototype deployment, to research this process, and to get public feedback on the design and feasibility of the BGF MOI. Three workshops were planned, for 2019, 2020 and 2021, the first of these to involve only local participants, the second and third to include representatives of national organisations of sea-users. Following local advertising of the project through print, broadcast and internet media, and an invitation to members of the public to register to attend, the first workshop was held in the offices of the Port Authority of Reggio Calabria on Wednesday September 11, 2019, and was attended by 55 persons. Of these, 28 were local persons (including students at UNIRC) who were interested in the concept of MOI or their socio-economic and environmental impact. It was this group who contributed the opinions we report here, and who are referred to as participants. The others present included representatives of local authorities who opened and closed the proceedings, members of the BGF project, and workshop facilitators.

After an introduction session, in which the BGF platform was described, each participant was provided with six post-it notes, and asked to write down three positive and three negative aspects of the BGF MOI from their perspective. In a ranking exercise, the participants placed these on a board which was split into positive and negative sections, each containing three sub-sections labelled one to three, where one represented a high priority comment and three represented a lower priority comment. This offered the participants the opportunity to voice and rank their own opinions, before they were split into three breakout groups to identify and discuss the social challenges and opportunities that the BGF MOI might present for Reggio Calabria. Each breakout group was provided with a facilitator, and elected a rapporteur to present in concluding plenary session a verbal summary, later transcribed. The qualitative data thus collected, from the ranking exercise and the break-out groups, were analysed in MS Excel, to identify the most prevalent positive and negative themes, following the thematic analysis protocol set out in [83].

5. Results

This section presents the main findings from analysis of the quantitative data before providing a short overview of the qualitative workshop data. SM tables will be found in the Supplemental Material. It should be kept in mind that survey and workshop participants were self-selected; we have used demographic data to explore the extent to which the participants are representative of local communities.

5.1. Opinion survey findings

Table 4 provides information on survey participants. Of the 108 people responding in Reggio Calabria, 76% were locals, there was an equal balance of respondents between the sexes, and there were more responses in the lower age groups (44%), explicable by the relatively large number of university students (37%). Of the 126 respondents on Islay, 56% were locals, there was an equal balance of respondents between the sexes, and there was a slight skew in the distribution of ages with 52% above 50 years old. In contrast to the Italian sample, there were very few young people aged 15 – 24, reflecting that many in this age range leave the island for work or continuing education [84].

Table 4
Information on survey participants.

	maximum number of respondents	108	127
	number responding on-line		25
		Reggio Calabria	**Islay**
Q5.1	Where do you live? [implying primary habitation]		
	locally (province or county)	77%	56%
	nationally (Italy or Scotland) but outside local area	12%	24%
	internationally	11%	20%
Q5.3	How would you identify yourself?		
	female	51%	52%
	male	48%	47%
Q5.4	Which range includes your age?		
	15–24	44%	6%
	25–49	25%	42%
	50–64	19%	26%
	65–79	11%	23%
	80+	0	3%

Table 5 summarises the main questions asked during the interviews, and the percentage responses obtained, with, in most cases the 'positive' and 'mostly positive' categories combined. The pattern of response was roughly similar in both locations, despite their geographical separation and socio-economic differences.

The results of the Wilcoxon analysis of Likert-scale opinions are shown in table SM1 (binary comparisons) and SM2 (three-way comparisons) and summarised in Table 6. The binary comparisons show that

Table 5
Summary of opinion questions and responses. 'Positive' includes 'somewhat positive'.

	maximum number of respondents	108	127
		Reggio Calabria positive	**Islay** positive
Q1.1.	What is your opinion of wind turbines that are at sea and used for electricity generation?	76%	88%
Q1.2	What is your response to a proposal to install wind turbines in the sea [near here]	63%	79%
Q2.1	What is your opinion of the farming of fish in the sea?	63%	48%
Q2.2	What would your response be, to a proposal to place a fish farm in the sea [near here]?	57%	46%
Q3.3	[Having been shown a picture] What is your first reaction to [MOI]?	85%	68%
Q3.4	How likely are you to eat fish produced in one of these installations?	65%	56%
Q4.1	What would be your response to a hypothetical proposal to place a… MOI in the sea near [here]?	70%	61%
Q4.3	… how likely are you to trust public officials to regulate the environmental impacts of this MOI?	37%	39%
Q4.2	Suppose that this hypothetical MOI was going to be installed near [here]. Would you prefer that it was owned ..		
	locally	43%	76%
	by a large national company	30%	21%
	by an international company	27%	3%

Table 6
important comparative findings from the survey, 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 Wilcoxon tests (combined where multiple comparisons), which examined differences in individuals' responses to each question in the pair. 'Global' contrasts with 'local', the former labelling the general idea of particular technologies, or their distant implementation, the latter referring to concrete implementation in waters near to the places where the survey was carried out.

Survey questions compared	Comparison as question	Finding (as answer to comparison question)
Binary comparisons (details in table SM1)		
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.
Q1.1 and Q1.2	Did respondents think less well of local OWE than of global OWE?	YES, respondents expressed less strongly positive opinions of potential OWE in their locality than of OWE in principle.
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
Q1.2 and Q2.2	Did respondents think less well of local FF than of local OWE?	MIXED: IL participants' responses to potential local FF significantly more negative than to potential local OWE; no significant differences in the case of RC participants' responses
Three-way comparisons (details in table SM2)		
Q1.2, Q2,2, Q4.1	Were respondents' opinions about about potential local deployments of MOI intermediate between those for OWE and those for FF?	MIXED: IL participants' responses for local MOI were significantly less positive than those for local OWE but significantly more positive than those for local FF; no significant differences in the case of RC participants' responses
Q1.1/2, Q2.1/2, Q3.4	Were respondents' opinions about eating farmed fish improved by associating FF with OWE in MOI?	NO: respondents' opinions about eating fish from MOI were significantly less positive than opinions about OWE and close to opinions about FF, whether local or global

- respondents at both sites tended to have a more positive general opinion about devices to harness offshore wind energy (OWE) than about fish farming (FF);
- respondents in both sites tended to have a more negative opinion about the possibility of local OWE capture devices than they did about these devices in the abstract – that is, a proportion of people liked the idea of the technology but did not want them locally;
- respondents in both sites did not distinguish, in their opinions, between the abstract idea of fish-farming and its local implementation;
- respondents in Islay (but not in Reggio Calabria) disliked local FF more than local OWE.

Before these surveys, we hypothesised that opinions about MOI would be somewhere between those for FF and for OWE. The three-way comparisons investigated this. In Islay, opinion about MOI was indeed intermediate, although willingness to eat fish from MOI was similar to opinion about FF in general: i.e., not improved by association with OWE in the BGF platform. In Reggio Calabria, opinions about MOI tended to be more positive than that for either OWE or FF, but willingness to eat MOI fish was not improved by the association with OWE.

There was some indication that responses were associated with demographics (Table SM3), although in most cases numbers in some categories were too low for significant conclusions to be drawn using chi-square contingency tests. However, in Reggio Calabria, Italian nationals were correlated with more positive views of global OWE than were non-nationals, and in Islay, Scots were correlated with more positive views of global FF and more negative views of local FF, than non-nationals.

Finally, one of the most striking outcomes of the surveys were the frequent responses suggesting distrust in the capacity of public officials to regulate environmental impacts of MOI (Table 5, Q4.3). In Italy, this lack of trust was shown independent of place of residence; in Islay, people living locally were significantly less trustful than non-locals (Table SM4). It may be noted (Table 5, Q4.2) that people questioned in Islay had a strong preference for local ownership of the hypothetical MOI; opinion was more divided in Reggio Calabria.

5.2. Facilitated workshop results

The individual ranking exercise during the Reggio Calabria workshop resulted in 158 comments, of which we report only on those shared by three or more participants out of the 28 who took part in the exercise. The main positive responses were related to stewardship of the marine environment and the potential socio-economic benefits of the MOI. For example, some participants felt that local deployment of a MOI would *'raise awareness'* about the marine environment, specifically about *'respecting and taking care'* of it. Others wrote that the MOI could bring *'progress and innovation for the city of Reggio Calabria'* and act as an *'incentive'* for younger generations to *'stay and work in Reggio Calabria'*, using their *'competencies and skills'* locally. Furthermore, there would be a *'strong contribution to the cultural and scientific growth of the local community'*. These views were carried into the breakout groups, where the positive aspects discussed related to job provision in the local area, which participants hoped would result in younger people choosing to stay. This was linked with the potential for a MOI to increase confidence in the local economy, but also to the ingenuity and skills that local people could provide. The *prestige* of hosting such a novel device, that the local University helped design and test, contributed to the discussions about positive aspects of the MOI.

The main negative responses during the ranking exercise concerned social perceptions about the platform. For example, participants felt it may be difficult to *'persuade people about the quality of fish produced'* from the platform, and high levels of *'scepticism'* and *'disapproval'* from *'local communities'* and *'fishermen'* were anticipated. Responders thought that many in Reggio Calabria had *'scarce information'* about renewable energy and aquaculture developments. It was also often mentioned that a platform would negatively impact *'navigation'* and *'maritime traffic'*. Likewise, when deliberating in groups over the challenges associated with an MOI, negative interactions with other marine users, including fisheries, was debated at length. Management of waste from fish farming, disease, and fouling was also specified as the main reason for scepticism about the platform. Participants felt that the way to reduce concerns and raise the social acceptability of the platform, would be to educate and inform local communities on renewable and aquaculture industries to reduce the likelihood of misinformation about their environmental impact and how they are regulated.

6. Discussion

Through our surveys and workshop, we have attempted to understand attitudes towards a potential MOI in two case study sites: one where a prototype of this technology will be tested (Reggio Calabria) and one where there are the correct biophysical conditions for a full-scale deployment (Islay). Our results contribute to the expanding literature base on stakeholder perspectives on MOI/MUPS and multi-use of marine space [13,15,20] and to the knowledge needed for MOI

developers to acquire local social licence to operate. We consider these findings in the context of our theoretical framework.

6.1. Communities and stakeholders

Although SLO is defined in terms of communities, we did not explicitly check that survey and workshop participants saw themselves as members of an Islay community or a Reggio Calabria community. However, in the case of Islay, there are many current initiatives labelled as (and on behalf of) 'community'. An example is a Community Development Plan for the southern part of the island [85], which reported that three-quarters of those responding to a survey felt part of the local community. In the case of Reggio Calabria, many participants in our workshop identified and spoke of the city and its people as a unit: for example, the benefits of local MOI deployment were considered to include improved *'prestige for the city*' and *'encouragement for future generations to invest their own intellectual and working resources on the local area*'. Thus, we assume, with moderate confidence, that we were dealing with communities of place at both study sites, although the strength and membership of these communities needs better investigation.

It is important, in our conceptual framework, to distinguish a 'stakeholder' in the strict sense from a member of a community relevant to SLO. In this strict sense (Table 1), a stakeholder is either a person or an organisation that has a legitimate interest in the outcomes of an Action Situation and thus has a claim for their voice to be heard and their claim weighted and perhaps accommodated during an Action Situation. The Stakeholder Reference Group (SRG) established by the BGF project in Reggio Calabria in 2019 was not part of a formal consultation process, because the formal requirements for permissions to deploy the BGF prototype were satisfied, independently of any public consultations, by applications to the Port Authority. Instead, the views of SRG members provided us with insights into community attitudes to MOI, and thus we here refer to its members as 'workshop participants' rather than as 'stakeholders'. In that the participants were self-selected, with UNIRC students being over-represented compared with the population of Reggio Calabria, their collective views might have differed from those of the community. While those views did not contradict the survey data, and helped provide some qualitative depth to its interpretation, young people (aged 15–24) were also proportionately over-represented in the survey (44% compared with 10% of the Italian population [86].

6.2. Survey opinions on offshore wind energy and fish farming

Studies examining perceptions on wind energy (offshore and onshore) explain these perceptions in a variety of ways [25,53,87,88]. Many of the factors referenced in these papers – such as the people–-place-process categorization in [25] – map to the Action Situation characteristics listed in Table 2. Additionally, whereas it has been found that people are often in favour of renewable energy technologies in the abstract [89], opinions about local implementations are diverse and dependent on variables such as trust in the company, procedural fairness in decision-making, and community benefits [90].

This abstract versus local difference in opinions is reflected in our results, as survey participants were less comfortable with the idea of OWE close to their homes, a drop of 13% for Reggio Calabria and 9% for Islay, although they both remained positive overall (63% for Reggio Calabria and 79% for Islay). The difference in positive responses between the two case studies, we postulate, is built on participants exposure to wind turbine technologies and the uncertainties that lack of exposure may introduce into perceptions. In Italy as a whole, the installed onshore wind capacity is 9.7GW but there are no operational offshore wind farms [91], whereas Scotland has 7.3GW of onshore and 1GW of offshore installed capacity and a further 4.4GW for offshore consented [92]. Further, Argyll and Bute (of which Islay is part) has 346 MW of installed capacity onshore [93]. Our suggestion is based on studies that show that people's opinions of OWE and onshore wind change as developments progress, with acceptance likely to increase once the turbines are installed [87]. Further, a recently published study on onshore wind in the U.S. found that the proportion of negative attitudes towards the technology is higher among those who live in an area prior to a wind development, than those who move into an area with established turbines [53]. Hence, our idea is that those who live on Islay may have a more certain understanding of what the technology means to their livelihoods and relationships with place, whereas for participants in Reggio Calabria the personal and social meaning of this technology may remain unclear.

In contrast to OWE, there was no significant difference between opinions of local and global fish farms in either case studies. However, there were fewer positive opinions about fish-farming than OWE overall, in both case studies. It is established that mass media plays a role in public opinion and over the past decade, the media narrative around fish farming in more economically developed nations in particular, has been framed with risk [27,94]. In both Italy and Scotland, there are several ongoing campaigns against fish farming, often based on concern for environment and fish welfare [34,95]. The media has also reported on farms in both Scotland and Italy where fish welfare standards were not adhered to (see for example, *The Guardian* [96,97]). It is likely that this narrative is reflected in the responses that we saw in both case studies. However, the Islay survey reported 52% negative opinions of FF, whereas in Reggio Calabria, respondents had an overall positive opinion of FF (63%). Positive opinions dropped to 57% for Reggio Calabria and 46% for Islay when participants were asked about FF in their local area. The difference between the two case studies can perhaps be explained through sociocultural context and seafood consumption patterns.

The average per capital consumption of seafood across EU member states is around 26 kg of per annum (averaged from 2005 to 2014). Southern states (including Italy) consume 37% more and Western states (including Scotland) consume 23% less than the EU average. Over the same time period, the UK has seen no change in its volume of consumption per capita, whereas Italy has seen an increase [98]. Qualitative comments noted during the questionnaires reflected this difference. In Reggio Calabria one participant remarked that they would buy fish, wherever it came from, due to its importance in their cooking. Contrarily, in Islay some participants said they would not buy fish, wherever it came from as it is not part of their diet. However, commercial and sports fishing is important to Islay, as evident in the 2011 opposition to a proposed fish farm.

6.3. Survey and workshop opinions on MOI

Our survey showed that combining the OWE and FF technologies on an MOI was seen as positive in both case studies, both in the abstract, and from a local deployment perspective. However, Reggio Calabria participants preferred an MOI over both OWE and FF (considered in the abstract) whereas Islay responses fell in between OWE and FF (in the abstract). In both cases, opinions on eating fish from an MOI were similar to opinions about FF, i.e., they did not improve by association with OWE. This could imply that fish production is not considered as better or improved simply by being associated with renewable energy generation or a more sustainable production system. It reflects a wider nuance in the social acceptability of different food systems, where scientific and engineering solutions are not the only criteria that people and communities use to assess their benefits or costs [28]. For example, in our workshop with stakeholders in Reggio Calabria, opportunities that participants associated with an MOI were largely related to job provision, a perceived solution to fixing out-migration of younger generations from the local area. More uniquely, an MOI in the local area was linked with '*prestige*' of hosting such a novel device and *'cultural and scientific growth of the local community*' as the local University would have helped in the design and testing of such a facility. Devine-Wright recorded similar feelings towards a tidal energy site in Northern Ireland [24], where the novel nature of the technology promoted

feelings of esteem for the local area, by participants. It should be noted that in our case, none of these opinions are directly related to sustainable food production systems, they are related to the needs of the community and 'fit' within community and place. Critically, these community and place-based perspectives are not confined to positive opinions, they are also associated with scepticism of the technology. A caveat is that workshop and survey participants were self-selected, and we need to explore further the extent to which the expressed opinions are representative of communities in the two locations.

Our workshop results showed that lack of information and potential conflicts with existing marine operations were aspects of an MOI that will require significant educational and information campaigns within the community to inform proper debate on the pros and cons of hosting the technology. Participants felt that there was currently insufficient information to make an informed decision on the viability of the MOI for their area. They were also cynical about management and regulation of the fish farm on the MOI by local authorities, which is shown in our survey results both in Reggio Calabria and Islay. This demonstrates that even though there may be broadly positive perspectives on an MOI in general, social terms and conditions apply at a local scale.

In the Islay survey, local trust in regulators was less than that by non–locals. This may link to the prior history of opposition to fish farming on Islay. In Reggio Calabria, there was no significant pattern, but this may be related to the smaller sample size of non-locals. In both places, local respondents had similarly low trust in public officials to regulate the environmental impacts of an MOI (37% Reggio Calabria and 39% Islay). In a similar vein, local ownership of the potential MOI was preferred to national or international ownership in both cases. However, there were variations in the extent of these preferences: Islay respondents were heavily in favour of local ownership (76%), but those in Reggio Calabria were more mixed (43% local, 30% national and 27% international). This shows that although there may be broad categorisations of what factors will play into public perspectives on an MOI, the details differ according to context.

6.4. Action Situations and SLO for MOI deployment

According to our theoretical framework, a proposal to deploy a full-scale MOI would initiate a concrete Action Situation in which the narrow focus would be the developers' application for the planning and environmental permissions required by relevant law, while the broader issue would concern the development of SLO for deployment of the technology. As outlined in the context of both case studies, the acquisition of permissions for and MOI must follow formal procedures (understood by the IAF as the 'rules in use': [37]) that typically involves scrutiny of documents to ensure compliance with planning and environmental regulation, together with consultation of designated stakeholders. However, existence of SLO for an MOI within the local community may influence such an Action Situation if the community is represented by official stakeholders, such as elected members of municipal authorities, or through public support or objection where formal procedures allow this to be considered. What we have aimed to do in this study, is to explore the opinion prior to any critical event that might trigger the crystallisation of community view on an MOI, highlighting conditions which may facilitate or hinder development of SLO. The SLO literature suggests that the factors that could play into the informal aspects of an Action Situation for the deployment for a full-scale MOI and the likelihood of garnering SLO for its deployment and operation include:

- *Community attributes*: Prior experience of both fish farming and offshore wind energy by the host community are likely to inform opinions, as seems to be evident in the case of Islay. Understanding what these perceptions are before applying for a deployment of an MOI may ease the way for better conversations about the merits and weaknesses of the technology and what measures are being taken to mitigate against concerns. Our study suggests that mechanisms that will reduce negativity towards MOIs include jobs that 'fit' within the context of the local area and contribute to culture, sense of identity, and the local market, as is evident in Reggio Calabria.
- *Actors and local governance system*: Perceptions of trust in local regulators to manage the environmental impacts of an MOI were low in both case studies. Although, our data does not include detail on the reasons for this, previous work has shown that trust in regulators is a key component of SLO [99] and further, that environmental concerns are a key driver for objections to fish farming [34]. More work is required to understand why reported trust in regulators is so low, and whether it is associated with falling trust in public authorities in general.
- *Developer characteristics and access/use rights*: Levels of information provision and engagement by the developer with local communities, and other users of the marine environment, may determine opinions on the deployment of an MOI and whether it receives SLO. As MOIs are a new technology and not widely recognised by the public or marine users, work is required to ensure that local people are informed about both the positive and negative aspects of the technology. Our qualitative data suggests that this information should include the technical details of an MOI, where and how much space they may take in the marine environment, the economic feasibility, and the likelihood of displacement of other uses.

7. Conclusion

The future of MOI technology depends on: a) sound engineering; b) economic viability; c) social acceptance of the end-products of farmed fish and renewables-derived electricity; and critically, d) Action Situations that will result in successfully garnering formal permissions for deployment of the technology at a site scale. There has been over a decade of research showing that consumer and public perceptions of aquaculture in Europe are tightly balanced between perceived benefits and risks. Consumers, the public, and local communities, are not convinced about the merits of a food product based solely on the scientific arguments for or against it. Likewise, the increasingly robust catalogue of research on perceptions of renewable technologies show that preferences are strongly linked to social and personal context, and benefits that may come with a development. Thus, combining these two technologies on board an MOI presents a unique social as well as technological challenge.

We have begun to address the social aspects of this challenge by studying community opinion in two European locations, the Scottish island of Islay and the Italian city of Reggio Calabria, that provide potential sites for MOI deployment. Although there were some differences in detail, and we have mentioned some caveats relating to self-selection of stakeholders and survey respondents, the broad pattern of our findings was the same in both places. People thought better of OWE than fish-farming, but remained moderately likely to eat fish produced in MOI. The majority distrusted regulators to control environmental impacts. The main differences were that people in Reggio Calabria anticipated benefits from MOI industrial activity in the region, and they were more likely to accept development by non-local owners than were people on Islay.

We have used our qualitative and quantitative data to show some of the factors involved in people's perceptions of OWE, fish farming, and of both combined in MOI: information provision as a basic requirement; community engagement as an expectation; low levels of trust in regulators; and the social and economic context of the area where an MOI may be deployed. These findings are largely consistent with those described in social license and social acceptability literature and more broadly, public perspectives on new energy technologies. Where levels of trust in regulators are low, as in both locations, then processes and procedures used to determine whether a deployment should go ahead, are likely to also be viewed with cynicism. Concerns about 'procedural

fairness' and 'confidence in governance' are known to impact the trust that local communities have in resource development/ exploitation companies and directly impact social license to operate for those activities at a site scale.

Finally, we have expanded the scope of Action Situation theory and attempted to reconcile the discrete outcome of time-limited Action Situations with the more diffuse and ongoing nature of SLO by the hypothesis that a set of community opinions can crystalise to impact SLO when an issue is introduced that sends strong signals through the communicative networks of communities of place or interest. The study described here has been preliminary in that it has taken place before such an issue. It may be that the deployment of the BGF aero-hydro prototype at the NOEL site in Reggio Calabria will cause such crystallisation, which we will be able to observe during a later part of the BGF project.

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Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A. Supplementary material

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