



Deliverable 1 – A guide to the characteristics and measures that are associated with establishing social license to operate for seaweed cultivation in the UK

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Executive summary

1. Background and aims

Across Europe and the USA, seaweed cultivation is being looked to as a source of low-impact food, feed, and chemical production and a mechanism for mitigation of anthropogenic impacts [1], [2]. Seaweed farming has the potential to provide important ecosystem services, such as bioremediation through uptake of excess nutrients, and coastal protection [3]. There is also interest in seaweed farming as an opportunity for supporting sustainable rural and island coastal communities through job-provision and value-chain development [2].

Aquaculture production statistics from the Americas and Europe, show either a decline or a levelling-out of overall aquaculture production since 2015 [4]. This can be attributed to several factors, including policy and licensing limitations, environmental constraints/ concerns, competition with other uses of the space, and social opposition [5], [6]. Recent evidence shows that despite the potential for seaweed aquaculture to form part of sustainable “Blue Economy”, it can still be subject to social opposition [7], [8]. Although the general public are largely supportive of seaweed cultivation in the UK [9], [10], this support is conditional on the industry performing in an acceptable manner. Further, when asked about seaweed cultivation operations in their local area, people show higher levels of scepticism [10]. Preliminary evidence from Scotland suggests that the models of ownership, the types of benefits to local communities, end uses, and the scale of seaweed cultivation, contribute to local-scale perceptions of seaweed farming [7], [10]. Evidence from France, which is the largest cultivator of seaweed in Europe, indicates that local scale social opposition can result in a reduction in number and the scale of the concessions that are granted for seaweed cultivation [7].

These factors combined, show the importance of understanding site-scale industry-community interactions for this sector as it develops in the UK. With the industry currently in a nascent state, there is the opportunity to learn lessons from other aquaculture sectors and identify and implement steps that can be taken to develop positive relationships between seaweed cultivation operators and local communities, communities of interest, and other stakeholders. This will not only benefit the industry as it grows, reducing conflict and the costs of planning and licensing, but will empower the communities that host the activities to negotiate appropriate benefits for their local area.

Social license to operate (SLO) is a framework that can underpin research into factors that foster positive industry-community relations. SLO is described as an on-going relationship between a host community and an industry/business where the industry/ business and their activities are held to certain standards set by the community, in exchange for the trust and support of the community [11]. The specific aim of this study is to explore the characteristics and measures that seaweed cultivation businesses and operators in the UK, could adopt that would result in positive industry-community relationships and SLO. The outcome is to develop accessible and industry-informed guidance on how to foster and improve SLO for cultivation organisations.

This study was conducted on behalf of WWF-UK as part of their programme of research into the potential of seaweed farming to meet the priority responses to the triple challenge: keeping temperature rise below 1.5C, ensuring nutritious food for all, and halting and reversing biodiversity loss [12]. This work contributes to the human and social aspects of the triple challenge, providing guidance on activities that may reduce the likelihood of social opposition to seaweed farming and subsequently, may improve the prospect of successful planning applications in a socially acceptable way.

2. Research programme

This project engaged with a variety of stakeholders across four case studies as well as the seaweed cultivation industry in the UK, collecting perspectives from those conducting operations through to

those who may interact with or be impacted by them. The case studies were chosen to cover areas where there are already small-scale cultivation sites, as well as a “null” case study, in Lowestoft in Suffolk, where there is no history of aquaculture. The other three case studies include a diversity of coastal communities across three UK nations; Dorset in England, Argyll and Bute in Scotland and Pembrokeshire in Wales, to provide a rich representation of the variation in culture, opinions, and uses of coastal and marine resources. The activities in this study were split into four tasks as follows:

Task 1 was to conduct a literature review on SLO, social acceptability, legitimacy, and seaweed cultivation in the UK, EU and USA. This literature review was used as a reference point for characterising strategies for developing social license for seaweed cultivation in the UK and formed the basis of a null case study interview questions and the Q-method¹ study set of statements.

Task 2 was to conduct the three in-depth case studies using a Q-method approach. Q-method is a means to study subjectivity in a semi-quantitative manner [13]. The final output was a set of “factors”, derived from Principal Component Analysis of 25 ranked statements collected through an interview process that asked participants how seaweed cultivation in the UK could develop in a socially sustainable manner. These factors showed shared narratives across the diversity of interviewees, providing a robust means for identifying where participants agree and disagree and allowing for exploration of why. Each case study involved conducting $n=3$ semi-structured interviews with stakeholders in the local area as part of the statement development process. A further $n=16$ interviews ranked the statements along a normal distribution bell curve and provided commentary from participants on their reasons for their rankings.

Task 3 was to conduct the “null” case study, where there is no history of aquaculture operations but there is scope to develop seaweed cultivation. The approach used qualitative interviews and was inductive and exploratory as most of the interviewees had limited knowledge of any type of aquaculture. $N=18$ interviews were conducted and qualitatively coded for emergent themes [14].

Task 4 used in-depth focus groups to explore and sense-check the identified SLO characteristics and measures from Tasks 2 and 3 with cultivation organisations and businesses representing different end-uses and different scales across the UK. This provided an industry-informed narrative on what SLO measures are already being undertaken and those that cultivation organisations may be willing to undertake in the future.

3. Key findings

3.1 Null case study – conditional support for seaweed cultivation

- The high level of unawareness of seaweed cultivation and lack of knowledge of processes and impacts relating to the industry was not associated with negative perceptions of it, either in general or for its potential development in the local area. There was general support for seaweed cultivation on the Suffolk coast.
- In the majority of instances, seaweed cultivation was perceived as benign or beneficial to the environment, in principle. Social benefits in terms of employment and local investment were also almost universally recognised. Concerns were mostly rooted in the behaviour of seaweed cultivators and, ultimately, whether they could be trusted to act in the best interests of the environment and society in which their farm was located. Consent was often conditional on sustainable practices being applied and caution was evident when considering the scale of operations.

¹ Q-method is described in more detail in [Section 2.1](#) of the full report.

- Where there was doubt that best practices would be applied, respondents sought security through various means. Three key supporting elements emerged as giving respondents the necessary confidence that seaweed cultivation operations would remain within socially acceptable parameters and providing the reassurance that the industry would develop in a controlled way: engagement, monitoring and adaptation, and regulation.
- Engagement, monitoring and adaptation, and regulation are essential components in the social safety net that reassures communities that seaweed cultivation in their local area is developing in a controlled manner with the interests of local stakeholders and impacts on the local environment adequately protected.

3.3 Q-method study – Environmental sustainability is part of social license to operate

- Factor analysis of the Q-sorts revealed three statistically distinct accounts of how seaweed cultivation in the UK could be developed to be socially sustainable: 1) prioritisation of environmental sustainability and responsible operator practices, 2) growth of the industry at smaller site scales, prioritising local social benefits and environmental sustainability and, 3) prioritisation of improved regulatory processes and business development.
- Environmental sustainability was perceived by factors 1 and 2 as the core reason for developing seaweed cultivation. Factor 3 prioritised other areas, but still agreed that environmental sustainability should be a priority. A summation of all of the responses around environmental sustainability is this: if seaweed farming is not environmentally sustainable, there is no point in doing it.
- The differences between the factors were in their ranking of statements on scale of farming operations, local benefits, and local jobs. Factors 1 and 3 shared the view that smaller-scale operations were less likely to be economically viable or competitive in an international market, so the industry should be looking to utilise development models can be competitive (within environmental constraints). Factor 2 linked environmental sustainability with both smaller scales and local benefits and local jobs, suggesting that economic viability of such operations could be sought through local and niche markets (such as high-end restaurants), and integration with other income streams, such as inshore fishing.
- The main area of consensus across the factors was a strong disagreement that large-scale multi-national owned farms is the way forward. All of the interviews advised that large-scale globalised ownership models generally result in negative consequences for the environment and for those who live near such operations. For some interviewees however, the concern was about the ownership of the cultivation operations rather than the scale. They felt larger scales would be required for economic viability, but multi-national ownership was undesirable.

3.3 Situating the findings within social license to operate theory

The findings from both the null and Q-method studies revealed several clear links between the way that seaweed farms develop and operate, including supporting structures (e.g. regulation and policy), and the likelihood of SLO. The aspects presented below are selected for their newness to SLO research, novelty for seaweed cultivation, or for being ubiquitous across both the null case study and the Q-method study.

Environmental sustainability was at the forefront of all stakeholder groups' commentaries on seaweed cultivation operations. Most interviewees advised that as the industry is in a nascent stage, it has the opportunity to develop in a way that is intrinsically environmentally sustainable. It was also recognised that the regulation is required to support environmental sustainability as more players enter the industry. Likewise, that expectation management is required as seaweed cultivation is one



of several industries with potential in the move to a low-carbon economy, and some of the current 'hype' might not be fully realised once enough environmental evidence has been collected. Environmental sustainability has been tangentially linked with social license to operate [15]; however, these case studies show that seaweed cultivation operations will not be socially acceptable unless they are environmentally sustainable from the outset. This puts pro-environmental behaviour of the operators and operations at front and centre of garnering social license to operate.

The **policy and regulatory processes** related to seaweed cultivation are currently underdeveloped and require significant improvements to facilitate expansion of the industry in an environmentally sustainable manner, particularly in areas where there is no history of aquaculture. Perceived or real lack of knowledge of seaweed cultivation in the regulatory arena is frustrating to potential cultivators but could also result in a lack of trust by communities and marine stakeholders. Perceptions of accountability and control for the way the industry develops and operates was linked with positive perceptions of its expansion. Trust in regulatory processes has been shown to influence opinions of aquaculture operations and has directly hampered expansion discussions in France [7]. Interviewees in this study advised that the impetus was on both industry and regulators to work together to develop regulatory structures and industry strategies that are fit for purpose.

Community benefits, local jobs, and responsible operator behaviour within the areas where the farms are located was important to most interviewees, and across all stakeholder categories. This echoes the findings of a diversity of social license to operate literature, where these three elements feed into positive relationships, trust-building, and the socio-political legitimacy of the activity from a site-scale perspective (see for example [16], [17]). Responsible operator behaviour includes good communication with stakeholders and communities, reducing disruption to other marine users, and following environmentally sound practices.

Perceptions of **acceptable scales** of the industry were diverse. Interviewees in the null case study and Factor 2 in the Q-method study preferred smaller scales, but Factors 1 and 3 in the Q-method study preferred to view scale as a matter of context. Where sites are selected based on the biophysical requirements of the seaweed being farmed, and at scales where there is commercial viability. There were opposing visions for what the sector should and could look like, from very local markets and small scales, to internationally competitive and large-scale. However, there was a consensus that whatever scale operations were, they needed to fulfil the basic requirements of economic viability and environmental sustainability, with UK ownership being preferable. From an SLO perspective, this is a complex topic that intertwines with site selection and social context, ownership, regulation and planning, and critically, it has no direct conclusions or concrete recommendations. This suggests that the scale of an operation is highly context-dependent and any decisions on scale should be informed not only by business viability and regulatory constraints, but mutual dialogue with the relevant marine stakeholders and communities of interest and place.

Finally, across all of the Q-method interviews, there was a strong sense that the seaweed cultivation industry in the UK is in a challenging position, where it is not fully developed, but where there are significant expectations already being placed on it. There is a balance requirement of how many societal (including environmental) and economic aspirations can be built into the industry as it develops versus letting it develop to a point where it is more capable of taking them on.

4. Key UK-specific recommendations for developing SLO for seaweed cultivation

This section presents 5 key recommendations of how the seaweed cultivation industry in the UK can begin to foster social license to operate as it develops. These are an amalgamation of prior work and the results of this study, which provide UK-specific context. They do not include the full plethora of



characteristics that have been linked with SLO, as some of these are not currently realistic for the nascent state of the UK sector. We advise that these recommendations are updated as the industry develops and expands.

Environmental sustainability is fundamental to gaining SLO for seaweed cultivation in the UK. Although there is currently a general acceptance of the industry, this is reliant on its presumed green credentials and responsible operator behaviour. **Recommendation 1:** As operations multiply and scale of site increases, effectively communicating evidence of environmental sustainability, and addressing concerns and questions from a range of stakeholders, about environmental practices, will become increasingly important. Adapting operational activities and plans for expansion as more science becomes available is also desirable.

Policy and regulatory processes are currently underdeveloped but are also perceived as a safety net for communities that have little to no understanding of aquaculture practices. A lack of trust in regulatory processes, particularly those related to planning and environmental impact, can impede development of SLO. **Recommendation 2:** The seaweed cultivation industry and relevant policy and regulatory bodies should engage with each other to address the issue of underdevelopment, and work towards a fit for purpose regulatory environment. This should include community consultation processes that are likely to facilitate SLO.

Responsible operator behaviour towards the communities they work in, and towards the natural environment, **community benefits, and local jobs** are intertwined with each other and with the likelihood of fostering SLO. Responsible operator behaviour, for example, could include provision of contextually relevant community benefits and local jobs can be seen as a community benefit where the industry is too small/ not profitable enough to provide other benefits. Included in responsible operator behaviour are also the ways in which operators interact with and respond to marine stakeholders and local communities. This is particularly relevant where seaweed cultivation operations displace other activities that people rely on for their livelihoods, such as fishing.

Recommendation 3: Engage in early and ongoing dialogue with relevant marine stakeholders about plans, to facilitate opportunities for compromise on design, operation, communication etc. Engage in timely (i.e. once sites have been selected, and plans are in draft form, but can be altered if required) and ongoing dialogue with communities local to the operation (including land-side operations) and relevant communities of interest. This should include basic information provision, as very few people know what seaweed farming is and what its end markets are. If possible, have a local person as the point of contact, and if the business is large, provide that person with the power to table changes based on their dialogue with stakeholders. As the seaweed cultivation industry in the UK is not yet at a stage where community benefits outside of local job-provision, is feasible, operators should use local supply-chains as much as possible. Community benefits in other forms should be re-visited if/ when the industry develops to the point where this is economically feasible.

Context-specific approaches to development means growing the right species, in the right biophysical environment, at the right scale for economic viability and environmental sustainability, whilst “fitting in” with the local social setting. This is critical to SLO as perceptions of the viability of an operation play into perceptions of acceptability. What might be right for one area, will not be for another. Some areas will be able to and willing to accommodate large-scale operations, whilst others might prefer smaller scales but more of them, yet others might not tolerate any. This finding marries the biological and technical aspects of seaweed farming, with the social aspects, and highlights the importance of considering all of them together when planning for a new site or site expansion.

Recommendation 4: When planning for new sites, take into consideration a) how they might fit with local communities (e.g. is the area designated for beauty or conservation purposes, does the



community have knowledge and skills relating to the marine environment, what are the local development plans on adjacent land for land-side operations, who are the neighbours and what do they do etc.), b) how it might impact current users of the area (e.g. fishers, yachting, kayaking, diving etc), and c) whether it will add to, make no difference to, or take away from the livelihoods and culture of people living in the area. These considerations should be developed in more detail on a site-by-site basis and according to the scale of the operation. If a large-scale operation is being considered, then conducting a partial or full Social Impact Assessment might help gather the evidence that is required to choose a site with increased likelihood of developing SLO.

Education on seaweed cultivation, its environmental interactions, end uses, and definitions of seaweed industry terms are all necessary to increase the general public's knowledge of the industry, as it seeks to expand in the UK, to help inform perceptions. There is currently a low level of knowledge of what seaweed farming is. The lack of basic understanding of what the industry involves, risks people filling their knowledge gaps with experiences of other industries that they perceive to be similar or have similar risks to seaweed cultivation. Examples include, monoculture agriculture, fish farming, shellfish farming, mechanical wild seaweed harvesting, hand wild seaweed harvesting, forestry, sea ranching, fishing, and offshore wind energy. Some of these industries have undesirable public perceptions associated with them, which could result in degradation of the current positive opinion of seaweed cultivation and reduce the likelihood of farms developing SLO.

Recommendation 5: The seaweed cultivation industry, scientists, advocates, and other relevant parties (e.g. food and drink associations, biotechnology clusters, interested coastal forums etc.) should engage in activities to increase the general public's knowledge of what seaweed farming involves, from hatchery through to product. This should include both the positive and potential negative aspects of the industry, to facilitate expectation management around what it can achieve. This will help prime the general public for seaweed farming expansion and improve dialogue and consultations with local communities when it comes to planning processes and engagement activities. It may also be advantageous for the industry to develop an identity that is not associated with other controversial activities related to seaweed, e.g. mechanical wild seaweed harvesting. This could be done through industry wide use of the same terms and definitions in information packages and during communication activities.

Guide to social license for seaweed cultivation in the UK

1. Background

Seaweed cultivation in Europe and North America is increasingly being looked to as a growth sector in the transition to a sustainable Blue Economy [18]. From pharmaceuticals to health and beauty, to plastics and biofuels, the demand for seaweed for commercial use, is expanding. In order to accommodate this demand and for farms to be economically viable, mechanised farming and large areas of sea will be required [3]. The social acceptability of different marine industries and uses can depend on set boundaries, such as the rules and regulations (law and policies) governing the activities and the biophysical interactions of the activity, and softer more changeable aspects such as community opinions, the media, and individual agency [19]–[21]. Currently, there are few studies on the social interactions that commercial scale seaweed production has or is likely to have in developed nations. However, the literature available identifies the potential for stakeholder conflict and competition for space [7], [22], community opposition [23], social perception challenges related to scale [10], and issues with comparisons to other industries that communities and the general public know more about [7], [10]. It is well documented that social opposition to aquaculture of some species, particularly fin fish farming, can lead to reduction in available space for the activity, increased costs and associated reputational damage caused by media and community campaigns, and legal challenges [5], [7], [24]–[33]. There is also evidence that engaging in activities that address the concerns that stakeholders and opposition groups may have, can reduce the likelihood of social opposition [7], [11], [15], [16], [29], [34].

As seaweed cultivation will have both positive and negative environmental and social interactions [3], [18], particularly at commercial scales, agents (individuals and/ or organisations) can use arguments based on such impacts to justify opposition [35]. Social license (or, licence) to operate (SLO) is an industry coined term pertaining to the likelihood of garnering ongoing support from local communities for industrial operations which have social and environmental costs [36]. It is not a “license” within the remit of the rules of planning and consenting or policy but is an informal consent which is increasingly being considered by aquaculture industries as a business risk management strategy, necessary for the smooth running of operations. For example, reducing the likelihood of objections to planning and consenting, stakeholder conflict, the risk of reputational damage, and legal challenges [15], [16], [37]–[39]. SLO could provide a useful framework for the seaweed industry to manage the risk of social opposition to expansion [35]. Likewise, it could also encourage the development of communication and good practice strategies by operators and may present a way for communities and other users of the marine environment to negotiate beyond compliance behaviour from the industry as it expands [7], [35].

These factors combined, show the importance of understanding site-scale industry-community interactions for this sector as it develops in the UK. With the industry currently in a nascent state, there is the opportunity to learn lessons from other aquaculture sectors and identify and implement steps that can be taken to develop positive relationships between seaweed cultivation operators and local communities, communities of interest, and other stakeholders. This will not only benefit the industry as it grows, reducing conflict and the costs of planning and licensing, but will empower the communities that host the activities to negotiate appropriate benefits for their local area.

Social license to operate (SLO) is a framework that can underpin research into factors that foster positive industry-community relations. SLO is described as an on-going relationship between a host community and an industry/business where the industry/ business and their activities are held to certain standards set by the community, in exchange for the trust and support of the community [11]. The specific aim of this study is to explore the characteristics and measures that seaweed



cultivation businesses and operators in the UK, could adopt that would result in positive industry-community relationships and SLO. The outcome is to develop accessible and industry-informed guidance on how to foster and improve SLO for cultivation organisations.

This study was conducted on behalf of WWF-UK as part of their programme of research into the potential of seaweed farming to meet the priority responses to the triple challenge: keeping temperature rise below 1.5C, ensuring nutritious food for all, and halting and reversing biodiversity loss [12]. This work contributes to the human and social aspects of the triple challenge, providing guidance on activities that may reduce the likelihood of social opposition to seaweed farming and subsequently, may improve the prospect of successful planning applications in a socially acceptable way.

A full literature review on SLO for seaweed cultivation can be found in the supplemental materials. Table 1, provides a brief overview of the characteristics that have been found to contribute to the development of SLO in the literature and table 2 presents the definitions of key terms in this report.

Table 1. Brief outline of the characteristics that have been found to contribute to the development of SLO in peer-reviewed literature. Table sourced from [35].

SLO attribute	Brief explanation	Sources
<i>Understanding the social context of the area</i>	Understanding the social and cultural norms of the communities local to an industrial activity is essential for ensuring any communication, community benefits, work-patterns, and working structures are appropriate. It can be essential to understanding what matters most to the community and therefore how to mitigate against any potential impacts.	[17]
<i>Trust and trustworthiness</i>	Trust is the outcome of interactions between two trustworthy parties. Trustworthy traits include; predictability, credibility and commitment, honesty and truth claims (verifiable factual claims).	[40], [41]
<i>Quality contact and engagement</i>	The quality of contact and engagement between an operator and the local community and relevant stakeholders is more important to SLO than the quantity of contact. Quality contact is associated with trust and pleasant and positive experiences with the operator.	[16], [42]
<i>Communication</i>	Communication comprises the ability to understand and be understood by others. However, in the context of SLO it also includes the history of group relations, e.g. the history of operator-community relationships in the local area, as well as the current negotiation.	[36], [43]
<i>Procedural fairness</i>	Procedural fairness is linked with transparent communication about decision-making and community benefits. It relates to the way that operators and regulatory agencies make decisions about the activity, and the workforce and supply-chain required to run it. If decisions are perceived to be fair by local communities and relevant stakeholders, SLO is more likely.	[15], [16], [44]
<i>Relationship-building</i>	Relationship-building includes many of the attributes associated with gaining trust such as; honesty, consistency, good communication, and collaboration. Relational quality is associated with more emotional connections (i.e. embeddedness in the community, shared values, etc.) and less with transactions (i.e. sponsoring local sports teams, monetary compensation for disruptions etc.) <i>“Relational quality is more important than transactional quantity”</i> – Baines & Edwards, 2018	[41]
<i>Visual and environmental impact</i>	Visual and environmental concerns are often cited as a motivation for opposition to aquaculture developments, particularly where they may interfere with conservation interests and tourism activities.	[39], [45]
<i>Maintaining social order</i>	Large-scale industrial activities can receive more negative social attention than small scale ones, despite, in some cases, better environmental and social responsibility standards. Small scale, locally owned operations can be viewed as more compatible with existing social order. Large-scale multi-nationals are far removed from local dynamics and can be viewed as an <i>“imposition”</i> on local communities. This can be related to understanding local social contexts and being flexible enough to accommodate changes to maintain social order, or gradually introduce changes in close collaboration with local communities and stakeholders.	[46]

Table 2. Key terms and their definitions.

Term	Definition
Aquaculture	Aquaculture is the farming of aquatic organisms, including fish, molluscs, crustaceans and aquatic plants. Farming implies some form of intervention in the rearing process to enhance production, such as regular stocking, feeding, protection from predators, etc. Farming also implies individual or corporate ownership of the stock being farmed [47].
Seaweed	Algae that are defined as aquatic multi-cellular photosynthesising organisms usually attached to the seabed by holdfasts that do not absorb nutrients (i.e. are not roots). Three main types exist (brown, green, and red) that differ greatly in their life cycles, bodily organisations, and biochemistry [18].
Seaweed cultivation	The deliberate introduction of seaweed to the environment on/in human-made infrastructure either by seeding or transplanting young seaweed onto/ into humanmade infrastructure or installing man-made infrastructure to allow seaweed spores to naturally establish and grow. Once the seaweed biomass has reached the desired size, or is in need of removal, it is harvested through manual or mechanical processes (built on the definition in [48]).
Wild harvesting	The removal of part of, or all of, a wild living seaweed from its natural position of growth. Wild harvesting can include hand picking, hand cutting (with hand-held scissors or rake), and mechanical removal (built on the definition in [48]).
Gathering	The collection of any wild or cultivated seaweed no longer in the position of growth. This typically refers to beach/shore-cast seaweed (built on the definition in [48]).
Social license to operate	<i>“The ongoing acceptance or approval of an operation by those local communities stakeholders that are affected by it and who can affect its profitability”</i> [49].
Community of place/ local community	A group of intercommunicating people who live in a particular geographical area. Used in this paper for communities that live within close proximity to a proposed seaweed cultivation site, or the infrastructure required to run such an operation such as slipways, ports and harbours.
Community of interest	A group of people who share an interest in a specific subject area or activity, but who may be geographically dispersed, but are intercommunicating through organised group activities either in person or via the internet, and through internet mediated forums.
Stakeholder	A person or organisation with a recognised interest in an operation or activity. E.g. regulators, businesses, environmental Non-Governmental Organisations, citizens.

2. Theoretical framework and research approach

This study uses the theory of social license to operate (SLO) to frame the research questions and interpretation of the data. It is not within the remit of this section or this study to discuss the validity of the theory or its history, however, we present here a brief overview of the reasoning behind the choice of SLO as the framework for our investigations, before presenting the research questions.

Within academic study, SLO was originally explored within the context of heavy, resource extraction industries, such as mining (see for example [16]) and paper manufacturing (see for example [15]). Since 2010, the concept has been successfully applied to marine sectors [50], particularly those with environmental, visible and spatial interactions with communities and other users of the sea (e.g. marine conservation [51] and finfish farming [45], [52]). While SLO has successfully been argued, within academic literature, as another term for 'legitimacy' [37], it is still considered relevant and useful as its use within industry and governmental organisations is prevalent [52]. For example, the United Kingdom [53], the European Commission [54], the United States of America [55] and New Zealand [56], all have industry-informed governmental documents either directly relating to social license to operate or referencing the concept.

There are several models of SLO that have been applied in the literature, the most prevalent being the pyramid model from Thomson and Boutilier model in 2011 [57]. We think it is useful to contextualise the pyramid model within two other SLO and social acceptability models, to show our reasoning for choosing the pyramid model as the SLO framework for this study.

The *triangle model* (figure 1) is a social acceptability model, based on renewable energy studies. It highlights the requirement for different types of acceptance processes before a project can go ahead, and while the technology is in operation. Renewable energy studies evidence a "social gap" between the general public's broad support for low carbon energy technologies, and the level of support they receive for specific projects [58]. As with Thomson and Boutilier's model, there is recognition that community acceptance requires distinct social interactions of justice and trust. However, this model also implies a wider group of stakeholders will be involved in acceptance processes, than the models specifically derived from SLO studies.

The *three-strand model* is based on the works of Gunningham, Kagan and Thornton between 2003 and 2004 [15] and the figure 2 adaptation is from Morrison [59]. This model suggests that three different licenses are needed for an operation to start and/ or continue, and meaningfully, that they relate to each and interact with each other. Of direct interest to this study, is that this model is based on the specific research question of why companies go beyond environmental compliance with law. In asking this question about environmental compliance, SLO emerged as a key topic. However, within this model, there is limited definition of the components that make up SLO, only the stakeholders that are party to the process.

The *pyramid model* (figure 3) was developed by mining businesses and consultants based on work over a 14-year period from 2000-2014 [37]. This particular iteration was published by Thomson and Boutilier (2011) [57]. It distinguishes between several 'levels' of SLO, with the lowest being that SLO is withheld or withdrawn (suggesting that the project/ operation is likely to receive objections/ social opposition), and the upper levels indicating that SLO has been granted to a more or less degree. In their 2011 publication, Boutilier and Thomson added four factors that make up the different levels of SLO. These were the perception of economic legitimacy (in the acceptance level), socio-political legitimacy and interactional trust (in the approval level), and institutionalised trust (in the identification level). They describe socio-political legitimacy as "*the perception that the project/ company contributes to the well-being of the region, respects the local way of life, meets the*



expectations about its role in society, and acts according to stakeholders' views of fairness."

Interactional trust they describe as the perception that the company and its management listens, responds, keeps promises, engages in mutual dialogue, and exhibits reciprocity in its interactions." Finally, they describe institutionalised trust as *"the perceptions that relationship between the stakeholders' institutions (e.g., the community's representative organisations) and the project/company are based on an enduring regard for each other's interests."*

We consider the pyramid model to be the most closely matched with the aim of this study; to characterise stakeholder perceptions of the requirements for SLO for seaweed cultivation in the UK as the industry expands, as this model is solely focused on SLO and its component parts, rather than where it sits within the spectrum of acceptance processes, as the other models attempt. Further, stepping ahead to the results of this study, the detail emergent from the data collected, required that the model(s) used to describe and interpret the findings were specifically focused on the characteristics within SLO. Although we will situate the findings within the broader dialogue on acceptance processes, the strength of this work is in its detail, defining specific measures that companies and communities can expect of SLO processes. Hence our choice for using this model as our framework for this study.

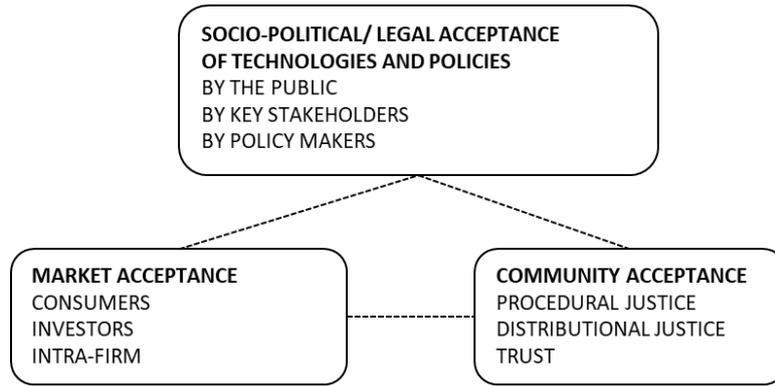


Figure 1. The triangle model, as adapted by Gehman, Lefsrud and Fast [37] from Wüstenhagen, Wolsink and Bürer (2007).

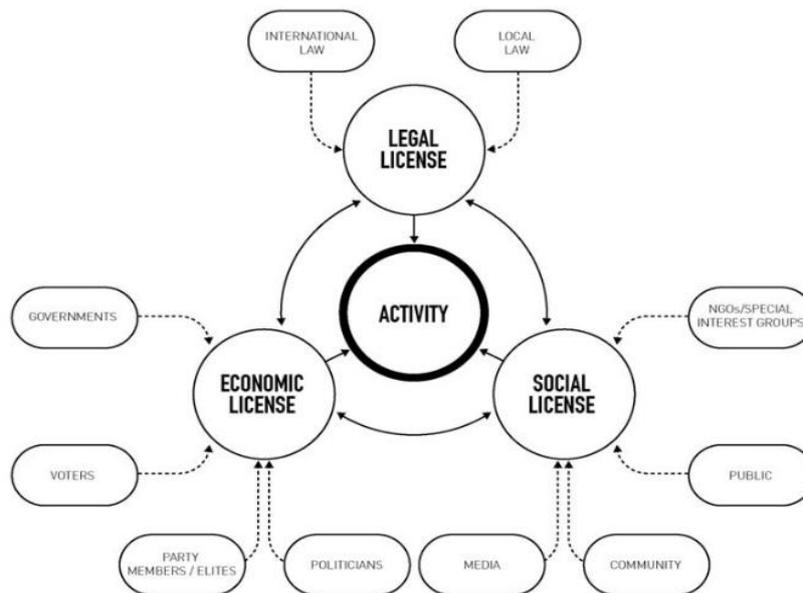


Figure 2. The three-strand model, as adapted by Gehman, Lefsrud and Fast [37]

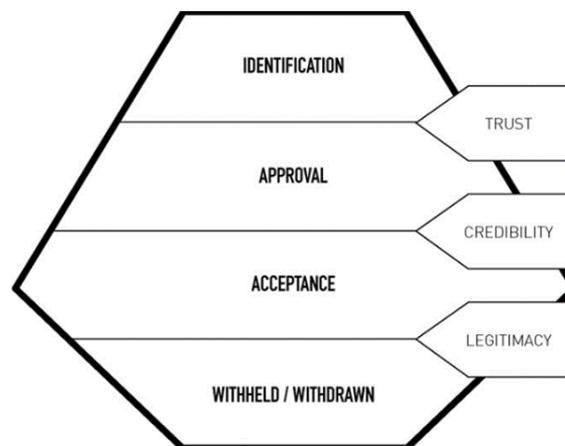


Figure 3. The pyramid model, as adapted by Morrison [59].



3. Methods

This study takes a mixed-methods, case study approach to investigating how seaweed cultivation in the UK can develop in a way that is likely to increase the opportunity for operators to garner social license to operate. As detailed in [Section 1](#), we see social license as one of the underlying factors in helping the sector to expand to commercial scales, whilst also recognising the requirements of local communities and communities of interest and developing in a way that is sympathetic to other users of the sea.

A mix of qualitative and semi-quantitative methods were used in $n=4$ case studies across the UK to reflect the difference in industry development. We conducted a “null” case study in a coastal community where there is no history of aquaculture operations but there is scope to develop seaweed cultivation (Lowestoft, Suffolk). The approach used interviews and was qualitative, inductive and exploratory as it was expected that most of the interviewees would have limited knowledge of aquaculture and seaweed cultivation and what that might involve (e.g. shore-side and sea-based infrastructure and operations, what seaweed can be used for etc). The interviews were designed to form an in-depth and contextually rich understanding of how a community with no experience of aquaculture, would potentially react to a proposal for seaweed cultivation, and the expectations that the community might have of a cultivation organisation that may decide to operate in their area. More details on the method used in this case study can be found in [Section 2.1](#).

The other three case studies were in locations where there are already experimental or commercial seaweed cultivation sites and used a Q-method approach (Pembrokeshire, Wales; Dorset, England; Argyll and Bute, Scotland). Q-method is a means to study subjectivity in a semi-quantitative manner [8], a detailed description of the method can be found in [Section 2.2](#). Q-method was chosen as it allowed us to show shared narratives across a diversity of interviewees, providing a robust means for identifying where participants agree and disagree and why. It also provided us with a means to rank and explore areas of social license to operate, enabling the identification of shared priorities across stakeholder groups.

2.1 Null case study methods

Lowestoft, Suffolk was selected for the null case study as a region with theoretical potential for seaweed cultivation but without any farms yet operational. Semi-structured qualitative interviews were conducted online in November and December 2021. The questions investigated perceptions of seaweed farming and its development in the local area, along with the characteristics and measures that UK seaweed cultivators could adopt to create positive relationships with local communities and other stakeholders. The aim was to identify how the seaweed cultivation industry in the UK can be developed to be socially sustainable. By conducting interviews in an area not yet impacted by the seaweed cultivation industry, it was intended to capture perceptions and anticipated impacts among a naive community.

A total of 18 interviews were carried out with a range of coastal stakeholders based in Suffolk in order to obtain various perspectives on the prospect of introducing seaweed cultivation to their local coastline. The groups represented were: 4 government/regulators; 3 conservation organisations; 2 NGO; 2 coastal volunteers; 1 each of fisheries organisation, recreational marine user organisation, enterprise organisation, Community Interest Company, community trust, aquaculturist, and sustainability development consultant.

The interviews were transcribed and analysed following the method outlined by [14]. The transcripts were thematically coded, and the codes grouped into 17 initial themes, which were

aggregated to 3 final themes: perceptions of seaweed cultivation, site development and seaweed cultivation management and regulation. The grouping of the emergent themes into the final themes is shown in Table 1.

Table 3. Aggregation of initial themes into final themes.

Perceptions of Seaweed Cultivation	Site development	Seaweed cultivation management and regulation
Lack of knowledge	Scale	Characteristics of cultivators
Seaweed cultivation as a novel industry	Market and use	Regulation and regulatory processes
Support for seaweed cultivation	Ownership	Challenges for seaweed cultivators
Association with other industries	Planning and design	Advice and guidance
Perceived benefits of seaweed cultivation	Engagement and cooperation	Setting standards
Perceived negative impacts of seaweed cultivation	Monitoring and research	

2.2 Q-method study methods

Q-methodology was developed in the 1930's as a means to explore subjectivity using a quantitative approach [60]. In practice, it combines the strengths of qualitative research, context-rich narratives, motivations, and explanations, with quantitative results [60]. It is particularly useful in researching topics which could be controversial or socially complex [61]. The overarching aim is to elicit the breadth and depth of opinions on a specific topic and group them according to shared and differing perspectives. This is achieved by asking participants to rank a set of statements on a normal distribution bell curve and provide a narrative during this process, explaining their thought processes [60]. Q-method has proved useful in sustainability studies, providing a practical way to engage with stakeholders, while unpacking complex socio-environmental and socio-economic subjects (see for example [62]–[64]).

The Q-method applied in this study follows the method set out in [65], where there are six steps: 1) developing the concourse, 2) creating the Q-sample (statements), 3) developing the P-set (interviewees), 4) the Q sort, 5) analysis of the data, and 6) interpretation. The concourse was developed through a literature review of studies on social license to operate for seaweed cultivation and more broadly social license in the marine environment. We also conducted $n=9$ expert interviews ($n=3$ in each case study site) with industry, and community representatives to garner their views on how seaweed cultivation operations could be developed in their area, in a way that is socially sustainable. These interviews were transcribed, and thematically analysed, contributing to the concourse. From both the literature review and the interview analysis, key phrases, themes, and quotes were extracted, and refined. The final number of statements in the Q-sample was 25. Table 2 presents the statements within each of the SLO pyramid model categories.

The Q-sort interviews were conducted with $n=16$ experts from five stakeholder categories, including: aquaculture (seaweed cultivators and downstream value-chain, finfish aquaculture), fisheries (inshore), government and regulators, civil society (industry and community groups, NGOs), and academia. The interviews were held on MS Teams, recorded and transcribed. The Q-sort was conducted via Google Jamboard, where the interviewee placed “post-it notes” containing the statements along the 4 to -4 ranking curve. An example can be found in Figure 4. We chose a relatively flat bell curve as the P-set were experts in their field [60]. The Q-sorts were analysed using the software, PQ method [66] and the statistical processes of Principal Component Analysis and Factor Analysis. This means that the narratives presented are the product of any subset of the



participants who revealed similar views through the distribution of the sorted statements. The factor analysis of the Q-sorts found a small number of ideal factors that capture an acceptable amount of the study's overall vector variance [60]. The software automatically provides eight factors; however, we chose a solution of three factors, as any more would have presented too much of an overlap between the factors. Finally, the factors were interpreted in detail alongside the accompanying qualitative interviews to provide an in-depth description of each factor.

Table 4. Q-method statements sorted into the social license to operate categories identified in the theoretical framework.

Economic legitimacy	Social and political legitimacy	Interactional trust	Institutional trust	Environmental sustainability
1 Large-scale seaweed farms run by multi-national companies is the way forward	2 Locally run small to medium scale seaweed farms are the way forward	6 Seaweed cultivators should behave responsibly	15 The current regulatory processes for seaweed cultivation are fit for purpose	5 Seaweed cultivators should manage the risks of any adverse environmental impacts
3 Local economic benefits should be put above nation-wide economic benefits	8 Seaweed cultivation should enrich communities through traditional uses and knowledge re-enforcement	9 Seaweed cultivators should communicate with other users of the sea	17 The current regulatory processes for seaweed cultivation are not fit for purpose	7 Seaweed cultivation should take place offshore
4 Seaweed cultivation in should be developed for local markets	13 Seaweed cultivation should provide community benefits and local jobs	11 Seaweed cultivators should involve stakeholders in influencing plans	20 Seaweed cultivators should rely on regulators to establish best-practice guidelines	10 Environmental sustainability of seaweed cultivation should be a priority
12 Co-operatives are a viable development option for seaweed cultivation companies	16 Seaweed cultivators should be aware of the social contexts that they work in	14 Seaweed cultivators should engage with local communities	21 Seaweed cultivators should work with researchers to understand and improve seaweed cultivation techniques and impacts	18 Seaweed cultivation is more environmentally acceptable than finfish cultivation
		19 Seaweed cultivators should provide transparent information about farming techniques to the public		22 Seaweed cultivation should have wider benefits that reduce environmental impacts in another sector
		24 Seaweed cultivators should learn from other areas or countries		23 Seaweed cultivators should aim to reduce environmental impacts in other sectors
		25 Engagement should begin at the outset of planning		

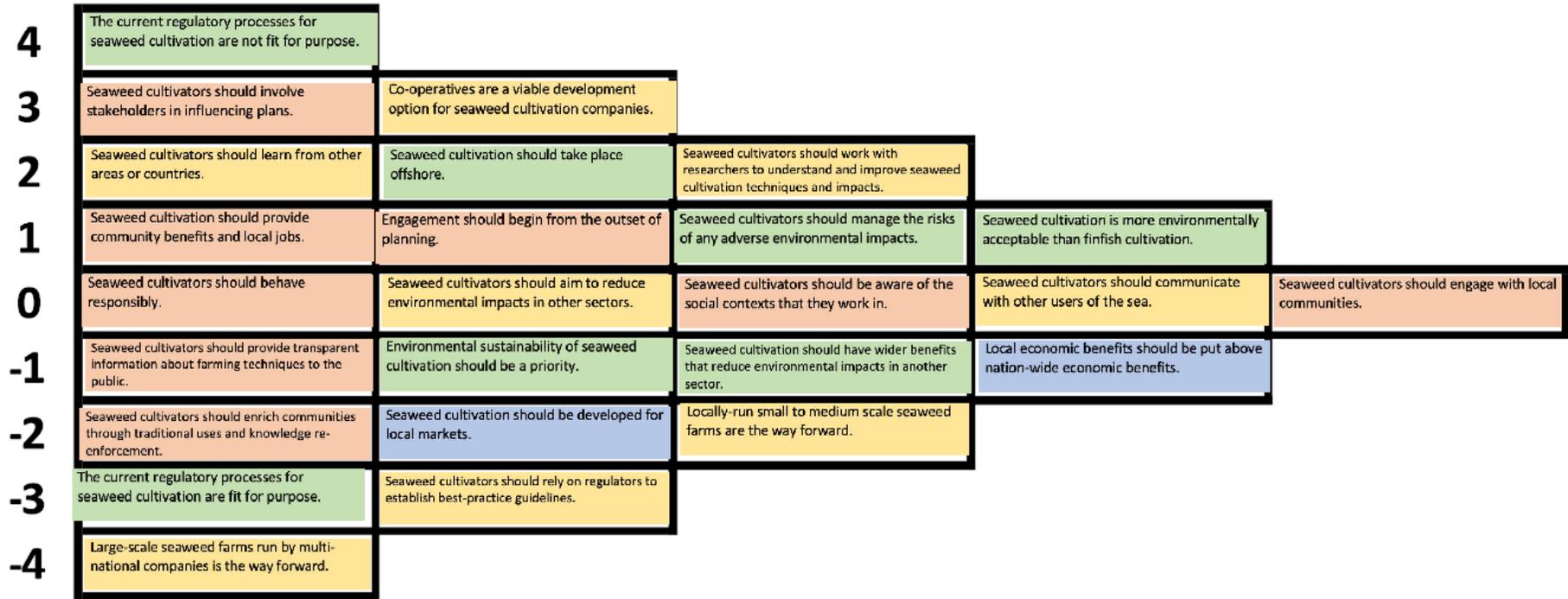


Figure 4. Example of a final Q-sort by interviewee A4 using Google Jamboard, via MS Teams

4. Null case study results

This section presents the results of the thematic analysis from the null case study, describing the findings for each of the three themes in turn.

4.1 Perceptions of seaweed cultivation

One of the key findings to emerge from the null case study hypothesis was a lack of knowledge about the seaweed cultivation industry. Two interviewees confessed to being unaware of the seaweed industry, with one suggesting this would be widely observed among the general population: *"I think it's a fairly alien concept to most people. Most people don't really think about seaweed as something that can be cultivated."* (D56). Furthermore, a lack of knowledge of impacts was widely expressed, alongside a need for more information. Six interviewees made reference to it being a novel industry, although views were split as to how this would affect attitudes towards it, with some participants suggesting it may lead to resistance, while another claimed a niche existed for it.

Interviewees expressed a high level of support for the development of seaweed cultivation in their local area, despite the expressed lack of awareness or knowledge and it being considered a novel, and therefore unchartered, industry. Twelve interviewees were explicitly supportive of seaweed cultivation development in Suffolk's coastal waters, with five of those on the condition that it is done sustainably. There were also some high expectations of it to support struggling coastal communities: *"I think it's wonderful. I think it will add jobs, create jobs for local small communities, rural communities, fishing towns, reinvigorate fishing towns again."* (D69).

Comparisons and associations were often made with other marine industries. Those specifically referred to were finfish aquaculture, shellfish aquaculture, offshore wind energy and the cruise industry. Associations with other industries, in particular finfish aquaculture, were sometimes negative: *"We only have to look to the salmon farming industry to see how there is a real problem with trying to get a social license. And we want to learn from the salmon farming industry with how it developed in the early days when it was a fairly ad hoc, almost free for all, and it made a lot of mistakes."* (D6). Participants who made reference to other marine industries were keen that seaweed cultivators learned from the way they have been developed and operated – what was done right, and what was done wrong? They also wanted seaweed cultivators to explore options to co-locate with other marine industries, in particular offshore wind energy, of which there is much established in the region, or the reuse of redundant infrastructure, for example from wind farms or oil and gas extraction to reduce waste of materials.

Interviewees described perceived benefits of seaweed cultivation. While they were asked in both the national and the local context, responses were predominantly framed in terms of local benefits. The most frequently raised was environmental benefits, followed by employment and community economic benefits. Seaweed cultivation was viewed as a local opportunity and a chance to diversify existing industries and support those currently employed in struggling businesses: *"I think the fishing industry itself is facing a lot of pressures from a number of different sectors. If seaweed farming were to be established, that gives an alternative income for the fishing industry, they have the ability in place to be able to diversify into seaweed farming, so it provides that opportunity."* (D6).

Perceived negative impacts of seaweed cultivation were predominantly underwritten by concerns about the unknown. Possible negative environmental impacts, in particular undiscovered ones, were the leading concern. Other common answers concerned competition for space and the associated conflict with other marine industries and recreational marine users. Concern was greatest for the fishing industry, viewed as already being under pressure or struggling to survive: *"it is almost*

inevitable that inshore fishermen will see the activity as yet one more activity competing for space in an already overcrowded area, in which they depend on being able to move around to take advantage of fisheries resources as they themselves move.” (D3). The visual impact of more infrastructure in what was perceived as an already busy area of sea was also a frequent concern of interviewees in the Suffolk case region.

4.2 Site development

Discussions on the acceptable scale of seaweed farming operations were impacted by many participants' lack of knowledge and experience of the industry. Visualising small scale and large scale was difficult and there was a tendency towards caution for fear of the local area being overwhelmed by this new industry. Operating at a small scale, or at least starting at a small scale with the potential to expand if successful and tolerable, was preferred, with only two participants supporting large scale operations. Other participants advocated for decisions on scale to be made on the basis of individual sites as context is critical to planning.

When questioned on markets and preferred use for locally farmed seaweed, interviewees would often make suggestions based on the extent of their knowledge of seaweed products rather than express preferences, and six participants stated that they had no preference. Of the uses mentioned, food was the most frequent answer, followed by animal feed and cosmetics. There was a stronger emphasis on a preference for the use of the seaweed being sustainable than there was for any particular target market for it. This involved seaweed being processed and sold locally, rather than being transported many miles, or being used in sustainable products such as bioplastics and biofuels.

As with scale and use, ownership was a topic that was constrained by the extent of knowledge that participants possessed on the development of seaweed operations. While unsure of how it would work in practice, there was a strong preference for local ownership, in particular community ownership or part-ownership of the operations: *“Well I certainly think there should be an opportunity for local communities to have some part ownership in these developments, because I think actually that sense of ownership then provides a feel of they’re getting the benefit, they’ve got that investment in that area, and they may be more inclined to therefore have a greater sense of pride in their local marine habitats, want to protect them even more, and then there’s also an opportunity for education as well I think.” (D33).* There was also an acknowledgement that private ownership, perhaps even by larger operators, could be an economic necessity due to high capital costs associated with establishing a seaweed farming business.

The need for robust planning was emphasised, with Marine Spatial Planning (MSP) specifically mentioned by three interviewees. Development of seaweed cultivation at present was criticised as ad hoc, and evidence-based decision making was called for. There were also suggestions of locating the seaweed farms offshore or in MPAs as solutions to spatial issues: *“And also I think again, coming back to the spatial issues, the potential for locating in other areas such as potentially marine protected areas, what’s the compatibility with certain types of MPAs, basically if an MPA’s going to result in the displacement of existing activities is there an opportunity, in those circumstances, to take seaweed farms that minimise conflict because of the requirements of other uses.” (D7).*

Engagement was an important topic for interviewees, seen as pivotal to achieving social licence. Engagement with stakeholders, in particular communities and other marine user was specified by a high number of interviewees. There was a desire for more information, with one interviewee stating: *“Clear presentation of objective factual information, in a manner appropriate to the target audience, is the best way to allow stakeholders to make informed decisions.” (D20).* Moreover, there were calls for greater participation of stakeholder groups in the form of cooperation, collaboration



and involvement in planning. *“I think it’s very important to interact and engage and work together with local communities and stakeholders, so I think that would be key, for them to be involved pretty much obviously from the planning stage to the decision where to do it and then to really get the community on board.” (D1).*

Monitoring and research were seen as key elements in developing the seaweed industry in a sustainable form: *“We would certainly expect them to provide ongoing monitoring from their development, and that monitoring to be independent so that the impacts of that infrastructure and that project were continued to be monitored throughout the life of the project, rather than just assessing the impact before it’s put in and then maybe ten years down the line or something.” (D33).* It was hoped that seaweed cultivators would collaborate with researchers, monitor impacts and develop ways to improve their techniques. The need to share findings and data to allow others to benefit from and build on their work was also stressed.

4.3 Seaweed cultivation management and regulation

When asked to discuss the characteristics or behaviour they expect from seaweed cultivators, references to various types of responsibility were the most frequently observed. These ranged from the general request that cultivators behave responsibly, to references to specific types of responsibility, such as towards the environment or social responsibility: *“We would expect them to keep the operation clean so that there was no pollution from it; we would expect them to respect the community and the wildlife and generally the landscape and the seascape. And just generally act responsibly and keep them in the picture rather than just imposing it upon people, so you’d need to take the community with you, so to speak.” (D56).* Other popular responses included transparency, being a good neighbour to communities and other marine users, to follow the guidelines, laws and plans in place for seaweed cultivation, and good communication.

Despite the lack of seaweed cultivation in this region and, for some interviewees, the lack of awareness or knowledge concerning it, the topic of regulation and regulatory processes exposed a wide variety of views and strong opinions on the current state of regulation and what it should be. There was consensus that the current regulation and regulatory processes are not fit for purpose. This was partly attributed to seaweed cultivation being a novel industry. Regulation was nevertheless regarded as essential by a high number of interviewees and the improvement of the regulation itself and the process, described as long, complex and expensive, was imperative. It was also stressed that the regulations should be established before the industry is, in order to guide the development of the industry: *“I think we need to have robust, appropriate regulations in place and a good understanding of seaweed farming before it can go ahead. There is a bit of a rush for licenses for seaweed farming, but this seems like a very ad hoc way of allowing seaweed farming to develop and to occur.” (D6).*

With regards to challenges for seaweed cultivators, sustainability was by far the most frequently expressed concern. This was followed by business concerns, a lack of funding and the challenge of making an operation economically viable, and social concerns, such as local opposition and conflict with other marine users over space. Other challenges mentioned on single occasions included: getting a licence, finding a location, capital investment, seasonality of employment, accessing markets or lack of a market, labour costs, political issues, dealing with unknown negative effects, and balancing the social, economic and environmental sustainability.

A small number of interviewees expressed a need for advice or guidance for seaweed cultivators to aid development of the industry. These were interviewees more familiar with the aquaculture industry, including one who was actively considering seaweed cultivation. A UK seaweed industry



platform and aquaculture hubs were suggested to facilitate the dissemination of advice and guidance.

Finally, the topic of setting standards beyond regulation was raised, with suggestions including best practice guidelines and a certification scheme.

5. Q-method study results

This section provides a description of the Q-method study results. A brief overview of the quantitative results is presented before an in-depth interpretation of the factors, including the accompanying qualitative narratives.

The factor analysis of the 16 rankings resulted in three different perspectives, with a total explained variance between the factors of 65% (see table 3 where F1= 24%, F2= 17%, F3= 24%). We view these factors as discourses and interpreted the narratives accompanying the idealised sorts (see figures 5-7) through the “crib sheet method” [60]. In practice, this means that we focused on the distinguishing statements, those that differ the most across the three perspectives, as well as analysing the areas of consensus, the statements that the perspectives agree on (see table 2 in the supplemental materials). The three perspectives were given titles, based on the idealised sorts and the statements that distinguished them from each other; 1) Environmental sustainability and responsible practices, 2) smaller scales, local social benefits, and environmental sustainability and, 3) regulation and business development. Although both factors 1 and 2 have environmental sustainability as one of their priorities there are distinct discourses in the narratives between the factors, on how it should be achieved. These are detailed in the sections below.

Table 5. Factor matrix (Q sort results) where X is a defining sort using the automatic flagging in PQ method software.

Stakeholder Category	Sort no	F1	F2	F3
Aquaculture	1	0.4625	0.3043	0.3922
Government & Regulation	2	0.7624X	-0.0523	-0.0026
Aquaculture	3	-0.0299	0.7209X	0.4933
Aquaculture	4	0.6501X	-0.3008	0.43
Academia	5	0.8157X	0.1836	0.2428
Fisheries	6	0.2304	0.1227	0.6928X
Aquaculture	7	-0.0823	0.5777X	0.5689
Civil society	8	0.1672	0.1368	0.7114X
Civil society	9	0.7461X	-0.0372	0.3838
Civil society	10	-0.002	0.7795X	0.0001
Government & Regulation	11	0.8120X	0.3608	0.1483
Fisheries	12	0.4253	0.5319	0.3847
Aquaculture	13	0.5215	0.6948X	-0.0753
Aquaculture & Fisheries	14	0.03	0.2957	0.7093X
Others	15	0.3048	0.1108	0.6988X
Government & Regulation	16	0.2975	-0.2626	0.7107X
	% expl. Var.	24	17	24

				24					
			21	18	23				
		25	16	17	7	22			
	6	19	14	11	15	12	20		
10	5	13	9	3	2	8	4	1	
4	3	2	1	0	-1	-2	-3	-4	

Figure 5. Idealised sort for Factor 1, Environmental sustainability and responsible practices. The colour coding represents the different aspects of social license to operate where blue = economic legitimacy, yellow = social and political legitimacy, orange = interactional trust, grey = institutional trust, and green = environmental sustainability.

				24					
			22	21	25				
		18	14	17	20	23			
	13	12	6	5	9	19	15		
10	3	11	4	3	8	16	7	1	
4	3	2	1	0	-1	-2	-3	-4	

Figure 6. Idealised sort for Factor 2, smaller scales, local social benefits, and environmental sustainability. The colour coding represents the different aspects of social license to operate where blue = economic legitimacy, yellow = social and political legitimacy, orange = interactional trust, grey = institutional trust, and green = environmental sustainability.

				19					
			24	10	22				
		13	18	9	16	23			
	25	11	14	5	8	2	20		
17	21	6	12	3	7	1	4	15	
4	3	2	1	0	-1	-2	-3	-4	

Figure 7. Idealised sort for Factor 3, regulation and business development. The colour coding represents the different aspects of social license to operate where blue = economic legitimacy, yellow = social and political legitimacy, orange = interactional trust, grey = institutional trust, and green = environmental sustainability.

4.1 Factor 1: Environmental sustainability and responsible practices

The main priority of Factor 1 (F1) was environmental sustainability seaweed cultivation operations. The stakeholder categories of the interviews that were flagged as defining sorts for F1 included government and regulators, aquaculture, academia, and civil society. The narrative around environmental sustainability (statement 10) in the interviews was largely linked to the idea that seaweed cultivation is an opportunity to develop an industry that is low carbon and has ecosystem benefits. Some interviewees advised that the operators are in a good position to develop their practices towards environmental sustainability because of the nascent status of the industry, i.e., they do not have to undo bad practice. There is the opportunity to embed environmental sustainability from the offset.

“One of the reasons for doing seaweed farming is to gain net benefits and if you’re not mitigating risks of environmental impacts then you’re going against the whole reason for doing seaweed farming in the first place.” – A24

Further, F1 prioritised responsible behaviour (statement 5) and the provision of transparent information about farming techniques (statement 19) more than the other factor arrays. In the interviews these two statements were interlinked, with interviewees describing how information

provision could be part of responsible behaviour. Two interviewees pointed out that this is particularly the case if an operation has displaced other activities, specifically fishing.

"Now, if there is a big area that needs taken up for seaweed farming, as opposed to other forms of farming, of fish farming, aquaculture and so on, then it obviously has knock-on effects to a range of other stakeholders, primarily fishing communities of various sorts." – B15

Further down the rankings, F1 disagreed that co-operatives could be a viable development model (statement 12), and that seaweed cultivation should reduce environmental impacts of other sectors (statement 22) more than the other factor arrays. Interviewees comments on co-operatives ranged from viewing them as an inhibitor to competition, through to seeing them as one of many options for development.

"So, the thing about cooperatives is sometimes it would limit the ability of individual farms to develop their products and sell them separately because technically all their products are meant to go through the cooperative and cooperatives sometimes don't give the flexibility of selling different species. It's usually something like milk or cheese or muscles, it's usually one product, whereas a lot of seaweed farms or seaweed companies, that would be interested in using the shared processing and route to market, might actually have a number of different seaweed products. This is the weird thing, this is the thing about seaweed if we use the term seaweed but we're really talking about 20-odd species that could be potentially a viable option for route to market." – B7

Interviewees comments on statement 22 were largely around the fact that seaweed cultivation operations *could* provide environmental mitigation services to other sectors, but that it should not be the central reason for its development.

"I think at this early-stage other sectors needs to focus on what they can genuinely do within their own sector before going to offset using other things, such as seaweed cultivation." – A4

Finally, F1 ranked statement 1, large-scale seaweed farms run by multi-national companies is the way forward, as the lowest. All of the interviewees in this factor very strongly disagreed with large-scale globalised ownership models as the sole way for the industry to develop. However, most also advised that they would prefer other models, such as inshore and smaller scale and national or local ownership. The reasoning ranged from uncertainty about the local benefits of the sector if it was to be owned internationally, was large-scale, and offshore, through to social representations from agriculture, where that development/ operation model has caused significant negative environmental and social impacts.

"Large-scale seaweed farms run by multi-national companies is the way forward." I disagree with that one. If you look at history, and agriculture, the likes of Monsanto are perhaps some of the biggest polluters in terms of fertiliser and also emissions. We wouldn't want a similar thing to happen for seaweed cultivation." – A24

The linkages between F1 and social license to operate are two-fold. First, responsible operator behaviour has been directly linked to the development of social license within several industries, aquaculture included (see for example [7], [55], [56], [67] and the literature review in the

supplemental materials). Second, environmental impacts have been identified as one of the reasons for social opposition to expansion of other aquaculture sectors, finfish in particular (see for example [45], [68]). In early social license literature, the mitigation of environmental impacts through improved relationships with local communities was one of the core reasons for developing social license activities (see for example [15]). However, environmentally responsible behaviour in and of itself has not been identified within social license models as one of the direct means to developing social license. It has been assessed and modelled as a mitigation strategy, listed as a subset of other social interaction behaviours that develop social license (see [57] for social license model examples). However, F1 neatly demonstrates, through narrative and ranking, how environmental sustainability forms a core part of the interviewees position on social sustainability. Environmentally responsible behaviour of seaweed cultivation operations could therefore be seen as a social license garnering activity, in and of itself.

4.2 Factor 2: Smaller scales, local social benefits, and environmental sustainability

Factor 2 (F2) ranked several statements higher than in any other factor array. Environmental sustainability (statement 10) was ranked the highest and community benefits and local jobs (statement 13), and small and medium scale operations (statement 2) were both ranked second highest. The stakeholder categories of the interviews that were flagged as defining sorts for F2 included aquaculture and civil society. The interviewees within F2 had very strong opinions on environmental sustainability, and provided similar reasoning to those in F1, that environmental sustainability is the fundamental reason for the development of seaweed cultivation. One interviewee advised that sustainability was no longer enough, and that the industry could provide environmental benefits.

“...but people look at the sea and they think, ‘Oh, it hasn’t changed at all.’ Well, it is, we’re destroying it and we need to do something positive about it, not take the policy of the best thing to do is do nothing, because we’re using the sea as a drain, you know, for so much of our activities. So, we need to do positive things that can help the marine ecosystems.” – A15

In contrast to F1, the interviewees in F2 felt strongly that smaller scale farms with clear links to the areas they would operate in, would be a beneficial way for seaweed cultivation to develop. However, they also presented caveats; one, economic feasibility as a concern at smaller scales, two, it is likely that larger scales are where the industry will end up eventually and, three, the focus should be on site suitability for species grown and the local communities rather than a dictated approach to scale. Interviewees noted that within the current market-led approach to the development of seaweed cultivation, and to be competitive within the Europe in particular, would most likely require industry consolidation and larger scales.

“And though we are looking eventually at probably larger scale seaweed farms, it’s not that I think it’s the way forward I personally like to see smaller, not necessarily small farms, but farms that have a better and direct association with the, I hate to use the term communities, but the people that it’s kind of gonna be situated near. Like the towns and the villages that they will be situated near, I think that is probably... I kind of like the many small kind of approach, which actually was what salmon farming was in the early days and, to an extent, is what oyster and muscle farms are still. And it doesn’t have to be small ‘cause you do need a certain degree of a size, but I think a farm, and because there are so

many species you can grow, should be suitable for the place that it is located.” –

B7

“‘Locally run small to medium scale seaweed farms are the way forward.’ I think if they can find a niche and they can sell it, maybe.” – C24

However, F2 also strongly agreed that the industry should develop in a way that provides community benefits and local jobs. The reasons for agreement with that statement ranged from site context issues, such as the seasonality of jobs in the areas where seaweed cultivation is likely to develop, through to linking community benefits with the likelihood of an operation gaining social license to operate. Even though the same interviewees noted that the industry was likely to require development at scale, they also advised that it was important to retain the benefits to the areas that were hosting the operations. Interestingly, the majority of interviewees who felt strongly about community benefits and local jobs were those already involved in the aquaculture industry.

“‘Should provide community benefits and local jobs.’ It’s all about providing benefit for the local community and providing meaningful jobs. And yeah, in my opinion it’s about bringing money back into the area, ‘cause again, what we suffer with round here is kind of like... you know, very seasonal influxes of people and money so keeping the economic benefits local would make more sense, you know, giving money back to the people throughout the year.” – A6

At the other end of the rankings, F2 strongly disagrees that seaweed cultivation should take place offshore (statement 7) and disagrees that seaweed cultivators should be aware of the social contexts they work in (statement 16) and that operators should provide transparent information about farming techniques to the public (statement 19). These statements were ranked lower in F2 than in any other factor array. The main reasons for strongly disagreeing with statement seven included interviewees feeling that although offshore cultivation is an option, the location of farms should be based on the site suitability according to species and end-use and economic feasibility during the start-up phase. Likewise, they advised that although offshore cultivation should be an option, it is not the only option, and could form part of a suite of different site models and locations.

“‘I think maybe if you’re gonna do it for carbon capture but not necessarily for eating just ‘cause it’s a lot of transport and the whole idea is to try and take out carbon – if we’re gonna go offshore for it it’s a lot of fuel <laughs>.” – A6

“‘Now I am looking at developing offshore cultivation but I don’t think it necessarily has to be, I think there is a space for tank-based cultivation, which would be land-based, and intertidal. So, I kind of don’t go, ‘Seaweed cultivation should take place offshore’, it doesn’t have to.” – B7

The narrative behind the low ranking of statement 16 was the same across all of the flagged sorts for this Factor and was present in other interviews as well; that operators knowing the social contexts that they work in so obvious that it does not deserve to be given a higher ranking.

“‘Kind of agree with that but it’s kind of linked with all the other [statements], if you’re already engaging with local communities you should be aware of the social contexts that you are working in.” – B7

In contrast, the reasons provided for disagreeing with statement 19 ranged from advising that the public would be satisfied by knowing that the industry is regulated, through to suggestions that

providing information on seaweed cultivation in itself is not enough, it needs to incorporate education about the marine environment. Both very different reasons for giving a lower ranking to the statement, but with the same outcome – that giving information to the public is not a priority for Factor 2.

“...but it’s sort of widening the remit on ocean literacy for the wider public and more needs to be done. And I don’t think just seaweed in itself, I think seaweed in the context of the importance of the ocean.” – A4

The concept of large-scale multi-national models of operations for seaweed farming was seen as contrary to the desire for local jobs and community benefits by the interviews in this Factor and was ranked lowest in the idealised sort. Most interviewees advised that it was not the scale they were in opposition to, but multi-national ownership. Interviewees felt that local ownership, even with larger-scale operations, would provide more benefits to the local communities hosting the operations.

“I think large scale seaweed farms is a good idea, but multinational companies tend to sort of take money away from local areas. So, I agree they’d probably be able to do it bigger and better but, take us for example, it’s a bit like it’s keeping it within the community, all the money’s staying within the community kind of thing. That’s my view on that.” – A6

Factor 2 links with social license to operate in three ways. First, in a similar fashion to F1, is the prioritisation of environmental sustainability above all else. Although environmental sustainability is not directly linked with social license to operate per se, behaviours which go beyond compliance with environmental laws have been identified as a way that industry can sway local opinions of their operations [15]. The second is the strong agreement that as the seaweed cultivation industry develops, it needs to provide community benefits and local jobs, regardless of the scale of operations. Community benefits and local jobs have been highlighted by studies on social license to operate across several industries, as a fundamental part of developing a positive relationship between an industry and local communities [17], [52], [67], [69]. Third, the two studies specifically conducted on social license to operate for seaweed cultivation in Europe have shown that smaller scale operations are more likely to gain social license to operate than large-scale operations [7], [10].

4.3 Factor 3: Regulation and business development

The main priorities for Factor 3 (F3) were developing a regulatory environment that is fit for purpose and enables the industry to develop and expand. In other words, F3 very strongly disagrees with statement 17, that the current regulatory processes for seaweed cultivation are fit for purpose. Unsurprisingly, F3 strongly agrees with the opposite statement (statement 15). To prevent repetition, we will only report on the narrative around statement 17. The stakeholder categories of the interviews there were flagged as having defining sorts for F3 included fisheries, civil society, aquaculture, and government and regulators. The narrative accompanying the strong agreement with statement 17 presented several arguments for this perspective which includes that the resources and time required to apply for the relevant licenses outweighs the size and ready-ness of the UK’s current seaweed cultivation industry. Interviewees also advised that the current regulations are restrictive, difficult to understand, not available (e.g. on biosecurity), and/ or that regulators do not currently have the expertise or policy guidance to deal with applications. These perspectives came from all three case studies and across all interviews (including those that were not flagged). One interviewee neatly summed up the current situation between regulators and the industry:

“...because it is a nascent emerging industry here in the UK then regulation wasn’t ready for it and so what’s happened is that you have the early starters having the pain of going through regulation.” – A4

Another suggested that although regulations are difficult to navigate, seaweed cultivation organisations should engage with the regulators to try and better the situation.

“A lot of seaweed farmers currently are SMEs or your microenterprises and I think that if you’re trying to juggle a marine licence application alongside actually developing a business then that’s pretty difficult. But I think there is some onus still on the seaweed farmer to understand the regulatory framework and to actually work with the regulators and policymakers to improve that.” – C1

Factor 3 strongly agrees with statement 21, that seaweed cultivators should work with researchers to improve cultivation practices, and statement 25, that engagement should begin at the outset of planning. The accompanying narrative to statement 21 included the view that seaweed cultivation in the UK is relatively new, and that understanding the processes will help both regulators and businesses develop. Another interviewee noted that seaweed cultivation is currently receiving a significant amount of ‘hype’, and that more research would be able to differentiate between ‘hype’ and definitive benefits. Likewise, from three aquaculture practitioners, there was the perspective that research could contribute to more efficient and effective operations, improving the viability of the businesses.

“I think it’s paramount that they work with researches from the start-off. I mean that’s what I’ve been doing, getting marine biologists and stuff in because it is a grey area and I think there’s a huge amount of research that needs to be done in doing it. So, I think every single seaweed farm, I think that is really important that research is done from the offset rather than just seeing a blank canvas of possibilities out at sea. It’s very easy to get carried away and chuck a load of stuff in the sea and say you’re doing good, but you know fundamentally if it’s good or bad once the research is done at the early stage then that can be built upon year-after-year and really understand what’s going on.” – A13

For statement 25, the narrative was relatively simple, engagement is a) a necessary part of the planning and consenting process and b) engagement covers such a broad variety of activities that most companies will undertake it. However, there were two interviewees that noted that engaging with other marine stakeholders and local communities, without a plan, could prove counterproductive.

“I would definitely agree with that. I guess there needs to be an element of... a developer needs to have an idea about what they want to do and where they want to do it before they start that engagement process, but they need to begin that engagement as early as possible so that if there are local concerns or local issues that they could actually be taken into account during that site selection, site planning process. I think I would agree with that but caveat it by saying that equally developers need to kind of have an idea about what their options are before they can actually begin that engagement process.” – B38

Factor three ranked statement 1, large-scale seaweed farms run by multi-national companies is the way forward, and statement 2, locally run small to medium scale seaweed farms are the way

forward, lower than any other factor array. For statement 1, the interviews flagged in this factor provide the simple explanation that the industry requires a development stage in inshore waters, before offshore areas are expanded into.

“I mean I think as well because across the UK the seaweed industry is still fairly embryonic, I mean yeah, there’s some large scale farms going in off the Northeast Coast of England, for example, but it’s still fairly embryonic.” – C1

The interviewees also advised that small to medium scale farms would likely not be competitive in the larger markets, in the long term. In other words, smaller scales are required for the current readiness level of the industry, but larger scales are likely to be necessary for the UK industry to become competitive in the future.

“I think that we need large scale for us to be competitor in Europe, otherwise we will still continue to lag behind the rest of Europe and we won’t be a key player. I don’t think that having small scale farms will, unless it’s just to supply say local restaurants and so forth, will cut it for an industry.” – A4

The focus of F3, on regulation and business development, is reflected in the accompanying narrative, which tends to view the statements that directly link with social license to operate, as something for the future, when the industry has a good evidence-base to facilitate economically feasible operations and can work with regulators to aid expansion. The only direct link to social license that this factor prioritised was that engagement should begin at the outset of planning. Social license to operate research has shown that early and ongoing engagement can facilitate the development of trust between an operator and a local community [17], [69]. However, in the interviewee’s explanations, engagement covered such a broad range of activities that it might not necessarily align with those that foster trust between operators and communities. A less clear connection to social license to operate within this factor, is that the actions of regulators and trust in regulatory processes has circuitously been linked with community opinions of marine activities, where a lack of trust results in less positive opinions i.e. social license to operate may also hinge on good regulation and enforcement of regulations, particularly those pertaining to environmental impacts [21].

4.4 Areas of consensus across the Factors

Although the z-scores for the consensus statements are all non-significant at $P > .01$ (see table 2 in supplementary materials), they provide interesting insight into the topics that stakeholders found more or less important for the socially sustainable development of seaweed cultivation in the UK. There were five statements identified by PQ method: statement three, local economic benefits should be put above nation-wide economic benefits, statement 14, seaweed cultivators should engage with local communities, statement 18, seaweed cultivation is more environmentally acceptable than finfish cultivation, statement 23, seaweed cultivators should aim to reduce environmental impacts in other sectors, and statement 24, seaweed cultivators should learn from other areas or countries. For the purposes of readability and brevity (and considering the non-significance of these findings), this report will focus on the two consensus statements that were ranked the same across all three Factors, statements three and 14.

All of three Factors positioned the statement ‘*local economic benefits being put above nation-wide economic benefits*’ as a ‘0’. Narratives included critiques ranging from agreement to disagreement, many of the interviewees felt that they agreed more or less with other statements. However, interviewees also ranked it as ‘0’ because they felt that it was too ‘obvious’ or that the arguments were too complex to be encompassed within one statement.

“I think... for me that’s obvious so I’m not going to say I think it’s a priority.” – B7

“No, I’m not sure that is the case actually. That’s quite a detailed, difficult nuanced argument.” – B15

For some interviewees there was, to some extent, the desire for local economic benefits to trump nation-wide economic benefits, but for others, the practicality of such a caveat is questioned, due to the nature of cultivation practices.

“I think the local economic benefits and the seaweed cultivation for local markets, the fact that I’ve put them kind of slightly lower priority reflects my thoughts around the larger scale or the cooperative kind of industry that’s needed to provide longevity of jobs and longevity of careers and things rather than just like bit-part. ‘cause if you’re growing kelp, it’s a six month of the year operation pretty much, what do you do for the other six months?” – C1

The second area of Factor consensus was that the interviewees generally agreed with the statement 14, ‘seaweed cultivators should engage with local communities’, ranking it as ‘1’. In the narratives accompanying the ranks, some of the interviewees noted that community engagement is a legal requirement, so felt that it was less of priority for the ranking exercise as it is already a necessity. However, most simply agreed, with some suggesting that it is interlinked with community benefits and, being aware of the social contexts that operators work in. One noted that if communities are to be engaged and to benefit from cultivation operations, it would be more difficult if the farms are located offshore (statement seven), another suggested that engagement should be more than a box-ticking exercise.

“...if we want local communities to be, you know, kind of creating accessible [redacted of initiative] initiatives and stuff, I don’t think offshore should be priority.” – B15

The narratives around these consensus statements shows that although the qualitative rank of ‘0’ and ‘1’ assumes the importance of 10 other statements over statement three, and six other statements over statement 14, the qualitative account provides a more multifaceted story. Nevertheless, the statements of consensus (and the narratives behind them) provide a good base for understanding which areas stakeholders are more likely to agree with each other on. That is, to some extent, local benefits are seen as a given, albeit with caveats. This is worth considering as seaweed cultivation expands, and the industry consolidates. Management of expectations, for both local economic benefits and well as community engagement, need to be balanced with the economic feasibility of operations.

6. Cross-cutting results describing activities that contribute to social license to operate

This section presents (as a table 4) the results of both the null and the Q-method study interpreted through the lenses of the activities that were described by the interviewees and how they could contribute to social license to operate (using the pyramid model described in [section 2](#)).

Table 6. Characteristics of social license mapped against the activities that could contribute to them, the associated actors and the 'level' of social license likely to be achieved

Characteristic of social license*	Activity(ies)	Actors	'Level' of social license
Economic legitimacy – the belief that the operation can exist as a viable enterprise	All actors: Provide information to the general public, local communities, and communities of interest on how seaweed cultivation operations are economically viable. In particular, how the seaweed will be used, especially if the market is not food/ agriculture feed. Basic background information on seaweed value chains could aid understanding of the processes farm to product. In turn, improving perceptions of economic legitimacy.	Seaweed cultivation operators, downstream value chain, research and development (including science, businesses, and NGOs)	Acceptance
Environmental sustainability – the farms can operate effectively without compromising the biophysical environment's ability to function into the future	<p>Operators: Work with scientists to assess the environmental interactions of potential (or operational) cultivation activities including environmental benefits. Engage in environmental monitoring and adapt operations if there are negative environmental interactions, even if they are still within licensing conditions.</p> <p>Operators and regulators and policymakers: Engage with each other on issues arising from the knowledge gaps, (e.g. biosecurity), to help policy and subsequent regulation develop in a way that can facilitate trust in licensing and regulatory processes for communities of place and interest, stakeholders and operators.</p> <p>Scientists: Work with operators, regulators and policymakers to help provide the evidence needed to farm in a sustainable manner. Act as a "critical friend" to the precautionary principal, considering the urgent requirement for moving to low/lower-carbon industries, and industries that have the potential to provide ecosystem services.</p> <p>All: Communicate these activities (particularly ongoing monitoring and adaptation) and the findings to communities of interest and the communities that may host cultivation operations. This will inform perceptions of the environmental sustainability of the operations and may also begin to foster trust in the industry and its supporting structures (e.g. policy, regulation, science) as they develop.</p>	Seaweed cultivation operators, regulators and policymakers, scientists	Acceptance
Socio-political legitimacy - the perception that the project/ company contributes to the well-being of the region, respects the local way of life, meets the expectations about its role in society, and acts according to stakeholders' views of fairness	Operators: Early, ongoing and effective communication and engagement with relevant stakeholders and communities of place and interest about seaweed farming operations, can facilitate positive operator-community relationships. This can help with expectation management, particularly about community benefits, during the start-up phase of the industry, and also opens effective avenues for discussions about expansion. Likewise, engaging with other marine users on understanding complexities caused by displacement of ongoing activities due to new seaweed farming sites, at an early stage, could aid problem solving (e.g. planning the farm so that kayakers can navigate the lines, ensuring slipways remain accessible to other stakeholders, working with fishers to negotiate acceptable compromises on both sides etc.).	Seaweed cultivation operators, regulators, communities of interest and place, other marine users	Approval



	<p>Regulators: Development of specific seaweed cultivation strategy documents, within or as aside to current and future relevant marine policy documents, could help both seaweed cultivators and communities of interest and place understand where seaweed cultivation “fits” within the vision of marine developments for different countries and regions in the UK, before any specific planning processes commence. This could help manage expectations of operators, marine stakeholders, and communities of interest and place.</p>		
<p>Interactional trust - the perception that the company and its management listens, responds, keeps promises, engages in mutual dialogue, and exhibits reciprocity in its interactions.</p>	<p>Operators: Engaging in meaningful dialogue with key marine stakeholders and communities of place and interest as farming operations continue, can help to foster interactional trust. This takes time. It is also likely to be easier for smaller-scale operations that are locally owned as embeddedness within the local community allows for organic conversations (e.g. at school drop-off, during sports and leisure activities, on community forums etc.). For larger-scale operations that have owners who are not present in the local area, keeping track of interactions and requests, and following up in a timely manner, is critical.</p>	<p>Seaweed cultivation operators</p>	<p>Approval</p>
<p>*Definitions taken from [57]</p>			

7. Discussion

5.1 Null case study

The high level of unawareness of seaweed cultivation and lack of knowledge of processes and impacts relating to the industry was not associated with negative perceptions of it, either in general or for its potential development in the local area. To the contrary, there was general support for seaweed cultivation on the Suffolk coast, with no evidence of NIMBY-ism detected.

In the majority of instances, seaweed cultivation was perceived as benign or beneficial to the environment, in principle. Social benefits in terms of employment and local investment were also almost universally recognised. Concerns were mostly rooted in the behaviour of seaweed cultivators and, ultimately, whether they could be trusted to act in the best interests of the environment and society in which their farm was located. Consent was often conditional on sustainable practices being applied and caution was evident when considering the scale of operations.

Where there was doubt that best practices would be applied, respondents sought security through various means. Three key factors emerged as giving respondents the necessary confidence that seaweed cultivation operations would remain within socially acceptable parameters and providing the reassurance that the industry would develop in a controlled way: engagement, monitoring and adaptation, and regulation.

These three factors are essential components in the social safety net that reassures communities that seaweed cultivation in their local area is developing in a controlled manner with the interests of local stakeholders and impacts on the local environment adequately protected. The security provided by these factors facilitates Social Licence to Operate. Unlike the characteristics of seaweed cultivators, which may take a long time to establish and lack a clear roadmap to implement, these are practical activities that the seaweed industry, regulators and researchers can engage in to increase social acceptability of seaweed cultivation operations and good relationships between seaweed farmers and stakeholders. They will also contribute towards displaying those characteristics that stakeholders seek in cultivators, such as responsibility and transparency, and building trust.

5.2 Q-method study

Factor analysis of the Q-sorts revealed three statistically distinct accounts of how seaweed cultivation in the UK could be developed to be socially sustainable: 1) prioritisation of environmental sustainability and responsible operator practices, 2) growth of the industry at smaller site scales, prioritising local social benefits and environmental sustainability and, 3) prioritisation of improved regulatory processes and business development.

Environmental sustainability was perceived by Factors 1 and 2 as the core reason for developing seaweed cultivation. Factor 3 prioritised other areas, but still agreed that environmental sustainability should be a priority. A summation of all of the responses around environmental sustainability is this: if seaweed farming it is not environmentally sustainable, there is no point in doing it.

The differences between the factors were seen through their ranking of statements on scale of farming operations, local benefits, and local jobs. Factors 1 and 3 shared the view that smaller-scale operations were less likely to be economically viable or competitive in an international market, so the industry should be looking to utilise development models can be competitive (within environmental constraints). Factor 2 linked environmental sustainability with both smaller scales and local benefits and local jobs, suggesting that economic viability of such operations could be sought

through local and niche markets (such as high-end restaurants), and integration with other income streams, such as inshore fishing.

The main area of consensus across the factors was a strong to very strong disagreement with the statement *'large-scale seaweed farms run by multi-national companies is the way forward'*. All of the interviews advised that large-scale globalised ownership models generally result in negative consequences for the environment and for those who live near such operations. For some interviewees however, disagreement with that statement was about the ownership of the cultivation operations rather than the scale. They felt larger scales would be required for economic viability, but that multi-national ownership of the operations was undesirable.

Finally, across all of the Q-method interviews, there was a strong sense that the seaweed cultivation industry in the UK is in a challenging position, where it is not fully developed, but where there are significant expectations already being placed on it. There is a balance requirement here, of how many societal (including environmental) and economic aspirations can be built into the industry as it develops versus letting it develop to a point where it is more capable of taking them on.

5.3 Situating the findings within social license to operate theory

The findings from both the null and Q-method studies revealed several clear links between the way that seaweed farms develop and operate, including supporting structures (e.g. regulation and policy), and the likelihood of SLO. The aspects presented below are selected based on them new to SLO research, novel to seaweed cultivation, or ubiquitous across both the null case study and the Q-method study.

Environmental sustainability was at the forefront of all stakeholder groups' commentaries on seaweed cultivation operations. Most interviewees advised that as the industry is in a nascent stage, it has the opportunity to develop in a way that is intrinsically environmentally sustainable. However, it was also recognised that the regulation has to be there to support environmental sustainability as more players enter the industry. Likewise, that expectation management is required as seaweed cultivation is one of several industries with potential in the move to a low-carbon economy, and some of the current 'hype' might not be fully realised once enough environmental evidence has been collected. Environmental sustainability has been tangentially linked with social license to operate [15]; however, these case studies show that seaweed cultivation operations will not be socially acceptable unless they are environmentally sustainable from the outset. This puts pro-environmental behaviour of the operators and operations at front and centre of garnering social license to operate.

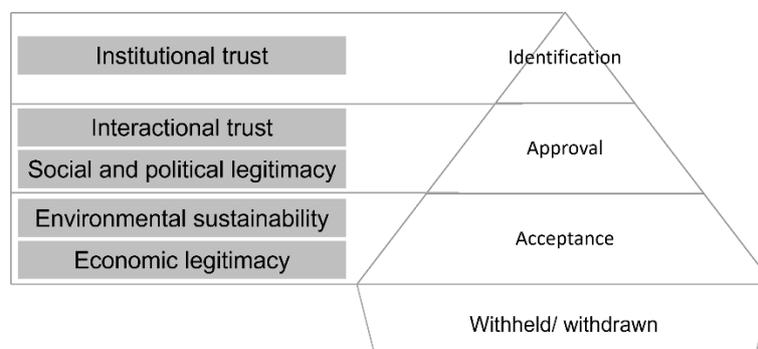


Figure 8. The amended pyramid model [57] of the levels of social license to operate, incorporating the new element of environmental sustainability at the 'acceptance' level.



The **policy and regulatory processes** related to seaweed cultivation are currently underdeveloped and require significant improvements to facilitate expansion of the industry in an environmentally sustainable manner, particularly in areas where there is no history of aquaculture. Perceived or real lack of knowledge of seaweed cultivation in the regulatory arena is frustrating to potential cultivators but could also result in a lack of trust by communities and marine stakeholders. Perceptions of accountability and control for the way the industry develops and operates was linked with positive perceptions of its expansion. Trust in regulatory processes has been shown to influence opinions of aquaculture operations and has directly hampered expansion discussions in France [7]. Interviewees in this study advised that the impetus was on both industry and regulators to work together to develop regulatory structures and industry strategies that are fit for purpose.

Community benefits, local jobs, and responsible operator behaviour within the areas where the farms are located was important to most interviewees, and across all stakeholder categories. This echoes the findings of a diversity of social license to operate literature, where these three elements feed into positive relationships, trust-building, and the socio-political legitimacy of the activity from a site-scale perspective (see for example [16], [17]). Responsible operator behaviour includes good communication with stakeholders and communities, reducing disruption to other marine users, and following environmentally sound practices.

Perceptions of **acceptable scales** of the industry were diverse. Interviewees in the null case study and Factor 2 in the Q-method study preferred smaller scales, but Factors 1 and 3 in the Q-method study preferred to view scale as a matter of context. Where sites are selected based on the biophysical requirements of the seaweed being farmed, and at scales where there is commercial viability. There were opposing visions for what the sector should and could look like, from very local markets and small scales, to internationally competitive and large-scale. However, there was a consensus that whatever scale operations were, they needed to fulfil the basic requirements of economic viability and environmental sustainability, with UK ownership being preferable. From an SLO perspective, this is a complex topic that intertwines with site selection and social context, ownership, regulation and planning, and critically, it has no direct conclusions or concrete recommendations. This suggests that the scale of an operation is highly context-dependent and any decisions on scale should be informed not only by business viability and regulatory constraints, but mutual dialogue with the relevant marine stakeholders and communities of interest and place.

Finally, across all of the Q-method interviews, there was a strong sense that the seaweed cultivation industry in the UK is in a challenging position, where it is not fully developed, but where there are significant expectations already being placed on it. There is a balance requirement of how many societal (including environmental) and economic aspirations can be built into the industry as it develops versus letting it develop to a point where it is more capable of taking them on.

6 Recommendations

This section presents 5 key recommendations of how the seaweed cultivation industry in the UK can begin to foster social license to operate as it develops. These are an amalgamation of prior work and the results of this study, which provide UK-specific context. They do not include the full plethora of characteristics that have been linked with SLO, as some of these are not currently realistic for the nascent state of the UK sector. We advise that these recommendations are updated as the industry develops and expands.

Environmental sustainability is fundamental to gaining SLO for seaweed cultivation in the UK. Although there is currently a general acceptance of the industry, this is reliant on its presumed green credentials and responsible operator behaviour. **Recommendation 1:** As operations multiply and



scale of site increases, effectively communicating evidence of environmental sustainability, and addressing concerns and questions from a range of stakeholders, about environmental practices, will become increasingly important. Adapting operational activities and plans for expansion as more science becomes available is also desirable.

Policy and regulatory processes are currently underdeveloped but are also perceived as a safety net for communities that have little to no understanding of aquaculture practices. A lack of trust in regulatory processes, particularly those related to planning and environmental impact, can impede development of SLO. **Recommendation 2:** The seaweed cultivation industry and relevant policy and regulatory bodies should engage with each other to address the issue of underdevelopment, and work towards a fit for purpose regulatory environment.

Responsible operator behaviour towards the communities they work in, and towards the natural environment, **community benefits, and local jobs** are intertwined with each other and with the likelihood of fostering SLO. Responsible operator behaviour, for example, could include provision of contextually relevant community benefits and local jobs can be seen as a community benefit where the industry is too small/ not profitable enough to provide other benefits. Included in responsible operator behaviour are also the ways in which operators interact with and respond to marine stakeholders and local communities. This is particularly relevant where seaweed cultivation operations displace other activities that people rely on for their livelihoods, such as fishing.

Recommendation 3: Engage in early and ongoing dialogue with relevant marine stakeholders about plans, to facilitate opportunities for compromise on design, operation, communication etc. Engage in timely (i.e. once sites have been selected, and plans are in draft form, but can be altered if required) and ongoing dialogue with communities local to the operation (including land-side operations) and relevant communities of interest. This should include basic information provision, as very few people know what seaweed farming is and what its end markets are. If possible, have a local person as the point of contact, and if the business is large, provide that person with the power to table changes based on their dialogue with stakeholders. As the seaweed cultivation industry in the UK is not yet at a stage where community benefits, outside of local job-provision, is feasible, operators should use local supply-chains as much as possible. Community benefits in other forms should be re-visited if/ when the industry develops to the point where this is economically feasible.

Context-specific approaches to development means growing the right species, in the right biophysical environment, at the right scale for economic viability and environmental sustainability, whilst “fitting in” with the local social setting. This is critical to SLO as perceptions of the viability of an operation play into perceptions of acceptability. What might be right for one area, will not be for another. Some areas will be able to and willing to accommodate large-scale operations, whilst others might prefer smaller scales but more of them, yet others might not tolerate any. This finding marries the biological and technical aspects of seaweed farming, with the social aspects, and highlights the importance of considering all of them together when planning for a new site or site expansion.

Recommendation 4: When planning for new sites, take into consideration a) how they might fit with local communities (e.g. is the area designated for beauty or conservation purposes, does the community have knowledge and skills relating to the marine environment, what are the local development plans on adjacent land for land-side operations, who are the neighbours and what do they do etc.), b) how it might impact current users of the area (e.g. fishers, yachting, kayaking, diving etc), and c) whether it will add to, make no difference to, or take away from the livelihoods and culture of people living in the area. These considerations should be developed in more detail on a site-by-site basis and according to the scale of the operation. If a large-scale operation is being



considered, then conducting a partial or full Social Impact Assessment might help gather the evidence that is required to choose a site with increased likelihood of developing SLO.

Education on seaweed cultivation, its environmental interactions, end uses, and definitions of seaweed industry terms are all necessary to increase the general public's knowledge of the industry, as it seeks to expand in the UK, to help inform perceptions. There is currently a low level of knowledge of what seaweed farming is. The lack of basic understanding of what the industry involves, risks people filling their knowledge gaps with experiences of other industries that they perceive to be similar or have similar risks to seaweed cultivation. Examples include, monoculture agriculture, fish farming, shellfish farming, mechanical wild seaweed harvesting, hand wild seaweed harvesting, forestry, sea ranching, fishing, and offshore wind energy. Some of these industries have undesirable public perceptions associated with them, which could result in degradation of the current positive opinion of seaweed cultivation and reduce the likelihood of farms developing SLO.

Recommendation 5: The seaweed cultivation industry, scientists, advocates, and other relevant parties (e.g. food and drink associations, biotechnology clusters, interested coastal forums etc.) should engage in activities to increase the general public's knowledge of what seaweed farming involves, from hatchery through to product. This should include both the positive and potential negative aspects of the industry, to facilitate expectation management around what it can achieve. This will help prime the general public for seaweed farming expansion and improve dialogue and consultations with local communities when it comes to planning processes and engagement activities. It may also be advantageous for the industry to develop an identity that is not associated with other controversial activities related to seaweed, e.g. mechanical wild seaweed harvesting. This could be done through industry wide use of the same terms and definitions in information packages and during communication activities.

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