Deliverable No. 8.2

Project acronym:

AquaVitae

Project title:

"New species, processes and products contributing to increased production and improved sustainability in emerging low trophic, and existing low and high trophic aquaculture chains in the Atlantic"

Grant agreement No: **818173**
Project co-funded by the European Commission within the
Horizon 2020 Programme

Start date of project: **1st June 2019**
Duration: **48 months**

Due date of deliverable:	30/11/2020
Submission date:	25/11/2020
File Name:	D8.2 Report on industry perceptions on current policy frameworks
Revision number:	01
Document status:	Draft/Final[1]
Dissemination Level:	PU [2]

Revision Control

Role	Name	Organisation	Date	File suffix[3]
Task leader Overall sections and contributed to section 4.1 and 4.2	Kåre Nolde Nielsen	UiT	16.11.20	KNN
Contributor (section 4.1)	Åsa Strand	IVL	19.10.20	ÅS

[1] Document will be a draft until it is approved by the coordinator

[2] PU: Public, PP: Restricted to other programme participants (including the Commission Services), RE: Restricted to a group specified by the consortium (including the Commission Services), CO: Confidential, only for members of the consortium (including the Commission Services)

[3] The initials of the revising individual in capital letters

Contributor (section 4.1)	Pernille Nielsen	DTU	19.10.20	PN
Contributor	Mercedes Fernandez Rosa Chapela	CETMAR	11.11.20	MM RC
Contributor (section 4.2)	Stefan Erbs	Bellona	25.10.20	SE
Contributor (section 4.2)	Ann-Magnhild Solås	NOFIMA	25.10.20	AMS
Contributor (section 4.3)	Isabel Sousa Pinto Itziar Burgues Gonçalo Marinho	CIIMAR	17.10.20	IS IB GM
Contributor (section 4.4)	Paul Tett, Suzi Billing, George Charalambides, Sofia Franco	SAMS	17.10.2020	PT, SB, GC, SF
Contributor (section 4.5)	Peter Britz	RhU	13.10.20	PB
Contributor (section 4.6)	Eric Arthur Bastos Routledge, Lucas Simon Torati	EmBraPa	20.10.20	EB, LT
Contributor (section 4.6)	Felipe Vieira	UFSC	20.10.20	FV
Administration Facilitator	Valur Gunnlaugsson	Matis	23.10.20	VG
Project Coordinator	Philip James	Nofima	23.10.20	PJ

Deliverable D8.2

Report on industry perceptions on current policy frameworks

30/11/2020

Executive Summary

Six workshops were held to gather insights from aquaculture producers and other stakeholders on what has promoted or constrained the development of low trophic species (LTS) aquaculture. The discussions focused on issues relating to public policy and regulation, licenses, food safety, and support for research, development and start-up, market aspects and industry organization. The workshops addressed macroalgae cultivation in northern Europe (Norway and Scotland) and in Southern Europe (Portugal), Integrated Multi-Trophic Aquaculture (IMTA) in Brazil and South Africa, and the case of offshore aquaculture (involving macroalgae and shellfish species) in a Nordic and a global context.

The study does not permit wide ranging generalizations, and outcomes of each workshop will be probably mostly informative in their own right. Nevertheless, overarching findings can be summarized as follows:

- A time consuming and complicated application process was identified as an impediment to the development of LTS aquaculture in all cases and regions.
- In South Africa and in Brazil, the further development of IMTA was noted to be impeded by regulatory deficiencies specific for this novel type of aquaculture. Similarly, regulatory uncertainty specific for offshore aquaculture was noted to lead significant investment risks, which consequently could constrain development of offshore aquaculture.
- In most cases addressed, workshop participants were concerned that novel LTS aquaculture production forms may be hampered by inadequacies in food safety procedures for the respective production forms and resulting products.
- The importance of financial support for R&D, innovation and start-up was highlighted in nearly all cases. Low trophic aquaculture has not developed yet to a mature and competitive industry segment, and its further development will depend on financial support.
- Public support was noted to be important for the development of LTS aquaculture in most cases. In some cases, it was noted to be important to analyze the positive effects of low trophic aquaculture. The findings from such analysis could help to inform the public narratives on aquaculture. This is important as public discourses in some cases do not distinguish between low-trophic aquaculture and less sustainable aquaculture forms.

Having workshops across the Atlantic has showed a certain common horizon of challenges for LTS aquaculture producers, policymakers, or researchers. Complex, rigid, and unbefitting regulations may hamper the development of novel LTS aquaculture systems.

The insights raised by producers in the workshops indicate that a good participatory system for industry in policymaking would improve the aquaculture governance in these specific new areas. Policymakers need to be more aware of macroalgae cultivation and IMTA, and markets should be further explored to develop these new policy arenas. Dialogue in the sector will pave the way for recommendations that can help to foster sustainable growth.

The public perception might be positive towards LTS aquaculture. However, this may not be the case in contexts where public discourses do not distinguish between LTS aquaculture and less sustainable aquaculture production forms. In such contexts, development of a more nuanced public debate could be supported through adequate dissemination of information on LTS aquaculture.

Mobilizing a co-creation approach, AquaVitae will organize high-level meetings with policymakers and industry representatives to address concerns regarding policy and regulations and discuss how these could be met. What this study contributes, is insights on what stakeholders perceive to either constrain or promote LTS aquaculture. This input is complemented by insights from the AquaVitae Deliverable 8.1, which reviews existing LTS legislation in the same countries and regions that have been addressed in this study. The findings of both studies will subsequently provide inputs for the later AquaVitae deliverables entitled “Recommendations for LTS aquaculture policy framework” (AquaVitae D8.3) and “Report on good practice for policy development for low-tropic level aquaculture” (AquaVitae D8.5).

Contents

1 Introduction

With an increasing human population, there is a need to increase the global production of food in a sustainable manner. As the fastest growing food sector in the world, aquaculture is considered as a sector with a crucial capacity to contribute to meet growing food demands (Subasinghe et al., 2009). In contrast to the farming of carnivorous fish species, aquaculture of low trophic-level species (LTS) such as bivalves and macroalgae is considered to have a strong potential for supporting sustainable expansion of food production (SAPEA, 2017; Barbier et al., 2019). This is because they are readily cultured, using them in aquaculture has few negative side effects and LTS have the positive environmental effect of reducing eutrophication levels in their environment.

It is therefore increasingly important to explore what respectively prevents or promotes the development of low trophic aquaculture. The AquaSpace project surveyed aquacultural producer opinions regarding the obstacles to expansion of the finfish and shellfish components of the industry in Europe and some other parts of the world (Galparsoro et al., 2020). Top of the list were “conflicts with other users”, making up 15% of responses; next were “administrative procedures/licensing“ at 12%. In total, “policy / management” (including the two items mentioned) made up 39% of responses, whereas “economic / market issues totaled only 17%.

Billing et al. (under review) explored site-scale social interactions of macroalgae cultivation within a developing commercial macroalgae cultivation industry (France) and an embryonic one (Scotland); they also surveyed macroalgae cultivation organisations across five European countries. They concluded that for large-scale multi-national owned macroalgae cultivation operations the default position for engaged stakeholders was limited trust, lack of consent, and legitimacy based initially on formal legal and planning processes, which led to the need to post-consent activities to gain social license. Conversely, local small-scale operators already had consent, trust, and informal legitimacy based on inter-personal relationships, placing them in a much better position to gain social license, or perhaps already had social license by default. Although there has been a widespread assumption that because macroalgae cultivation is environmentally relatively low risk (van den Burg 2019) it is therefore more socially acceptable than other marine aquaculture industries. However, this is not the case (Campbell et al., 2019). There are potential for unforeseen social and ecological consequences of the emerging macroalgae cultivation industry. The study by Billing et al. (under review), showed that inter-personal relationships, context-related perceptions of environmental risk, and levels of trust in regulators and operators, fed into social license for cultivation operations to the same extent as observations of, and views about, environmental impacts.

This report presents outcomes of an investigation of views of LTS aquaculture producers and other stakeholders on what respectively prevents or promotes the development of low trophic aquaculture. The focus is broader than what was the case for the studies referred to above, as it includes, but is not limited to, issues relating to public policy and regulation, licenses, food safety, and support for research, development and start-up. Other crucial aspects that are not directly related to the role of public policy and regulation, such as market aspects and industry organization, are also addressed.

The report is a contribution to the AquaVitae project, which has the main objective of increasing aquaculture production in and around the Atlantic Ocean in a sustainable way by developing new and emerging low trophic species, and by optimizing production in existing aquaculture value chains. Through collaboration on research and innovation, and by contribution to a cross-Atlantic policy and

stakeholder dialogue, the project aims to increase cooperation, knowledge exchange and learning in the Atlantic area on issues relating to LTS aquaculture.

Challenges or barriers to LTS aquaculture might be local or common to several regions and production systems. Similarly, solutions might be found that have applicability in other contexts. This makes it reasonable carry out a comparative study, with the aim of identifying specific as well as common challenges. The value chains that AquaVitae will focus on include macroalgae production, integrated multi-trophic aquaculture, production of new echinoderm species, underutilized shellfish, as well as finfish species and cross-cutting topics (by-products and feeds). The value chains are investigated through 13 case studies in the project. Due to resource limitations, the scope of this report was limited in terms of the value chains and case studies covered, as well as the countries where they were addressed. Consequently, the scope of the present work was limited to include macroalgae cultivation in northern Europe (Norway and Scotland) and Southern Europe (Portugal), and Integrated Multi Trophic Aquaculture (IMTA) in Brazil and South Africa. In addition, the case of offshore aquaculture (involving macroalgae and shellfish species) was addressed in a Nordic and a global context. While this selection left out some of the case studies and value chains in AquaVitae it is sufficient to allow for comparisons between similar LTS production types across Atlantic regions (IMTA in South Africa and Brazil) as well as within an Atlantic region (macroalgae cultivation in Northern and Southern Europe). Another reason for focusing on macroalgae and IMTA systems is that these generally represent some of the more mature case studies within the AquaVitae project in the sense of being closer to a commercial production scale. This is important because discussions about cases representing a higher Technology Readiness Level are likely to reveal more insights on what respectively constraints or promotes a development of low trophic aquaculture.

This report complements, and can be read together with, the AquaVitae report “Report on current policy frameworks for aquaculture (D8.1)”. Outcomes from these two reports will provide inputs for “Recommendations for LTS aquaculture policy framework” (AquaVitae D8.3) and “Report on good practice for policy development for low-tropic level aquaculture” (AquaVitae D8.5).

As described in more details in the following section, a series of workshops was arranged with producers and other stakeholders with experience from the context of these case studies to identify where regulation and policy have supported or inhibited innovation, and route to market and to identify common inhibitory or supportive mechanisms. The outcomes of these workshops are presented in section 3, which is the main section of the report. This is followed by a discussion (section 4) and a short conclusion (section 5).

2 Methodology

The research reported in this document aimed to examine the opinions of producers about policy frameworks, with the following core research question slightly modified from that in the AquaVitae DoA:

- How do regulation, and policy, support, or hinder companies' start-up, growth, innovation, and route to market? How do producers think that regulation and policy might be improved?

This section gives an overview of the methods used to answer this question, explains why they were chosen, and considers limitations on information gained in these ways. In overview, AquaVitae partners made use of meetings arranged for other purposes to hold face-to-face workshops or distribute questionnaires, and in some cases followed these up with telephone interviews. These events took place between October 2019 and February 2020 and are summarised in Table 1. As they were being planned, a general-purpose workshop protocol was drafted with the aim, as far as possible, of ensuring comparability of findings across the individual studies.

Fig.1 Overview of workshops and their locations. More details in Table 1.

Table 1. Overview of workshops and other information gathering events held in support of task 8.2

Event	Date	Value chain(s)	Region and country	Attendance
Workshop on offshore aquaculture	16.10.19-18.10.19	Macroalgae and bivalves	Nordic and global focus	Workshop with 31 participants (producers, researcher, and public administrators)
Workshop on macroalgae cultivation in Norway	25.02.20	Macroalgae	Europe / Norway	Workshop with 27 people (producers, research, and public administrators)
Questionnaire at Scottish Seaweed Industry Association meeting	18.02.20	Macroalgae	UK / Scotland	25 workshop attendees contributed opinions in a survey (out of about 60 total)
Workshop on macroalgae	22.10.19	Macroalgae	Portugal	Workshop with 20 participants (mainly producers, regulators, and researchers)
Workshop and telephone interviews on IMTA	12.11.19	IMTA	South Africa	Workshop with 31 producers and selected interviews (government representatives and industry)
Workshop on IMTA within Brazilian National Shrimp Fair	15.11.19	IMTA	Brazil	Workshop with 25 participants (producers, researchers and aquaculture students)

2.1 General-purpose workshop protocol

A protocol (Annex 1) containing general workshop questions and an information letter to be sent in advance to workshop participants was drafted during the summer 2019 to provide guidance on preparing and delivering workshops that complied with General Data Protection Regulation (GDPR) and ethical guidelines. The general questions and their purposes are summarised in Table 2. The

specific questions and the information were adapted to the workshop topic, context, and the time available.

Table 2: general-purpose questions that could be used to elicit opinions

Introductory (intended to 'warm-up' participants for detailed questions	What are the main challenges with setting up and developing an aquaculture production company? What are the main challenges for growth and expansion? What are the main factors that support or hinder development and expansion?
Support for [IMTA/specific LTS aquaculture] development	How have a) policy, b) regulation and c) stakeholder groups supported your company's start-up, growth, innovation, and route to market? We are particularly interested in any aspects specific to [the type of aquaculture in question: IMTA, macroalgae, offshore]. How important is each type of support? Please provide examples.
Constraints on [IMTA/specific LTS Aquaculture] development	How have a) policy, b) regulation and c) stakeholder groups constrained your company's start-up, growth, innovation, and route to market? We are particularly interested in any aspects specific to [the type of aquaculture in question: IMTA, macroalgae, offshore]. How important is each type of constraint? Please provide examples. At which level (i.e. international, national, regional, local) do you see that these constraints are located? Do you know how they have been or could be addressed, e.g. by proposing alterations to current frameworks, or lobbying? Do you feel empowered to do this?
Pathways to improving policy and governance	What are your thoughts on/ overall perception of the level of support provided by current governance frameworks applied to your business? What is your overall perception of the level of agreement/balance between policies for environment/societal protection and policies to enable business growth? In which cases has this protection been helpful or unhelpful to development? Could you identify improvements to regulation and policy? In your opinion what should be done/changed? How and by who (at which level)? What do you think would be the benefits of such changes? What do you foresee as the challenges to making/implementing these changes?

2.2 Workshops

Workshops provide a public forum in which participants can be informed about context and can discuss, understand, and reply to the questions. Participation has been found to work best when group size is small, generally with ten or fewer people, and when skilled facilitators encourage engagement of participants and conversations amongst stakeholders as well as with workshop leaders. Ideally participants should be able to review and comment on the written account of workshop findings. Issues that might influence findings include: procedures by which participants are selected to ensure that they are representative of the target community; articulateness of participants, bearing in mind the language and vocabulary used; participants willingness to engage in productive discussion instead of, or as well as, simply communicating the views of their organisations.

Stakeholder workshops were the only, or main, method in five out of the six studies. Detailed descriptions of the way they were carried out, are provided in the reports that follow; each study was an adaption to local conditions and issues.

2.3 Questionnaires

Whereas the flow of information in a workshop is ideally synchronous and three-way (from organisers to participants, from participants to organisers, and amongst participants) that in questionnaires is asynchronous and two-way, and does not allow participants to achieve a common understanding with each other or organisers as to the meaning of the questions. Nevertheless, paper or electronic questionnaires were efficient ways of collecting information about opinions, and minimised demands on participants' time. The latter is important in cases where 'stakeholder fatigue' is significant.

Questionnaires can provide a quantitative data by means of tick-boxes, questions about priorities or intensity of response. In addition, write-in boxes garner qualitative data that can be used to expand or explore opinions.

Questionnaires were the main method in only one study (Scotland). They were used there because of multiple demands on the time of those participating in the event used to deliver the questionnaires; the LTA industry is small in Scotland, and many stakeholders had already been involved in workshops on similar topics.

2.4 Telephone Interviews

Interviews using telephones and semi-structured (or open-ended) questions allow more flexibility and interactivity than do questionnaires. They expand the reach of a study beyond those who are able or willing to attend face-to-face workshops. They were used in only one study (South Africa), in order to supplement the findings from a workshop.

2.5 Selecting participants

The aim of the task leading to this deliverable was to discover the opinions of persons involved in low-trophic aquaculture value chains, concerning regulation and policy for LTA. Thus, recruitment of relevant and representative stakeholders was crucial, and was largely addressed by embedding workshops or questionnaires in events organised by or for the LTA producers. This approach avoided many of the practical, ethical and data-protection difficulties associated with identifying and engaging persons representative of the population involved in LTA; indeed, in cases where the industry is small, the events were reckoned to involve the majority of producers. There was however a complication, to be considered in analyses, in that workshop participants and questionnaire respondents included researchers and public officials.

3 Outcomes

3.1 Workshop on offshore aquaculture

3.1.1 Introduction and scope

Despite a declining growth rate, the human population is predicted to approach 10 billion people by 2050 (UN 2019), increasing the need for sustainable food production globally. As the fastest growing food sector in the world, aquaculture is considered a key sector with a capacity to contribute to meet growing food demands (Subasinghe et al., 2009). However, the potential to expand aquaculture is often restricted to coastal areas, where aquaculture competes for space with other maritime activities. For this reason, aquaculture is predicted to expand into offshore areas. Fish farming further from the shore may have less negative environmental impact than it has in near shore areas but may still be a source of environmental concerns (Holmer, 2019). In contrast to the farming of carnivorous fish species, aquaculture of low trophic-level species (LTS) such as bivalves and macroalgae is considered to represent excellent candidates for supporting a sustainable expansion of food production (SAPEA, 2017; Barbier et al., 2019). This is the case as they are readily cultured, and as they have positive environmental effects, notably as they reduce eutrophication effects.

It is important to note that the term "offshore aquaculture" is unclear and often inappropriate (Troell, et al., 2017; Bak et al., 2020)[4]. Although the term is understood in different ways, "offshore" generally refers to a geographical dimension (e.g. distance to the shore or to the baseline[5]). For instance, a report by the Norwegian government considers aquaculture beyond 1NM from the baseline as offshore aquaculture (Norwegian Government, 2018). However, the issue of exposure is often at least as important as the geographical aspect, and this has motivated pragmatic definitions such as the definition adopted by the FAO (Kapetsky et al., 2013):

> "In general Offshore Aquaculture may be defined as taking place in the open sea with significant exposure to wind and wave action, and where there is a requirement for equipment and servicing vessels to survive and operate in severe sea conditions from time to time. The issue of distance from the coast or from a safe harbour or shore base is often but not always a factor" (Drumm, 2010).

The main driver for moving aquaculture offshore is the competition for space in areas that are particularly attractive to other uses. When looking for space to expand aquaculture, moving production further away from the coastline is not necessarily the most relevant or feasible alternative. In practice, it is often more relevant to discuss opportunities for expanding aquaculture production into "high energy environments", which refers to areas that are either near shore or offshore. The competition for space is less intense in high-energy environments because they represent technically

[4] The definition of offshore/open ocean/high energy areas is currently under review in the ICES Working Group on Open Ocean Aquaculture lead by Prof. Bela H. Buck. (https://www.ices.dk/community/groups/Pages/WGOOA.aspx (last visited 12.10.20).

[5] The United Nations Convention on the Law of the Sea defines the baseline as is the line along the coast from which the seaward limits of a state's territorial sea and other maritime zones of jurisdiction are measured ((https://en.wikipedia.org/wiki/Baseline_(sea) (last visited 19.10.20).

challenging environments for many maritime activities. Consequently, high-energy environments are also less attractive as aquaculture sites from a producer's perspective than near shore areas.

The capacity for LTS aquaculture production in high-energy environments (including offshore areas in a geographical sense) is progressing in terms of research and development, experience with siting, management arrangements, and market development. This, however, poses new technical challenges and a need for revised governance structures related to regulatory aspects and co-use of areas (Norwegian Government, 2018), logistics, food safety, and funding to support development of LTS aquaculture in highly demanding environments. To gain insights from practitioners, researchers, and managers, a workshop was set up to address status and challenges with expanding LTS aquaculture in offshore areas and high-energy environments, with a particular focus on technology development, policy and regulation issues and social perspectives.

3.1.2 Approach

The international workshop "State of the art and future development of LTS culture in high energy environments" was held at the Kristineberg Research and Innovation Centre, Sweden, 16-18 October 2019.

In addition to plenary sessions, the workshop included sessions on technology, policy and regulation, and social aspects of aquaculture development[6]. The session on policy and regulation issues for low trophic offshore aquaculture was developed and held to serve the specific needs of the task in the AquaVitae project, of which this report is an outcome[7].

A set of questions on policy and regulation issues was developed and discussed in three groups in the workshop. The set of questions was distributed to the workshop participants in advance, together with an information letter that described how, and under which conditions the information would be used, as consistent with GDPR requirements (Annex 2).

The workshop was attended by 31 participants from 11 nations, including aquaculture producers with experience from offshore and high energy environments, administrators and political representatives, and researchers and engineers. The groups were designed to maximise the diversity of expertise, such that each group comprised persons with hands-on experience with commercial or non-commercial offshore aquaculture, expertise in research/engineering, and expertise in policy, regulation and decision-making concerning aquaculture. Additionally, the groups were set up to cover different geographical focus areas, ranging from Nordic to global perspectives. The outcomes from the three groups were subsequently synthesised into a single text.

[6] The workshop was chiefly arranged and lead by Åsa Strand, and resulted from cooperation between several research projects, including AquaVitae).

[7] The workshop session on policy and regulation issues was designed and lead by Kåre Nolde Nielsen.

3.1.3 Outcomes

The discussions on what respectively promotes or constrains a development of LTS aquaculture in high-energy environments were informed by the experiences of the participants, which mostly related to European countries. This experience is, for the most part, described in the form of vignettes providing perspectives on policy, regulation and management issues in European countries, but also includes a section on USA perspectives, providing insights from a context where macroalgae farming has become a more widespread activity. This was followed by cross-cutting sections on social dimensions of offshore aquaculture, co-use of areas, and on how LTS aquaculture development within and beyond the baseline can be further supported. To end, main findings from the workshop are briefly presented.

Background and concepts

The notion of offshore aquaculture was discussed. The terms "aquaculture in high energy environment" and "exposed aquaculture" are appropriate for capturing the main aspects of offshore aquaculture and is seen to mainly represent a design and production challenge. However, the geographical notion of "offshore", i.e., the distance from the baseline of a coastal country, is relevant when addressing the regulatory frameworks relevant for aquaculture production[8].

Regulations and allocations relating to fisheries and for nearshore aquaculture were developed in the 1970s and 1980s. While the development of offshore kelp farming, as well as of other forms of LTS aquaculture, have gained traction more recently, regulations and allocation mechanisms to support this have not been developed in general. New Zealand has been identified as the first country to adopt legislation for integrated coastal zone management until the 12-nautical mile limit of its territorial sea (Makgill and Rennie, 2012). As such, New Zealand may be taken to represent a pioneering country in terms of providing a legal framework that provides for offshore aquaculture.

European perspectives on policy, regulation, and management

EU countries are required to have a Multiannual National Strategic Plan for the development of aquaculture activities (European Commission 2016), and this supports aquaculture development[9]. The importance of area planning was highlighted by the observed that the short coastline available to Belgium (68km) has necessitated very detailed spatial planning, which potentially benefits aquaculture development.

Participants expressed a perception that aquaculture is given a low priority in spatial planning processes compared to other marine activities. This creates a risk that aquaculture will be left with areas not regarded suitable for other uses, and they may not be well suited for aquaculture either. Another concern raised by the workshop participants was that it is problematic if decision-makers mainly receive information on biological constraints. Information on technical and logistical constraints will also be critical from a producer's perspective.

Within the territorial sea, there is generally a potential for streamlining the regulatory framework, notably for the application for licenses. There is a need for an enabling policy environment that facilitates that aquaculture developers can easily go through the permit and establishment process. For instance, the Swedish Agricultural Board has recently completed a review of the current legislation connected to aquaculture permits as requested by the Swedish government. It was observed that high

[8] Presentation by Bela Buck at the workshop (17.10.19).

expectations have been invested with this task[10]. However, a workshop participant expressed the view that the revision work is insufficient, as it has a strong focus on fish, and that similar previous initiatives of this kind have not resulted in significant changes.

Access to coastal space or sites for aquaculture is limited by delays in the administrative process, and the protracted process of obtaining approval of sites hinders development. Meeting participants deemed uncertain if moving to high energy or exposed areas could curb this problem. Better legal advice, targeted training in the problem context, and better information could help the administrators to make decisions quicker.

As producers are subjected to time pressure, it was considered helpful to have an organisation that can support producers with the application processes. This is the case in Ireland, where aquaculture has been prioritized and regarded as a significant element of economic developing strategies. Similarly, in Germany there is a "regulatory scout" that can help applicants through the application process in a complicated regulatory environment.

On a national level, recent legislation has been developed and adopted to allow establishment of offshore windfarms (e.g., Germany). This happened as there was a noticeable policy driver for getting this legislation in place. Before this legislation was in place in Germany, an ordinance was drawn up for companies to apply for building offshore wind farms, which would otherwise not be possible. This shows that it is possible to shorten legislative delays for offshore aquaculture provided that the political will exists.

Policies and regulations are needed for aquaculture production beyond the baseline in many European countries. One way forward could be to include aquaculture provisions in marine spatial plans extending until 12 NM. Issues relating to food production should be included in marine spatial plans. It was noted that EU legislation can override national legislation, but as to date, the aquaculture governmental departments fall under different sectors across the EU (i.e., under an Agriculture Department or a Fisheries Department). Beyond the territorial sea, it will be too risky for companies to invest in offshore aquaculture without an established regulatory framework.

It was observed that coastal planning is subjected to overlapping jurisdictions, and that this causes problems in decision making and planning. If no measures are taken to improve the situation, this would lead to a situation where too many different authorities are involved in the prospective management of offshore aquaculture, for which can be expected to be complicated due to interaction with other maritime activities. However, offshore aquaculture may also represent an opportunity for simplifying the legal and regulatory framework for aquaculture (Norwegian Government, 2018).

In many countries involved in offshore aquaculture (research, development and/or commercial production) there is no clear regulation. A complicated and unclear application process is often a constraint for aquaculture expansion, not least in areas beyond the baseline of the countries. In general, the lack of a legal and secure framework for aquaculture in the outer areas of its territorial sea and beyond represent a hugely important barrier for development of offshore aquaculture production.

Norway

In Norway, the government granted free production licenses to companies that committed themselves to develop prototypes of installations for offshore salmon aquaculture (i.e. so called "development licenses"). Once the prototypes are developed, the companies can convert the development licenses to ordinary production licenses. As the latter licenses are very valuable, this arrangement provides

[10] At the time of writing (late October 2020), a proposal for simplifying aquaculture regulations had been submitted to the Swedish government.

strong incentives for companies to invest in research and development of offshore aquaculture designs. Two of these prototypes are now in operation. Although these prototypes are located within the baseline, they are designed to withstand the forces of exposed locations further offshore. A recent report (Norwegian Government 2018) observed a scope to simplify the application for aquaculture licenses in Norway in the area beyond the baseline + 1NM, which surpasses the area within which the municipalities have authority.

Sweden

In Sweden, municipalities administrate waters within the baseline + 1NM. In waters beyond the baseline + 1nm and until the limits of the territorial sea[11], both national and municipal planning is in place. For most of the waters beyond 300 meters from shore, one needs to seek a permit from "Kammarkollegiet" (the Chamber collegium) to use this water as it is considered a state resource. Within 300 meters from land, the landowner usually owns the rights to the water, but ownership is often not easily established.

Inside the territorial sea, there is an attempt to streamline regulations in Sweden. In theory, the same number of permits would currently be needed beyond 12NM as within. There are, however, no aquaculture farms in the Swedish EEZ beyond territorial waters. Such permits would need to be handled on a national scale, as the county municipal boards do not have jurisdiction beyond the territorial waters.

At a national level, politicians present aquaculture as the "future" and there is an action plan for development of aquaculture, however the action plan is weakened by an absence of measurable goals. It was noted that there is little support for aquaculture at a start-up level.

Researchers and entrepreneurs have obtained permits for commercial test plants for macroalgae production. It is easier to obtain such a permit if it is limited to a production area no larger than 0.3 hectares. It takes less than 6 months to obtain permit for a small production site, and it could take 3 years or more to obtain a permit for a larger one. There is at present no clear practice in how to handle macroalgae farms, but mussel farms have a clear permit protocol.

UK

In the UK, aquaculture producers benefit from a system to apply for a lease to get ownership of the stock. This provided protection from others harvesting the area. A drawback of this system is that the application process is very complicated and long. Similarly, aquaculture development is supported through a planning system that identifies areas suitable for aquaculture, but it was noted that the processes to obtain a permit is complicated.

Authorities support aquaculture, for instance in relation to identification of Natura 2000 sites. However, at the recently hosted NAEMO workshop[12], nature protection and agencies involved in nature protection were identified as an obstacle for aquaculture development, and this issue should be addressed further.

When considering how aquaculture development can be supported, lessons can be learned from a comparison of the aquaculture development within the UK. In Scotland, salmon farming has become

[11] The territorial sea extends until the baseline + 12NM, but the Swedish territorial sea is further limited in the certain areas, following agreements with adjacent countries. https://www.msp-platform.eu/sites/default/files/download/sweden_january_2020.pdf

[12] https://www.scottishaquaculture.com/news-events/neamo-workshop-oban-30-oct-2019/ (last visited 10.10.20)

a large industry with support from government. This can be contrasted with the development in Wales, where aquaculture is a small scale and a less coordinated industry. When the industry consists of few and small companies, it will not have a strong voice. Larger companies have the capacity to influence politicians' views on aquaculture, which in turn may lead to broader acceptance of the industry.

The existence of an organisation of private companies and institutes connected to marine activities, which are paying membership (the Blue Cluster) is considered positive. Governmental funding is allocated to the cluster and can then be distributed to projects suggested from partners within the cluster. In Wales, the presence of a Seafood cluster was observed to create support for the seafood industry, including aquaculture.

USA perspectives

In the USA, individual states have jurisdiction over "state waters", generally extending 3 NM seaward from the shoreline. While the US officially recognizes a territorial sea (0 to 12 nautical miles) and the contiguous zone (12 to 24 NM), these have little influence in relevant legislation. The regions outside of state waters and within the 200 NM EEZ are generally referred to as "federal waters" and are managed by the US federal government.

A few states have recognized areas of interest for commercial aquaculture, but these zones are generally not adopted in state or federal legislation. As per a 2018 court decision and pending legislation, it is unclear whether any federal agency has authority to manage aquaculture in federal waters. In the absence of a legal framework, producers will depend on good contacts in the administration to increase the chances of obtaining a license. There are presently one experimental and one commercial shellfish culture operation in federal waters, respectively on the Atlantic and Pacific coasts. Additional mussel and finfish farms have been proposed for federal waters off the coasts of California and Florida, respectively. Companies developing these farms are working with multiple agencies to obtain various permits for their operations.

The "kelp revolution" in the near shore areas of Maine represents a successful case of expansion of macroalgae production. Many farmers are young women, having a positive impact on the gender balance in the sector. The necessary investments are limited, and in general the entry barriers for new producers are small. Macroalgae farming was associated with public opposition at start, but the public perception of the industry was changed by young producers speaking with an informed voice at public hearings on permits. The industry is seen to have several positive impacts, including enhancement of socio-economic aspects, and the production of sustainable food. The industry had thus gained a wide social acceptance. It is relatively easy to obtain licenses for small scale production. The application process is simplified to "1 stop shop" arrangement, as is aimed for in Germany. Different lease classes are available. "Limited-Purpose Aquaculture" leases are the easiest to obtain, but production area that members of a single family can apply for is limited. "Experimental" and "Standard" leases allow more production but require more from the applicant. This regulatory framework has been developed for the area within state waters (3 NM), and a similar framework will be needed for areas further from the coast as well.

Currently, the expansion of small-scale kelp production has not led on to large-scale and offshore production. In addition to regulatory uncertainty and complexity, there may be several reasons why this is the case. There is a lack of personnel with relevant offshore experience. Furthermore, to get permission to establish a large-scale production plant, the producer will need to demonstrate durability and safety. There are no design standards for offshore kelp and shellfish production such as those for e.g. salmon farms in Norway. In the absence of such standards, engineers must be overly conservative in their designs, in order to avoid risks. Such conservatively designed offshore production structures are costly to construct and deploy. Finally, the market may also represent a bottleneck for large scale and offshore production.

Co-use of areas

Pros and cons of co-use of areas, notably wind power installations and aquaculture, were discussed.

Major benefits for locating aquaculture in wind farms were mentioned to include a shared permit processes, hence reducing the risk of permit process delays; that the facilities are more protected from boat traffic; and that there are often port facilities available in relation to wind farms. It takes years of gathering information to achieve the permissions necessary for large-scale aquaculture facilities, and this process can be significantly reduced through co-use of wind farm areas, where most of the required information is already available. From the wind farm perspective, having LTS aquaculture in the area could represent favourable public relations (PR) opportunities. This is the case as offshore petroleum companies have earlier used the case of enhanced fisheries around oilrigs for PR purposes. The question was raised, however, whether the potential PR benefits of co-use with LTS aquaculture would outweigh the perceived disadvantages from a wind power perspective. There is some opposition to establishing more wind farms. Including aquaculture in wind farms may contribute to reduce opposition towards wind farms by presenting a more efficient use of the area and by adding another sustainable activity. In Belgium, fish aquaculture production is not allowed to increase nutrient levels in the water, unless the nutrient discharges from the production are compensated. This presents LTS aquaculture in wind farms as an option for achieving the compensations required for fish farming.

The opinions regarding the attitudes within the windfarm sector towards aquaculture were perceived to be somewhat mixed. In older wind farms, there is a tendency towards a negative attitude towards aquaculture, often resulting in impossible guidelines for establishment such as over dimensioning of anchoring systems, expensive insurances and specific requirements on vessels. The windfarms are more prone to accept restoration projects that require less maintenance and less gear floating on the surface. In other cases, wind farms are beginning to see the benefits of having aquaculture in the area and are reaching out to make this happen. Furthermore, new windfarms may have an obligation to support other activities than wind. There are ways to increase the incentive for aquaculture in wind parks. For example, in Korea, fishers are offered a benefit, for instance, producing seafood, if they allow offshore wind farms.

Furthermore, there are challenges with co-use of areas. The main concern raised was that areas selected for wind farms are not necessarily the best for aquaculture. This was highlighted in the question: why would you choose to put a farm in a wind park if you could choose not to? Wind farms are windy! There are also logistical challenges with offshore aquaculture in windfarms, for example requirements of special boats that are approved by the wind power company. In the view of workshop participants, there is a risk of repeating mistakes from near-shore culture site selection, where aquaculture is often given permission or is directed to areas no one else is using, which from an aquaculture perspective may not be the best sites. It was raised that co-use is not a question of choice in some areas, it is simply a must due to space limitations.

In Europe, an action plan for multi-use of areas has been developed within the H2020 project MUSES[13]. In addition, the SOMOS project conducted research on production of macroalgae in combination with wind energy[14]. In this context, issues relating to potential regulation and permits are discussed but have not been resolved yet. There are designated areas for offshore windfarms, and a demand for activities in these areas that can operate alongside wind power (co-use activities). Although this remains difficult in practice, aquaculture is considered an option for multiuse in wind power areas, where other activities such as fisheries are not considered desirable or possible. Restoration of oyster reefs is another area that may be more welcome and less problematic in these areas.

[13] https://muses-project.com/ (last visited 10.10.20)

[14] https://www.wur.nl/upload_mm/7/a/5/3991d341-3989-484f-8f25-cd5583fd51f9_SOMOS_brochure.pdf (last visited 19.10.20)

Access rights and social perspectives

The issue of ownership of resources within a country's EEZ, and beyond its territorial sea, was discussed. At the face of it, this area represents a national common. The concern was raised that offshore aquaculture development would lead to ocean grabbing (Bennet et al., 2015), with limited number of large companies, potentially international companies, securing large holdings of aquaculture licenses, thus leading to a concentration of ownerships relating to the utilization of ocean space.

The UNCLOS provides coastal countries with a possibility to extend the boundary of the territorial sea until 12NM (Makgill and Rennie, 2012). Coastal states that have claimed a 200NM EEZ have exclusive rights to use resources beyond the 12 NM zone and within the 200 EEZ. However, moving structures may potentially be regarded as ships rather than exploiters of marine resources. Ships have an internationally agreed right of free passage, regardless of flag state.

A concern was raised about who would benefit from revenues of a potential development of large-scale offshore aquaculture production. While near costal aquaculture mostly creates scope for local jobs and incomes, larger scale offshore aquaculture could, in a globalized economy, potentially benefit other regions or countries than the state that holds the right to the EEZ in question. It is also a potential concern that big offshore kelp producers could undermine the existence of small nearshore producers.

It was observed that terminology matters. The term aquaculture covers sustainable and non-sustainable practices. There is much talk about Blue Growth and Blue revolution. But on a local level, for producers, these terms have little meaning.

Support for LTS aquaculture development within and beyond the baseline

There was a general perception that LTS aquaculture is not given sufficient priority by governments, regional and local authorities, and the public in most regions. This prompted the question on how support for LTS aquaculture can be mobilized. Other prioritized areas of activities (e.g. wind energy, wave energy) have been developed with support from subsidies. Why is this not done to enhance LTS aquaculture? For these activities there was a vision driving the development and that vision resulted in an enabling environment. That is lacking for aquaculture. Why is aquaculture treated differently than, for example, agriculture which are allowed subsidies? This is surprising as the $C0_2$ footprint from LTS aquaculture is much lower than from most vegan food.

There are arguments for and against subsidies for LTS aquaculture. The industry must be able to stand on its own, and if a high-quality product is produced, subsidies will not be needed. However, businesses will need to know that they will be able to sell their product at a reasonable price. Without subsidies, it seems difficult to transform the industry from the current small-scale activities to a large-scale industry. Funding is a key factor for moving offshore and it seems imbalanced that other activities, perhaps less sustainable ones, receive subsidies when LTS aquaculture is clearly a sustainable activity. There are some subsidies available through the European Maritime and Fisheries Fund, but very little for large scale aquaculture. Norway was lifted as an example of how governments can enable aquaculture and how this may result in positive attitudes to aquaculture. Ireland is another example where aquaculture is promoted by the government.

There is a need to promote the benefits of LTS aquaculture in society, for example as previously mentioned by lifting LTS as sustainable food items, but also other ecosystem services provided by LTS aquaculture. An example of this is the macroalgae that can be added to the diets of cows to reduce their methane emission. There are currently many projects working on developing high-value products from kelp which may enhance economic sustainability of kelp farming.

There was a general perception that, from an industry perspective, the priority should be on developing aquaculture in near shore or coastal areas rather than in offshore areas. Offshore aquaculture is risky, costly, and requires extensive investments in technology development. As such offshore and high-energy environments should be considered a last resort for aquaculture expansion.

Circularity in production systems and the value of LTS aquaculture was also addressed by the mention of phosphorous sequestration, which will be a key feature in the future. There is a need to change towards circularity in the use of phosphorous. This can be done by capturing phosphorous in marine biomass and thereby bringing it back to land-based systems, and this is currently a talking point within the sector. Providing subsidies or PES (payment for ecosystem services) systems for capturing Phosphorous or Nitrogen in sea-based biomass could enable business models. There are discussions about this, for example in Sweden.

The shells from oysters and mussels could potentially also be used as a carbon sink, and finding good uses of shells is a topic of high interest as this would contribute towards a circular economy with zero-waste (A. A. Alonso et al 2021). In the US and in Europe there is a shortage of shells, which are used as cultch in restoration and in stock enhancement projects.

It was observed that LTS aquaculture has a large social footprint in some areas, and producers consequently get support from the local communities that they contribute to. However, in some areas establishment of new aquaculture companies is resisted by local communities that are already engaged with competing activities.

It was remarked that the public has generally negative perceptions of aquaculture, including LTS aquaculture. For instance, it was observed that the general public perception of aquaculture in Denmark tends to be negative, partly as it is seen to constitute visual pollution of marine space. In countries or regions where aquaculture is viewed negatively by the public, it is possible that initiatives to combine windfarms with LTS aquaculture could help to improve the public perception of sustainable aquaculture production forms.

Aquaculture producers have on occasions been able to impact policy and regulations through dialogue and lobbying. Some producers noted that authorities are often receptive to the views of the industry. NGOs also have power to influence policy and regulations in similar ways.

A possibility for supporting the development of LTS aquaculture in marine spatial planning is to prioritise this activity in areas with a higher potential for aquaculture than for other marine activities (e.g. shipping).

Tax benefits or other monetary incentives were discussed as means to support offshore aquaculture developments. Monetary incentives for promoting offshore aquaculture can relate to the notion of ecosystem services. This would for instance reward aquaculture production that constitutes a carbon sink or captures nitrogen or sulphur from the water mass[15]. The NutriTrade project, with a focus on the Baltic, has investigated this approach.

Collaborative R&D innovation projects together with companies and funding for such activities were also recognized as productive and important.

Arguments for and against moving offshore

Although many participants identified a need for LTS aquaculture to move offshore, especially for large scale production, there is a risk that offshore LTS aquaculture can be presented as the only solution

[15] Examples also include approaches of using mussels as mitigation tools: https://www.mumipro.dk (last visited 01.11.20)

https://www.bonus-optimus.eu (last visited 19.10.20)

for aquaculture, whereas coastal aquaculture should also be prioritized. Many farmers expressed related concerns about being expelled from coastal areas, or of repeating a mistake from near-shore aquaculture, namely that aquaculture is relocated to areas which in many cases are areas no one else is using, and which are not suitable for aquaculture either. If indeed the objective is a low carbon food system, why are we trying to site farms further offshore and within wind farms thus adding to their carbon footprint?

Offshore represents a harsh production environment with high costs and logistical challenges. As a case in point, food safety issues for aquaculture may prove to be complicated to address in offshore environments. This involves issues with sampling and with control responsibility in offshore areas, and the associated control costs will be much higher than for near shore areas. Hence, from an aquaculture perspective, why go there? If proper siting of low carbon aquaculture farms is a priority, perhaps other users of marine space should be displaced. By targeting offshore/large scale LTS aquaculture systems, there is a risk of losing local, small-scale actors. Offshore aquaculture cannot replace inshore aquaculture, but they can complement each other, there should be room for both. There was concern that the "go offshore message" could be picked up by the governments as "ok do that", in which case the aquaculture could be put in a situation where activities are directed offshore instead of making room in near-shore areas. It was expressed that the industry wants to choose if they want to go offshore, not to be forced there. This risk must be mitigated by highlighting the importance of near-shore, small scale, and large, offshore LTS aquaculture systems.

In general, an increased use of offshore areas is anticipated, and this may enhance opportunities for offshore aquaculture. Electricity hubs can be expected to develop in offshore areas in the near future. This will transform the entire shipping sector by re-allocation of products to smaller vessels and shift the importance of coastal transports to connect to long-distance transports (which will still be using diesel). This will allow big ships to stay out at sea, which will save energy. Electric coastal vessels are coming quickly, and demonstration vessels already exist. The next step forward is about the price coming down. This opens possibilities for aquaculture in offshore areas, as infrastructure and power supply will be readily available.

Due to higher production costs, a shift form near shore to offshore will need to be linked with a shift from small scale to large scale. Going large scale is not always the obvious choice from a business perspective, and it cannot be achieved unless a stable market is available. Expansion requires stability and a solid knowledge of the future market and large capital needs caused by infrastructure that is capable to cope with offshore conditions and size of operations. Smaller enterprises cannot provide the needed capital. In some cases, however, offshore is the only possibility. Examples mentioned is Belgium with a very limited (and crowded) coastline, and Korea where aquaculture is too extensive to expand in near-shore areas and where disease/use of antibiotics and plastic pollution promotes a shift towards offshore areas. Conflict of interest with tourism was also highlighted in many areas, further promoting a move offshore. For fish culture the arguments may be more obvious as feeding of fish causes eutrophication in the sense that a solution to pollution is dilution. This provides a rationale for offshore aquaculture with higher trophic level fish species, but the rationale does not apply to aquaculture with bivalves or other low trophic species. For bivalve aquaculture offshore production would only be considered if near shore production is impossible. From a circularity perspective, retention of Nitrogen and Phosphorus will be less efficient in offshore areas.

The participants at the workshop on offshore aquaculture, Kristineberg, Sweden 16-18 October 2019[16].

3.1.4 Main findings

- LTS aquaculture will need access to new areas in order to expand. The competition for space is intense in near shore areas, and this drives research and development effort to enable the use of new production areas. However, it is difficult for producers to succeed with aquaculture in offshore/high energy environment due to high costs, technical challenges. From a producer's perspective, aquaculture expansion into high-energy environments therefore represents a last resort.
- The market for LTS aquaculture products is another limiting factor for offshore products. With varying market prices, it is risky to invest into expensive offshore equipment. This is the case as products produced offshore are unlikely to enter a new market and will thus compete with "nearshore" products that involve lower production costs.
- Many European countries have not established regulatory framework for offshore aquaculture. This creates a strong barrier for the development of offshore aquaculture. This is the case as, beyond the territorial sea, it will be too risky for companies to invest in aquaculture due to regulatory uncertainty.
- Prior to a possible future breakthrough for offshore aquaculture, issues of equity and rights should be given careful consideration to ensure a socially adequate and fair development. In part this would require measures to avoid negative consequences of ownership monopolization through a sea grab of offshore production rights.
- A cumbersome application process regarding licences and permits represents a common obstacle for producers, and this impedes expansion of LTS aquaculture. This problem can be reduced by simplifying and standardizing the application processes ("one-stop-shop") and/or by establishing appropriate guiding services. These measures have been used in some countries and are regarded as effective.
- LTS aquaculture is hampered by a negative public perception of aquaculture in many countries. An important reason for this is that public aquaculture discourses often do not differentiate between different aquaculture practices. Efforts to support a more informed public debate could outline environmental benefits of LTS aquaculture.

[16] https://aquavitaeproject.eu/state-of-the-art-and-future-development-of-low-trophic-level-species-culture-in-high-energy-environments/

3.2 Workshop on macroalgae cultivation in Norway

3.2.1 Introduction and scope

Macroalgae are photosynthetic primary producers which merely require sunlight, sufficient nutrient concentrations in the surrounding ocean and suitable culture conditions to produce biomass with a range of possible applications. As marine cultured species, they have the potential to circumvent a range of limiting factors associated with terrestrial biomass production - such as agricultural land- and freshwater use, or the need for fertilizers. For these reasons, macroalgae cultivation is often seen as a partial solution to the problem of sustainably expanding food, feed and biomass production (SAPEA, 2017; Barbier et al., 2019, Costello et al 2019), while potentially enabling a portfolio of climate change mitigation and adaptation strategies (Duarte et al 2017, Froehlich et al 2019, Gattuso et al 2018, Hoegh-Guldberg et al 2019).

In 2018, 178 tonnes of macroalgae were harvested from farms in Norway. This is a small quantity compared with the 1 353 220 tonnes of fish produced the same year, of which 95% were from salmonid species (Directorate of Fisheries, 2019). There is a growing interest in macroalgae farming reflected in the number of approved licenses for macroalgae farming increased from 54 in 2014 to 475 in 2019. One company reports that it will double its current production to 300t next year.[17]

The fact that Norwegian aquaculture industry is heavily dominated by salmon farming makes it less resilient towards potential negative impacts (e.g. climate, pathogens, marketability, or management actions that curb productions volumes in order to address negative environmental effects of salmon farming). This highlights the need to identify calls to more diversified and sustainable forms of aquaculture in Norway (Torrissen et al 2018, see also The Bellona Foundation 2020). Salmon farming releases substantial amounts of carbon, nitrogen and phosphorus. Macroalgae cultivation may be used in Integrated Multi-Trophic Aquaculture (IMTA) arrangements, farmed near the salmon pens. As macroalgae take up nutrients from their environment and incorporate them into tissue growth, they will contribute to reduce eutrophication effects, and may thus have positive environmental effects (Anon. 2018, Karlsson-Drangsholt & van Nes, 2017, Chapman et al. 2014).

This section reports outcomes from a workshop that addressed what constrains or promotes development of macroalgae aquaculture in Norway. Macroalgae cultivation emerges within a policy and regulation framework developed for purposes other than managing macroalgae production. Accordingly, the workshop addressed whether existing frameworks are appropriate for macroalgae cultivation and whether or how they can be improved to facilitate a sustainable and societally desirable development of macroalgae cultivation.

3.2.2 Approach

A workshop entitled “Seaweed Aquaculture in Norway: Socio-Environmental Benefits and Policy Frameworks” was held 25th of February 2020 at the headquarters of the Bellona Foundation in Oslo,

[17] https://www.nrk.no/vestland/oppdrettsgigant-doblar-produksjonen-av-tare-for-andre-aret-pa-rad-1.15196844 (last visited 13.10.20)

Norway. The workshop resulted from a collaboration between two H2020 projects, AquaVitae and GENIALG[18], as both address aspects of macroalgae cultivation. The workshop included a group session on perceptions of socio-environmental benefits of macroalgae cultivation, which was arranged for the GENIALG project. For the purposes of the AquaVitae project, we listed set of questions about what constrains or promotes development of macroalgae cultivation. The questions were distributed to the workshop participants in advance of the workshop, together with an information letter that described how, and under which conditions, the information would be used, as consistent with GDPR requirements (Annex 3). Verbal confirmation and agreement on the utilization of the information was obtained from all present participants. The questions were discussed in groups and in a subsequent plenary session.

The workshop was attended by 25 participants, including macroalgae producers and representatives from macroalgae producer associations, representatives with different roles in aquaculture administration of aquaculture (including local, regional and national levels of aquaculture administration, as well the Norwegian Food Safety Authority and the Research Council of Norway), environmental NGOs, researchers and political representatives. Four groups were designed to maximise the diversity of expertise, such that each group comprised persons with hands-on experience with commercial or macroalgae cultivation, researchers, and persons with experience in aquaculture administration or other aspects of aquaculture. A person from each group was tasked with taking notes from the discussions, and another guided the discussion through the questions. After the workshop the participants were given an opportunity to revise the group's notes. The four sets of notes were subsequently combined into a single text.

3.2.3 Outcomes

The outcomes of group discussions on what respectively promotes or contains a development of macroalgae cultivation in Norway are synthesized, organized and presented in relation to a number of key themes below.

Current status

As macroalgae cultivation is gradually emerging as a new industry in Norway becomes important to address practical and administrative challenges and consider further market possibilities. A participant noted that it is a young industry, and that uncertainties still exist in the production, for example regarding optimizing biology and technology. The start-up process often proves to be a considerable challenge for smaller actors. It was repeatedly noted that larger investors – for instance salmon aquaculture companies looking to ways to diversify their activities – can have a significant impact in terms of building macroalgae farming businesses with a higher potential to remain in the sector in the long term.

[18] https://genialgproject.eu/ (last visited 10.10.20)

Administration and regulations

An industry participant remarked that the application process for a license is demanding, but doable. It is important to plan how to carry out that process, and to take time aspects into account. An administrator remarked that it initially took a long time to process applications for permits, but almost everybody that applied has received one. Before June 2019, the application process was not subjected to regulations on process time, and the handling of the application could therefore potentially take a very long time. The processing time for application is now, at least in theory, limited to 22 weeks, and the application is therefore unlikely to represent a limiting factor.

As one industry representative remarked, complaints to authorities by local interests might significantly delay a process. The participant saw this as unfortunate and unneeded, as "democracy has already had its say" when the community planners designated an area as fit for aquaculture.

The application for a macroalgae production license requires approval from several different authorities. Yet, a producer noted, it is relatively clear what the applicant must do, and guiding information is available. On the other hand, producers that are new to the game describe the licensing and start-up processes as challenging. A small-scale producer stated that this is difficult as the framework is not completely developed yet.

From 2019, the regional authorities manage the applications in a process that involves different other authorities. An inter-county aquaculture cooperation has the ambition to assure that procedures are consistent across counties and arranges regular coordination meetings for administrators.

The license is easier to obtain if the municipality has established a plan for its coastal area with designated areas for aquaculture. Otherwise, the macroalgae producer must apply for a dispensation before an application for aquaculture can be processed. An administrator noted that it is important that the industry is proactive and makes its needs heard. An important aspect is that the industry requests areas to be designated as fit for aquaculture/macroalgae production in communal plans.

A producer explained that it can be an advantage to set up a macroalgae production system in municipalities with established aquaculture production. This implied that there was infrastructure ready to use. Macroalgae cultivation of a certain scale requires considerable amounts of equipment (in this case 80 lorry loads of equipment). The macroalgae producer could to a large extent use secondhand equipment from salmon aquaculture.

Macroalgae licenses are generally free to obtain, except some handling costs and a deposit (3000 NOK per 1000 m^2, maximum 200 000 NOK). The deposit is charged to cover for the costs of removing production equipment in case of bankruptcy. This measure was put in place following experiences with bankruptcy in mussel farming, with subsequent troubles with clearing up equipment. A deposit is mandatory for macroalgae cultivation from June 2019 and county administrators remarked that the number of applications declined significantly after. However, the size of the deposit was considered to be reasonable, at least by some of the participants, who noted that it is costly to clear a farm if someone abandons it, and that the amount should not be large enough to stop someone from applying. Others considered it prohibitive, especially for those who lack backing by a larger investor such as a salmon company.

Environmental requirements may involve the assessment of effluents and the level of contaminants in the production area.

There is no standard for environmental assessments for macroalgae production. Environmental assessments in relation to licenses issued by the Ministry of Trade, Industry and Fisheries for production areas more than 100.000m^2 shall be conducted following a dialogue with a county official (Fylkesmannen – The County Governor) with responsibility for environmental aspects. The County Administration can, together with other institutions, request an environmental assessment as attachments to applications for aquaculture production. It is common that an environmental assessment is attached to an application for fish aquaculture.

An environmental assessment is not always needed, and currently no standard exists for environmental assessments of macroalgae production. It is possible to have a dialogue with authorities concerning the requirements in relation to a particular case. In one case, a producer needed a license to produce 4000t, and this required an environmental assessment. The cost of such an assessment is 10000-15000 euros. It seems better to have some years of harvesting before conducting the assessment as it will be more relevant to measure impacts at that stage, and there appears to be sufficient flexibility to allow this. There is a need to have a dialogue with the regional authorities (the County Governor, Directorate of fisheries) about such issues.

It can be expected that application procedures and requirements will be more comprehensive in the future in pace with the development of the macroalgae production sector. This is likely to make the application process more expensive. As a related point, macroalgae producers can currently use secondhand equipment from salmon aquaculture. There is no requirement to certify the production equipment. If this changes, production costs will increase for macroalgae producers that rely on secondhand equipment.

In general, the monitoring requirements for macroalgae producers are currently modest. Essentially, producers need to report how much they produce to the Fisheries Directorate. However, a person observed indications that authorities may begin to inspect working conditions for employees in macroalgae production.

When directly asked whether international, national, or local regulations pose challenges, the responses varied. For small producers, it is the national ones. It was remarked that “we cannot sell kelp to China if we are not allowed to produce in the first place”. European regulations only apply to those that export to the European Union (EU), where the market is limited.

Funding research, innovation and start up

Regional funds supporting research and development and “Innovation Norway” - the national development bank - have been important together with “Skattefunn”, a tax deduction scheme for companies undertaking research and development activities. Several applications from macroalgae producers have received support from regional research councils. Regional development support has also been given to networking and algae projects. There are differences between regional research funds and regional development funds. A common feature for these is that the applicant must provide 50% own funding, which was said to work as a safeguarding measure boundary: If a producer fails, the cleaning up not only to be covered by state money. Having an investor implies a sort of validation of the proposed idea or concept from the business sector, often the oil or salmon farming industry.

The Research Council of Norway (RCN) has funded a national macroalgae research and technology development platform led by SINTEF, in addition to supporting applied projects from industry and scientists. RCN projects are of different types and involve working with researchers and/or companies doing research to develop processes and products. The industry can apply for funds to support their own activities or do this in partnership with researchers at institutes or universities. This is useful for validation. A different funding source is needed for developing a technology to industrial scale, as this needs to provide for engineering rather than for research. Innovation Norway supports this part of the value chain.

A producer noted that his company participates in research projects and welcomes researchers to assess environmental impacts. But research in a production context needs to be solution oriented, and this contrast with a research attitude that is mainly about identifying problems. The time aspect is also important, as producers cannot wait 10 years for results. In that case, they must take steps to obtain the required knowledge themselves through fast-track processes.

A producer questioned the role and priorities of national funding schemes. Macroalgae production has received attention from time to time, but how does the state allocate funding? Do they put their money where their mouth is? Another producer expressed the view that professed ambitions for macroalgae cultivation are high at the level of national politics, but there seems to be a disconnect between that ambition and a long-term strategic and actual development of the industry.

A producer stated that the policies are mainly about increasing the production of macroalgae ("Go for it!"), but less on how to do this ("That's for you to find out"), i.e. leaving it to the producers to develop good practices. This was seen to pose an extra risk to the start-up businesses, since they are asked to proceed in an area where knowledge is lacking, and where future regulations may require changing practices after investments are made.

Having partial funding for a project helps to attract the interest of other potential sources of investments. The producer can say that they have a certain amount, and that they now need another certain amount to complete the funding of a given project. With "Skattefunn", companies get 20% reimbursement of R&D costs in the subsequent year. This contributes to innovation. Another producer observed that when applying for funding or seeking help, it is difficult to understand what is required and why. "We're a small company, and when presenting our plans, we're often met with "that sounds difficult". Yet we must bring in 50 % of the funding ourselves – which is difficult when there is lack of knowledge of the industry. You have to have money to start doing this." This may favor former salmon farmers, as they may have access to sufficient funding. It was also noted that it is challenging to obtain funding for macroalgae cultivation with new species.

Regional authorities cannot support a specific company, but they can take initiatives to increase awareness and provide funding for projects by collaborating with companies and/or institutions. The county council is engaged in regional development, and provides funding to Innovation Norway, which in turn provides direct support to a business. Further, the County Councils support smaller research projects, involving at least one research and one business partner through regional R&D funds. Finally, the County Councils provide funding for regional projects, which comprise more than one business partner. Municipal councils also facilitate support for various kinds of startups. Remarking on the challenges of starting up, one group discussed the role of research funding for strengthening smaller farmers on their way to profitability. The group developed the perception that the system currently

tends to favor those with industry backing, yet it is uncertain if and how the research and innovation system can improve the chances for smaller initiatives. Self-critically a researcher wonders if the ones that perhaps have made most money are the researchers. Perhaps focus of the research needs to shift more from pure research to business-focused research?

Participants in the workshop noted that there is a lack of integration between funding for research and innovation, and the licensing process. The Food Safety Authority has initiated a dialogue with Innovation Norway because Innovation Norway provided funding for projects with species that may be novel as food source and thus forbidden to use as food in Norway. A possible measure would be to make it mandatory for applicants to discuss the regulatory frameworks and possible limitations with the relevant authorities, because the Innovation Norway and the Research Council of Norway may not evaluate this. As an example, sea cucumber and some macroalgae species, are probably not allowed as food in Europe, even though they may be allowed in some countries in Asia or Africa. It was also noted that while it is feasible to do research on new species, this type of research should not be undertaken with the idea that it will lead to a profitable business model within five to ten years.

Another example of mismatch between project funding and regulation relates to the requirement that the species to be farmed occur in an area. There are known examples of companies applying for funding for species that were not allowed in their region. This is related to a lack of knowledge, where people see a list of possible species, and do not realize that they may not be allowed to produce these in their region. There is a gap in understanding what macroalgae is, and a lack of knowledge on taxonomy. This knowledge must be developed and shared to define and relate to regulations in an appropriate way[19].

Environment and sustainability

Researchers remarked that they have had carried out a lot of fieldwork in recent years to learn about the effects of kelp cultivation. They are wondering how to communicate the resulting knowledge to authorities and others.

An administrator replies that positive effects of kelp cultivation are exciting topics, but the negative effects, e.g. related to unwanted spread of genetic material, are much more important when it comes to regulations. It is an open question if breeding of kelp will be pursued, and if and how one will deal with issues of genetic spread in that case. Today cultured macroalgae must be of local origin, understood as using genetic material from plants harvested within 100 kms.

An industry representative confirms that they use local kelp, but also referred to a conversation with a biologist that downplayed this concern as kelp spores are, in any case, dissipated long distances with the currents. However, an administrator cited a study that showed that genetic spread of sugar kelp may be a significant problem as there are many local strains that differ genetically. A careless scaling up of industry may quickly endanger this local diversity, as has been seen in the case of breeding of coastal cod, where local genetics were not taken into account.

Others touched on the possibility for kelp farming to be used in a greenwashing of salmon farming, and that salmon farmers therefore may want to invest in kelp farming. It was also pointed out that salmon farmers are interested in the positive effects of IMTA. A researcher noted that IMTA is difficult to achieve in practice. The kelp absorbs the most nutrients in the spring while salmon excrete the most

[19] As mentioned in the accompanying AquaVitae Deliverable D8.2, EU has a catalogue of alien species and the "novel food regulations" which will be of interest for macroalgae cultivation.

nutrients in the autumn. For this reason, the researcher has little faith in direct IMTA, but more faith in multi-trophic cultivation in a larger area, e.g. in a fjord system or along a coastal area.
Discussions about the carbon capture potential of kelp meet skepticism from industry: How to run a profitable business by dumping kelp at sea? Yet, the question was asked how much kelp people can actually be expected to consume. The group agreed that before depositing kelp biomass in order to capture carbon, it might be wise to extract valuable components from the biomass and/or using it for bioenergy. It was noted that the field may have somewhat moved away from using kelp for energy. One researcher doubted that it will be straightforward to deposit kelp in the depths of the sea to begin with, as it will be difficult to prevent it from reentering into an active marine carbon, nutrient and energy cycle. In any case, macroalgae cultivation must first become a profitable industry before it will be possible to cultivate 18,000km2 offshore for use in carbon capture[20]. Macroalgae cultivation could possibly become a government initiative on carbon storage and sequestration, but a lot of innovation work would be needed before it would be practically possible to capture carbon on such a large scale through this strategy.

Product quality standards and certification

Authorities have basic quality standards, with a focus on product safety. There is also a possibility of developing and using private standards.

A producer noted that there is a need for a quality standard for macroalgae. The ISO 22000 standard can be used to document and certify food safety through the supply chain, but it does not address the product quality as such. One company sends their product to Denmark to analyze and document product quality. The product quality needs to be quantifiable and to allow for quality grading. The macroalgae association has a project on this. It requires capital to develop and use such a standard. This is possible for big companies, but not likely to be possible for small scale producers. There are high costs involved linked to payments for audits and inspectors. Buyer needs to audit and sample production to know about its quality. There is a need for developing a cost-efficient system to handle this. A standard for algae and algae products has recently been published (cf. EN 17399), and includes basic definitions for the sector, but does not cover quality aspects.

There is a possibility to achieve environmental certification of macroalgae production. This concerns whether the production use chemicals, environmental conditions, recycling etc. It is not about the quality of the product. At the time of the workshop, only one macroalgae producer in Norway (Ocean Forest) was certified by the Aquaculture Stewardship Council (ASC). Ocean Forest managed this because it is a big company and because it could apply for certification for macroalgae together with its application for certification of salmon production. There is a particular challenge linked to environmental certification of Integrated Multi-trophic Aquaculture (IMTA) as excretion from non-organic salmon will imply that the macroalgae part of the IMTA production will not be organic[21].

[20] The numbers refer to a SINTEF estimate of the area that will theoretically be required to capture Norway's annual GHG emissions by way of kelp biomass.

[21] Legal references for the issue of organic production of macroalgae in the EU are presented in the Aquavitae Deliverable D8.1.

Food safety

There is no specific authorization or approval of food production that is not food from animal origin or listed as novel food. However, if producers intend to produce macroalgae as food, they must officially *register* as a food producer, and list what they are going to produce. This will enable the Norwegian Food Safety Authority to make inspections. This process is not integrated with the license application process.

The producers are responsible for the safety of food products, and this applies to all food producers in the EU. A producer explained that they developed a protocol for production in line with requirements. This involves the designation of clean zone, how to transfer persons or materials between zones etc. Also, contamination risks (e.g. droppings from seabirds) have to be identified and addressed. This is done through a Hazard Analysis Critical Control Point (HACCP). In this case, the food safety authority came and looked at the developed protocol and requested a few changes. Furthermore, the development of the protocol had been helped by acquisition of a macroalgae production company as the protocol of the acquired company could be used as a starting point for a new protocol.

There are several open questions concerning the safety of food product regarding iodine content. Denmark, Sweden and Norward regard concerns with iodine similarly, whereas the EU threshold for iodine is more conservative. More research on risk levels and thresholds for iodine seem warranted. One of the groups discussed whether there is a need for clearer regulations regarding iodine content in food products. The group agreed that there is no need for specific regulations, for instance a threshold value, as long at the producers are responsible for the food safety of their products. We need more scientific data before such regulations can be made, as poorly set thresholds can be damaging to local industries. It is important not to make specific and detailed regulations prematurely, that is, before the necessary knowledge is in place.

Food safety regulations at an EU level was a main barrier for macroalgae cultivation in Norway. Research supported and published by European Food Safety Authority (EFSA) has identified a range of food safety risks for macroalgae used for human consumption (Monteiro et al., 2019). For understandable reasons, food safety authorities generally tend to take a conservative stand on acceptable content of harmful components, and this creates a potential barrier. There may be skepticism towards consuming macroalgae food products due to high levels of iodine and heavy metals such as cadmium. Some producers have decided to cope with iodine contents by placing a label on the product, stating that it may be harmful if it is consumed in excessive quantities. This practice is voluntary. It was recommended that producers obtain knowledge about their products, for example by analysing its components, but this is not mandatory.

Market aspects

A producer noted that there are positive trends for macroalgae cultivation, especially linked to the vegan movement. In general, there is increasing emphasis on plant-based food, meat free days etc. This requires a supply of sustainable plant materials, and macroalgae represents an ideal plant-based meat substitute.

Allergens in macroalgae, for instance due to presence of crustaceans on harvested material, represents a market barrier. This creates a need to find ways to analyze, reduce or destabilize allergens. Producers try to fast track the development of the knowledge and technology needed for this.

Iodine content is a barrier due to European food safety thresholds for this element. A producer mentioned an example, in which the iodine content strongly limited the amount of macroalgae that could be added to a snack product. With no removal of iodine, only 0.5% macroalgae could be added. A fermentation process can reduce iodine content by 70 percent, but this still limits the macroalgae content in the snack product to 8%. Accordingly, there is a need for research and development for cost effective removal of iodine from macroalgae. Similarly, ways to reduce cadmium and other heavy metal content also are needed.

Macroalgae producers normally freeze the product after harvesting. Some clean and sort it first. This step of the value chain raises many costs, and the biomass degrades quickly if it is not handled well. Some try to shorten the value chain by harvesting, packing and freezing within 15 minutes. However, freezing damages cell structures. The product can also be vacuum packed to provide a fresh product. A challenge is to find ways to stabilize macroalgae at a bulk scale. In fermented form, the macroalgae can be used as an additive in salmon feed.

The big challenge is about how producers can cut their production costs to make a profit. This could be about the scale of production, but it is also about technology development.

A producer has an organic product, with a nice taste, but the product does not look as good as it tastes. This makes it difficult to convince buyers. A particular challenge here is about how chlorophyll can be retained after fermentation to preserve the original color.

It was asked if macroalgae can be used for feed. What are the barriers? Are there any regulatory issues? The main challenge here is to have stable volumes and low production costs. A producer was involved in a project aiming to use macroalgae in pig feed and salmon feed. The problem is that the buyers of these feeds do not want to pay much extra for having macroalgae as an added component unless it has a clear added value. Hence, a future for macroalgae in relation to feed will need identification of beneficial effects making the consumers willing to pay a price premium for animal produce where the utilized feed has contained macroalgae. Currently, there is no foreseeable way to make macroalgae a cheap product. The production is highly capital intensive. There is a need to develop efficient bio-refinery technology.

There are no official marketing channels for macroalgae, but the three producer associations do some marketing work.

Industry cooperation

A producer explained that producer associations are important to facilitate knowledge exchange. This will help new producers to, understand regulatory requirements and solve problems or buy or borrow materials. The associations have telephone lists with all the producers. They can call each other and exchange knowledge. The producers are competitors and there are some things they normally do not share, like protocols for sterilization. But in general, there is a cooperative spirit between the producers in the macroalgae association. Another gives a different angle on this - likely arguing from another market position; While there are a lot of arenas for producers to participate, there is no central interest group where members more openly share information. There is a lot of secrecy now. “Dumping” might also be a problem when financially desperate actors flood the market, lowering the price for the whole industry

Public acceptance

Regional authorities have in some cases tried to promote macroalgae cultivation, for instance with creating events with chefs and schools, arranging seminars and supporting network development. As a case in point, a County Council has developed an initiative that involved students from a secondary high school, which were invited for seminars on macroalgae. Events like this get into the media, hence contributing to increase the awareness on macroalgae cultivation. Similarly, Denmark has established small macroalgae cultivation platforms to get more people interested in the subject.

On a local level, skepticism towards macroalgae production can be based on the changes and restrictions it makes on the use of the marine environment related to e.g. fisheries, aquaculture, leisure activities and environmental qualities. And, as one industry participant remarked, the potentially positive impacts may not be well known to politicians, perhaps especially at the local level. Another participant remarked that the challenge is not only about spreading knowledge about the industry, but also about establishing a kind of consensus that can be communicated to other stakeholder groups in society – locally and nationally.

3.2.4 Main findings

The main limiting factor for establishing macroalgae cultivation is obtaining the needed capital: people, location, and technology. Main conditions for establishing profitable businesses over time include consistent and well-constructed regulations, and a stable market demand.

Main aspects that have promoted the development of macroalgae cultivation in Norway include:

- Funding: Public and private capital is needed and has been provided. Public funding reflects confidence in the industry facilitating private investments.
- Sharing of knowhow through associations and national R&D networks. The industry is characterized by a collective and cooperative spirit.
- Support from local authorities, although the level and types of support differ between regions and municipalities.
- Efforts are implemented to raise awareness about macroalgae cultivation.
- Use of lower costs secondhand equipment from e.g. salmon farming. The use of secondhand equipment is made possible by a current lack of regulation and monitoring of equipment standards for macroalgae cultivation.
- Flexibility in relation to requirements for assessment of environmental impact can help macroalgae producers in the starting phase.
- A positive market trend was identified, as there is increasing demand for vegan food, sustainable foods etc.
- Properly designed regulations were also seen as a factor to promote the development of the industry, yet it was noted that there is still room for improvement on this matter.

- Salmon farmers have contributed with aquaculture experience, technological knowhow, and funding.

Main aspects that have constrained the development of macroalgae cultivation in Norway include:

- A lack of a quality standard. This standard is needed to allow product quality and price differentiation. Further, the whole industry is subjected to reputational risks from bad products sold by individual producers. It is expensive to develop and use standards. High productions volumes appear needed to make this possible.

- Content of iodine and heavy metals and allergens. Cost effective mechanisms to remove these are required. The current upper iodine threshold is a recommendation, not a limit in food products. There is a demand for scientifically well-founded standards on safe levels of iodine consumption. Uncertainties regarding safe consumption may translate into marketing challenges. A stronger knowledge base will be required to preserve consumer trust.

- Lack of capacity in management and research. There is a gap between what we do know and what we need to know to make adequate regulations. Likewise, it is important that the political will to regulate does not override the need for adequate knowledge. Avoiding premature regulations is seen as important.

- Risk for start-up businesses. First, finding funding for new species and/or novel industries may be challenging when there is a lack of familiarity with industry among possible industry funders. Second, the novelty of the industry also leads to concerns that the authorities will change the requirements in the future, meaning that equipment and practices may need to change in a few years.

- Lack of familiarity and knowledge about the potential benefits in the general public may make local protests more likely

- While Norwegian politics at times have embraced macroalgae farming – and there certainly are a wide range of initiatives in research, industry and public accommodation of this new form of aquaculture - it is also argued that concerted long-term industry building has yet to be made a clear national priority

- The licensing system was somewhat inconsistent and inefficient the first years, with varying barriers for applicants and varying case processing times, however this seems to currently be rather comprehensively addressed within the newly emerging management regime


Scenes from the workshop 25.02.19, Oslo. Photos by Avril Hangbridge.

3.3 Macroalgae cultivation in Scotland

3.3.1 Introduction and scope

This section focuses on Scotland within the UK. Scotland has its own legal system, and authority over its environment and aquaculture is almost completely devolved to its government and parliament in Edinburgh. Whereas the east coast of the Scottish mainland has many features in common with that of other countries around the North Sea, the western coasts and the islands are more similar to Norwegian inshore waters, being interrupted by many long-sheltered inlets of good water quality: the sea-lochs, firths and voes that equate with Scandinavian fjords.

Scotland has a long history of macroalgae use, dating back to at least the Iron Age, where it was used for fertiliser and fodder. From 1720 – 1840's industrial use of *Laminaria* (kelp) in bleaching, soap, and glass-manufacture processes was a significant source of income for some islanders (Bumstead, 2005). During the 20th century there were several revivals of use of macroalgae in industry along the West Coast of Scotland, including for iodine and alginate production (Angus, 2017). This legacy of macroalgae use continues today with several companies still conducting wild harvesting operations of a variety of macroalgae for several uses. All these operations are relatively small-scale and high value. A commercial bid for large-scale kelp harvesting ran into major public opposition and a new law that effectively banned it.

Nevertheless, the Scottish Government and some Local Authorities are looking to increase the use of Scotland's macroalgae resources for economic and social development (Marine Scotland, 2017; Stanley et al., 2019). In 2017 the Scottish Government released a Seaweed Cultivation Policy Statement, in support of 'small to medium scale' macroalgae farms.[22] At the same time, the Scottish Seaweed Industry Association welcomed an increase in membership numbers from 2016 – 2018, reflecting a return to interest in using macroalgae as an economic resource and the potential for its use to sustain populations in remote and rural coastlines. However, as of 2020, macroalgae cultivation in Scotland is still in its infancy with only a few small commercial operations and small experimental farms.

3.3.2 Approach

The Scottish Seaweed Industry Association (SSIA) met in Oban on 18 February 2020. On the following day attendees took part in a set of workshops held in the SAMS campus at Dunstaffnage, 3 miles from Oban. SAMS used this occasion to administer a questionnaire concerning perceptions of aquaculture policy and regulation in relation to macroalgae farming.

Starting from the stakeholder workshop protocol (Annex 1), a short questionnaire with five sections was developed, each containing tick-box or write-in options. The section headings were:

[22] Policy: see www2.gov.scot/Topics/marine/Fish-Shellfish/seaweed (last visited 01.11.2020) and Marine Scotland (2017), which state that "in principle, the SG is supportive of small-medium farm seaweed cultivation", defining small-medium as up to 50 x 200 m long-lines.

1. “Please describe your relationship with aquaculture and reason for attending today’s event”, which aimed to collect information to distinguish producers from others.

2. “Permissions needed for macroalgae farming. Which of the following do you know or think is needed to start and operate a macroalgae farm in Scotland?” This aimed to ascertain what was known about current regulation.

3. “Public policies. As far as you know, does Scottish government have policies on seaweed farming? If you are aware of such policies, can you identify one way in which they are good, and one way in which they are bad, for seaweed farming?”

4. “(Experience of) Interactions between seaweed farming and other uses of the sea”, which aimed to provide data concerning the potential value of MSP as well as for studies of SLO.

5. “What is needed, in your opinion, for seaweed farming to succeed?”

The GDPR-compliant questionnaire, appended to this section, was designed to be easy to answer quickly. It was also made available, using a GDPR-compliant tool provided by the University of the Highlands and Islands[23]. Results from the paper survey were copied to the online version for ease of analysis.

3.3.3 Outcomes

Out of about 60 people attending the workshops at Dunstaffnage, 25 took part in the survey, with 23 paper and 2 on-line respondents. Both quantitative and qualitative data were obtained. The appended questionnaire includes numeric information on responses. The ‘correct’ answers to Q. 3 have been added.

Summary of quantitative findings:

- Most participants attended the event on behalf of a company/agency/organisation, 19 compared to 7 attending on their own behalf. One participant gave no further answers.

- Most of the participants were involved with the macroalgae cultivation sector (around 60%). Two options received the most responses: ‘I work in or own a firm providing resources for aquaculture, e.g. gear, spat, feed, or supporting services, e.g. survey, mooring deployment, insurance’ (10) and ‘I or my company invest in or are interested in investing in these kinds of aquaculture’ (13).

- In terms of the permissions required to start a macroalgae cultivation operation, most respondents either knew (~44%) or thought (~40%) that all the listed options were required. Of the options, a lease from Crown Estate Scotland, and a Marine Licence from Marine Scotland, received the highest ‘know’ responses, while preparations for an EIA and Habitats Regulation Appraisal received the highest ‘think’ response. Options for CAR and ABP licences received the highest ‘don’t know’ responses. In fact, a CAR (Controlled Activities Regulations) licence is not

[23] online at https://uhi.onlinesurveys.ac.uk/ssfa-survey (last visited 15.11.2020)

required while an ABP (Aquacultural production Business) licence is required. The confusion may be the result of lack of regulations dealing explicitly with macroalgae farming.

- Most respondents (15, 60%) knew that the Scottish Government already had policies for macroalgae farming in place.

- Regarding interactions with other marine users, most participants reported or expected positive interactions with other marine users. Participants were however more pessimistic about commercial fishing or shipping, expecting more negative interactions in future.

- Finally, in terms of the importance of certain factors related to macroalgae farming (question 5), most were ranked as moderate urgency. The most important factors (those with the highest sum of the product of number of respondents and inverse scores) were, in order: 'Provision of start-up, product development, and marketing advice by a public body'; 'Availability of start-up finance from public or commercial sources' and 'Strong public enforcement of bio-security measures to prevent spread of diseases of seaweed'.

Some qualitative information:

Question 3 asked for opinions on public policies. Positive write-ins mostly welcomed the existence of a published policy, seeing it as a start for development. Negative write-ins complained that this policy was not specific to macroalgae but based on that for mussel farming: e.g. "lack of seaweed-specific wording in policy inhibits industry progress". Additionally, there were complaints about regulatory complexity: "obtaining consents is complicated, difficult and lengthy - needs streamlining" and "too many different and sometimes duplicated regulations, precautionary principle inhibits sensible risk analysis". All this qualitative information confirms and reinforces findings and suggestions about legislation in macroalgae in the accompanying AquaVitae Deliverable D8.1.

Question 5 asked what was needed for macroalgae cultivation to succeed. Write-ins included:

- "The pendulum needs to swing back from extreme environmental protection to sensible risk analysis and thereby encouragement to entrepreneurs."

- "Information campaign about compelling logic for seaweed and shellfish farming – perhaps take ideas from Greenwave.com."

- "Supply chain/networking events to bring potential partners together – bridge the gap between growers and markets."

- "Think there is a definite need to learn from mistakes of the aquaculture industry (disease, pest burden, etc.)."

- "Sufficient community and stakeholder engagement to inform designation of farming zones in the right locations; preparations of sufficient good practice guidance to ensure impacts are managed. Research to support guidance to ensure this is evidence-led."

3.3.4 Main findings

The results of this survey perhaps reflect the embryonic state of macroalgae farming in Scotland, with the highest scoring support issues concerning the need for start-up advice and finance. Biosecurity was also an important concern, but Marine Spatial Planning issues were seen as less important. There were some complaints about policy weaknesses and regulatory complexity.

Questionaire: Perceptions of aquaculture policy and regulation in relation to seaweed farming

We invite you to take part in a study of opinions about public policy and regulation in relation to seaweed farming. Participation is voluntary and anonymous, and requires completing the questionnaire below or on-line at https://uhi.onlinesurveys.ac.uk/ssfa-survey. We do not ask for information that can identify you personally. We will use our findings to inform Scottish Government and European policy makers and will provide a summary to the SSFA. Similar studies are being carried out in relation to seaweed and shellfish farming in Norway, Sweden, Portugal, Brazil and South Africa, as part of the AquaVitae project funded by the European Commission's H2020 research programme (grant no. 818173), and you can find out more at https://aquavitaeproject.eu. The local data manager is Dr Paul Tett of SAMS (paul.tett@sams.ac.uk), and summary data will be managed by Dr Kåre Nolde Nielsen of the Arctic University of Norway, in Tromsø (kare.nolde.nielsen@uit.no).

1. Please describe your relationship with aquaculture and reason for attending today's event.

Please tick all applicable boxes; adding text where requested will help us but is optional.

I am attending on my own behalf	7	I am attending on behalf of a company or agency or organisation	19

	seaweed	shellfish	finfish
I work in or own a firm providing resources for aquaculture, e.g. gear, spat, feed, or supporting services, e.g. survey, mooring deployment, insurance *(tick relevant boxes)*	4	3	3
I work in or own a firm carrying out aquaculture *(tick relevant boxes)*	4	0	1
I work in or own a firm transporting, processing or marketing the produts of aquaculture *(tick relevant boxes)*	4	0	1
I or my company invest in or are interested in investing in these kinds of aquaculture *(tick relevant boxes)*	8	3	2
I or my company would like to set up a farm *(tick relevant boxes)*	6	2	1

I work for government (local or national, including regulatory)	*Tick, or write name of agency or Authority* 4
I am an elected representive, or I represent a community group or NGO	*Tick, or write name of constituency or organisation* 4
I am a researcher into aquaculture or am studying it for a qualification	*Tick, or write field of research or name of qualification* 2
I have other reasons for attending this event	*Tick, or write reason* 6

2. Permissions needed for seaweed farming. Which of the following do you know or think is needed to start and operate **a seaweed farm** in Scotland? (*Please tick one box in each row).*

	know	think	don't know
Lease from Crown Estates Scotland NEEDED	19	4	1
Preparation of an Environmental Impact Assessment NOT NEEDED	7	13	1
Preparation of a Habitats Regulations Appraisal MAYBE NEEDED	3	13	3
Planning Permission from a Local Authority ONLY NEEDED ONSHORE	9	9	2
Marine Licence from Marine Scotland NEEDED	20	4	1
CAR licence from SEPA NOT NEEDED	2	6	7
Aquaculture production business licence NEEDED	3	7	7

Are there other permissions that you know or think are needed? (*Please write in)*

3. Public policies. As far as you know, does Scottish government have policies on seaweed farming?
Please tick one box.

Yes	Maybe	No	don't know
15	5	3	2

If you are aware of such policies, can you indentify one way in which they are good, and one way in which they are bad, for seaweed farming? *Please write in*

Good	Bad

4. Interactions between seaweed farming and other uses of the sea. *(Please tick all relevant boxes)*

Other sea-user	Have experienced positive interaction	Have experienced negative interaction	Expect positive interaction in future	Expect negative interaction in future
Commercial fishing	3	3	8	10
Recreational fishing or boating, or ecotourism	3	2	13	5
Other sea-farmers	5	1	13	3
Civilian or military shipping	0	1	1	12
Coastal communities	6	2	16	3
Other (*write in*)				

5. What is needed, in your opinion, for seaweed farming to suceed? *(Please tick boxes, or write 1 if important and urgent, 2 if important in the medium-term, and 3 if desirable but not urgent.)*

Designation of seaweed farming zones by Scottish Government or Local Authority or Marine Planning Partnership	*Score = 35*
Provision of start-up, product development, and marketing advice by a public body	*Score = 46*
Availability of start-up finance from public or commercial sources	*Score = 54*
Existence of a body to drive demand for seaweed products	*Score = 37*
Strong public enforcement of bio-security measures to prevent spread of diseases of seaweed	*Score = 44*
Strong public regulation of water quality where you farm	*Score = 32*
An organic certification scheme for your product	*Score = 30*

What other public actions would be beneficial? *(Please write in the box.)*

THANK YOU!

3.4 Macroalgae cultivation in Portugal

3.4.1 Introduction and scope

The Portuguese Association of Applied Algology (APAA) is an association for people in the algae sector, which carries out scientific, educational, technological, and industrial activities. The APAA promotes collaborative networks among people in the algae sector by identifying and characterizing activities business in the sector in Portugal, and by stimulating collaboration between the different national organizations in boosting the sector. In Portugal, this sector has already become significant, encompassing more than 20 companies and more than 10 R&D groups with relevant activity in macro and microalgae with approximately 300 employees in 2019. The APAA invited the most relevant stakeholders within macro and microalgae production and development to a conference in 2019.

3.4.2 Approach

On October the 22nd, 2019, the Interdisciplinary Center of Marine and Environmental Research (CIIMAR) hosted a re-launching conference were a wide range of stakeholders from the micro and macroalgae were present. This conference was the perfect breeding ground for an exchange of perceptions on the challenges facing this sector.

In this context, a workshop was held entitled: "How to transform the potential of the algae production in Portugal regarding economic development. Reflections around the barriers and strategies for their mitigation" (*Como transformar todo o potencial do sector das algas em Portugal em desenvolvimento económico? Reflexão em torno dos constrangimentos e medidas concretas à sua mitigação*) in which we enlisted 20 participants, and it was led and moderated by the Director of PROALGA, the Portuguese Association of Algae Producers. The participants mainly included producers, regulators, and researchers, comprising a diverse range of aquaculture experiences.

A set of questions to be addressed in the workshop were distributed to the workshop participants in advance of the workshop, together with an information letter that described how, and under which conditions, the information would be used, as consistent with GDPR requirements (Annex 4).

The workshops approach was explained to the participants as an open discussion, no groups were made, and everyone got invited to take the floor and share perceptions. It started with the explanation of the workshop's main objectives, description of the dynamics as an open discussion guided by questions from the workshop protocol (Annex 4).

The workshop was conducted as a general discussion, in which moderators, guided the participants through the questions, which were formulated with an aim to examine producer's perceptions of policy frameworks. The questions covered the development of the companies, enabling factors, barriers, and pathways to improve policy and governance. The workshop was included in a larger event (APAA conference) for which most of the participants had already introduced their company, ongoing research, and their views on the further development of their companies.

3.4.3. Outcomes

Policy and governance as enablers

Which policies support(ed) your business and how?

Policies enable the development of the sector at different levels: international, European level, national level, and regional level.

Internationally, the UN's Sustainable Development Goals are identified as enabling policies for the algae aquaculture, as the sector can embrace various goals (mentioned: Goal 2, 9, 12, 13 and 14).

At the European level, policies support the development of the sector as projects about algae aquaculture are being successfully funded and encouraged. This was perceived to reflect the political interest in developing the sector. It was noted that it is not problematic to get projects approved for development of algae aquaculture in Europe. European funded projects examples mentioned in the talks included ValorMar, GENIALG, Integrate IMTA, and SeaColors.

Internationally and nationally, overall, there is a certain amount of risk capital also available for investment in the algae aquaculture, which also shows a political will or interest in the development of this sector. Examples of other funding initiatives include the AlgaTec EcoBussines Parc.

Some examples of national policies are the Blue Bio-economy Road Map for Portugal, a set of tools to guide all stakeholders towards sustainable development and innovation in the marine sector, including algae aquaculture. It was endorsed by the Minister of the Sea to CIIMAR Research Centre. Another example is the BlueBio Alliance, which is a national network that includes all subsectors of the marine bio-resources value chain in Portugal, where products from marine algae aquaculture are included. These initiatives help and facilitate the development of the sector. Portuguese Start-ups and Small and Medium Sized Enterprises (SMEs) like ALGAplus, Seaweed Energy Solutions, a4f (algae for future), Buggy Power are part of the BlueBio Alliance, and benefit from the synergies it creates. The Blue Bio-economy Road Map and the BlueBio Alliance reflects political interest in supporting the development of the sector that provides tools and network opportunities, which benefit the sector.

Which regulations support(ed) your business and how?

Regulations enable commercial activities and are crucial for quality control and standardization. Regulations and standards thus facilitate the aquaculture activities, e.g. as it supports trade within and between European countries as well as with third countries. Without such trading rules, the sector will not develop. These regulations are being updated in parallel with the growth of the activity in the sector, and they are needed to facilitate the further development of the sector.

Which stakeholder groups support(ed) the development of your business (e.g. agencies, associations, institutions, regulators, policymakers)?

Associations of stakeholders, such as PROALGA (Portuguese association of Algae producer) or APAA (Portuguese Association of Applied Algology), are important supporters of the aquaculture activity. These stakeholder groups, by providing communication and interaction among stakeholders, facilitate and enable the development of the sector.
Stakeholders' actions (individually or in association) boost the development of regulations and policies along with the development of their business and their necessities. Those developments eventually turn into benefits to other producers and, overall, to the whole sector.

Another aspect mentioned was the fact that among producers, being start-ups or SMEs, there is no actual competition in the market, but cooperation to build up this sector. A motto of the sector could be: “better together”.
Additionally, it was mentioned that there is a *critical mass* enough at this time in the sector for the development of algae production activities in Portugal: there are companies (big, SMEs and start-ups), universities and research institutes, research projects and investment projects that interact among each other and that are, overall, boosting the development of marine bio-resources industries including algal aquaculture. The existence of a good number of stakeholders in the sector is identified as a positive aspect that enables the activity.

How has society supported the development of your business (e.g. social license)?
Society is identified as one of the stronger points that enable and facilitate the development of the sector.

There is a general public awareness of the positive aspects and benefits of the development of the marine sector that overspills to algae aquaculture. There is a general vision of the importance of the ocean to achieve sustainable development, reflected by a sentence repeatedly: “the future is in the ocean”.
Algal aquaculture is not generally seen as a damaging industry by the general public.
The general public is interested in nutrition and health, and therefore are interested in the alternative products the algae aquaculture can provide to full fill their need in terms of health and nutrition. There is a real market of people that are interested in new products that come from the sea, which is a main supporter of the algal aquaculture sector.

Policy and governance as barriers
In your opinion what are the main challenges in terms of policy and regulation?

Regulation is the major constraint that the sector faces. The legal framework is identified as a barrier or constraint. The legislation is not up to date, mainly because the development of regulation is not done at the same pace as the development of the industry.
CEN and ISO standardization norms and frameworks are not updated to the algae production scenario in Portugal. Norms and rules are the same for any kind of aquaculture activity, rather than be specific to algae production separately, which is different from animal aquaculture activities.
The development of the sector is complex, and the main identified barrier is that the regulatory agencies limit the activity, as they embrace the precautionary approach, rather than accompany the development of the existing knowledge to support this specific industry and develop specific norms and rules.
Bureaucracy represents a major constraint too, as it is complex and involves many actors that limit the development of the sector and adds more complexity to the processes.
The IAPMEI (Instituto de Apoio às pequenas e Médias Empresas e à Inovação – supporting institute for SMEs and innovation in Portugal) provides a classification of activities in clusters that some find problematic. The clusters for the enterprises have sub-clusters and subdivisions but it is not clear where to classify some companies on the sector, and this represents a constraint.
Producers need to communicate with the Ministry of Environment, and Ministry of Economy and not only with the Ministry of Sea affairs, which has been the case so far. The lack of aggregation of the

whole activity in one ministry has sometimes led to empty conversations with the environmental ministry policymakers that are not capable of acting for the benefit of the aquaculture sector.

Technological constraints were also identified. The main challenge of the production industry is to achieve economies of scale: producing more at lower prices or selling for higher prices, although the technology is a critical factor in some cases.

Lack of transparency concerning international trading rules is identified as another barrier. European aquaculture players need a level-playing field with products from third countries. The lack of common standardization rules, mandatory analysis or certifications or the weak enforcement and control of the norms and trading rules, make the European and, therefore, Portuguese producers less competitive in the market, and this represents a barrier to development.
Another opinion that was expressed was that the exigent academic career needs to be focused on developing science to serve the sector rather than on publishing. The "publish or perish" aphorism, which describes the pressures to succeed in an academic career, often represents a drawback for the application of scientific advances to the industry. Science should not only be measured in terms of scientific publications, but also on its contributions to the industry.

Which stakeholder groups have constituted a barrier to the development of your business (e.g. agencies, associations, institutions, regulators, policymakers)?

The lack of communication among stakeholders was identified as the main barrier to the development of business in the sector. Even though the associations of stakeholders have been identified as enablers in some cases, in other cases, the wide number of associations result in individual efforts directed for the interest of each of the particular associations, rather than a general effort for the sector.

How has society hindered the development of your business (e.g. social license)?

There are no main barriers identified that hinder the development of the business that come from society. It is identified, nonetheless, that education and communication need to be enhanced from the sector to the society, as misleading information to the general public can lead to barriers in the future, so even though it does not represent a barrier now, education on these matters should not be forgotten.
Some examples where society has been identified as a *potential* barrier were mentioned.
Spirulina producers identified that, generally, the average consumer assigns a certain quality to products from some geographical origins (i.e., there is a general negative perception of Spirulina imported from China). Information about the test and controls a product needs to pass to be placed on European markets is not readily accessible for the consumer. Misinformation can contribute to an overall obscure perception about algae consumption and can become a constraint in the future.
In the case of macroalgae products, it is difficult for the general public to perceive whether the iodine content of macroalgae is beneficial or not regarding health, as too much iodine can be detrimental too. Studies need to be performed in this direction and strategies to inform the general public need to be transparent, so consumers can make informed choices about algae aquaculture products. This lack of clarification can become a barrier in the future.

Investing efforts to identification and resolve potential misunderstandings, and to clarify myths around algae consumption and use in general, will reduce the risk that public perception becomes a barrier for the industry. It is necessary to talk about food safety in society.

Pathways for improving policy and governance

What are your thoughts on/ overall perception of the level of support provided by current governance frameworks applied to your business?

What is your overall perception of the level of agreement/balance between policies for environment/societal protection and policies to enable business growth?

The level of agreement between policies for environmental protections and policies for business growth is well documented in the cases where a production facility is integrated inside a protected area such as Rede Natura 2000 (Ria Formosa and Ria de Aveiro). In these cases, there are some constraints that arise from being part of a protected area, but they have been integrated in a way that has worked successfully showing that there is a good alignment between the two policies.

It was also mentioned, regarding this issue, that producers accompanied by academics and supported by scientific data are more likely to obtain permits for certain activities within protected areas in Portugal. When scientists work with producers and provide information, the regulation authority (Instituto da Conservaçao da Natureza e das Florestas- ICNF) will be more inclined to cooperate. Environmental protection regulations that do not permit the cultivation of alien/introduced species make the investigation and understanding of their potential impossible, which represents a constraint on development due to lack of research.

In which cases has this protection been helpful or unhelpful to development?

Overall, the attendants concluded that the inclusion of some aquaculture producing activity within Red Natura 2000 areas concludes that it is neither helpful nor unhelpful, it has its advantages and drawbacks, but overall, it balances out neutrally.

The regulation of alien species is identified as unhelpful for the development of the sector.

Could you identify improvements to regulation and policy?

In your opinion what should be done/changed?

During the discussion, some recommendations, and strategies for improvements to regulation and policy were identified and described.

First, communication with regulatory agencies and governmental authorities needs to be improved. Communication forums, for producers, end-users, investors, regulation agencies, government authorities, and academic researchers need to be encouraged to support discussion and advance understanding on the constraints that were described above. The discussion about “enablers and barriers” needs to be shared with stakeholders beyond the production and research communities and involve authorities and regulation agencies. In the past, these discussions and contacts with regulation authorities have led to the development of licensing processes that benefited the industry.

This communication needs to be transversal to authorities, end-users, and include the general public. More information about algae aquaculture in the media is also needed. A communication strategy with a high influence on society will bring attention from authorities to the difficulties the sector faces, and it is supposed to encourage discussion and efficient problem-solving.

The development of “Marca Portugal” will serve to support a strategy to internationalize the products that are produced nationally, but also to be better positioned on the national market. This has worked in the past with other products and developing such a marketing strategy could be beneficial to the aquaculture sector. This “Marca Portugal” strategy needs to be based on standardization rules and quality control that will create trust in Portuguese products.

Another strategy proposed to make improvements in regulation and policy is to quantify the additional values that algae production provides by applying Ecosystem Services frameworks. The valuation of services such as regulation of water quality, regulation, and maintenance of habitats for biodiversity, carbon sinks in terms of climate change mitigation and ocean acidification, to mention some examples, will effectively serve policymakers and regulatory agencies to differentiate these production activities from other production activities (such as aquaculture of carnivorous fish) that have been identified as more detrimental to the environment. Algae aquaculture provides benefits to society beyond biomass production that should be considered by regulating authorities. Regulation could differentiate the industries according to the impact and benefits they provide. For this, a first step would be to quantify how much benefits they provide and the methods they use to create these benefits. The values of the different types of capital (natural, human, social, financial, and infrastructure capital) need to be accounted for and be presented to authorities to inform the development of new strategies and regulations. This can result in tax reduction or subsides that can facilitate the development of the sector.

What do you think would be the benefits of such changes?

Overall, a better understanding of the sector’s difficulties and benefits, informing changes in regulations, could facilitate the development of the sector.

4.4.4 Main findings

The top six challenges identified (not placed in order of importance):

1. Quantify the benefits that algae aquaculture provides by applying the Ecosystem Services approach for more effective communication. Understanding by governance and regulation authorities of the benefits from the industry.
2. Technology developments represent a challenge, as technologies are not yet developed at an industrial scale, and more research in technological development is necessary for scaling up production.
3. Bureaucracy is complex to navigate, it encompasses too many actors and it slows down advances in the industry that leads to unproductive processes.
4. Communication with governmental authorities and regulation institutions represents a challenge and is necessary to develop strategies for the authorities to better understand the difficulties that the producers face and what constrains their development.
5. Communication with the general public through the media about the sector benefits and importance in a transparent way. Provide evidence-based information about the different types and different qualities of the products in the market and call the attention of the authorities.
6. Academia and industry need to develop together. On the one hand, producers need to have access to scientific advice. On the other hand, academia needs to understand the needs of the industry development and support it with research.

3.5 Workshop on IMTA in South Africa

3.5.1 Introduction and Scope

Aquaculture is a very small industry in South Africa with reported commercial production in 2019 of 7103t comprising of abalone (*Haliotis midae*; 1657t), trout (*Onchorhynchus mykiss*; 1550t), mussels (*Mytilus galloprovincialis* and *Perna perna*; 3055t), oysters (*Crassostrea gigas*; 383t) and tilapia species (460t) (Data supplied by the Department of Fisheries, Forestry and Environmental Affairs). Interestingly, most cultured species can be considered 'low trophic', with the exception of trout. An estimated 3000t of macroalgae (Ulva and Gracilaria) is also cultured in integrated multi-trophic IMTA with abalone but is not reported in production statistics as it is not sold, but fed directly to the abalone (DAFF, 2014).

The South African government has prioritised aquaculture as a sector with high growth potential and has committed to a comprehensive aquaculture policy and regulatory framework which accommodates IMTA. The cabinet approved National Aquaculture Policy Framework (DAFF, 2013) provides an ambitious and comprehensive sector development plan. It is regarded as being central to the achievement of the goals of the National Development Plan, which envisages aquaculture as a provider of decent jobs and livelihood opportunities, while the New Growth Path provides a blueprint to develop industries under the agriculture job driver. Under these policies, aquaculture is viewed as a means of alleviating poverty, unemployment, and inequality through enhanced food security. Commercial aquaculture development is supported through the Department of Trade and Industry's Industrial Policy Action Plan (IPAP3), which provides a suite of capital and other grants for developing aquaculture enterprises.

The South African government has implemented a policy of stimulating investment into commercial aquaculture by means of grants and subsidies. The Aquaculture Development Enhancement Programme (ADEP) fund, which offers reimbursable cost-sharing grant of up to a maximum of R20 million (equivalent of about 1.4 M EUR) or 40% of qualifying costs in machinery and equipment; bulk infrastructure; owned land and/or buildings; leasehold improvements; and competitiveness improvement activities. Parastatal development finance institutions have made significant loans and grants available to the aquaculture sector. The parastatal Industrial Development Corporation (IDC) has made several loans to aquaculture companies and has played a key role in providing finance for the development of the sector. The State's National Empowerment Fund (NEF) and Comprehensive Agricultural Support Fund (CASP) have provided finance for small scale mussel farmers in Saldanha Bay to enter production and processing partnerships with the existing commercial companies. The priority attached to aquaculture sector development was emphasised in 2014 by its inclusion in the Presidential "Phakisa Ocean Economy" suite of sector projects to be supported with fast-track planning and implementation. A suite of 23 projects were identified and detailed plans for implementation drafted.

The designated lead authority for aquaculture is the Chief Directorate: Aquaculture and Economic Development within the Fisheries Branch of the Department of Forestry and Fisheries Environment (DFFE). A substantial investment has been made to develop a dedicated aquaculture staff within the DEFF and a close working relationship and cooperation exist between government and industry in respect of sector development and management.

National coordination occurs through the National Aquaculture Intergovernmental Forum. Government support measures to the aquaculture sector include aquatic veterinary services, research support and technology development, shellfish water quality monitoring to meet EU standards, environmental monitoring and authorisations, development and monitoring of product standards for export, zoning of state land and water for aquaculture, promotion of producer associations, support to small scale aquaculture projects, revitalisation of state hatcheries, bursaries for post-graduate training in aquaculture, training of staff through the Sector Education Training Authorities (SETAs), enabling legislation, and value chain building initiatives.

Under existing legislation, marine aquaculture rights, permits and regulation is currently governed by the Marine Living Resources Act of 1998 (MLRA), while freshwater aquaculture is governed by agricultural legislation. Aquaculture rights (15 years) and annual permits are required to operate a marine aquaculture business in terms of the MLRA. Various aquaculture specific regulations, guidelines and policies for aquaculture have been promulgated under the Marine Living Resources Act. In terms of environmental legislation, aquaculture is a listed activity in the EIA regulations of the National Environmental Management Act with clear guidelines on obtaining authorisation. The EIA process in South Africa is regulated and very consultative and transparent. Aquaculture is a listed activity under the EIA regulations and macroalgae cultivation is provided for with only a 'basic assessment' required for less than 60t per annum production (DEA 2014).

Macroalgae cultivation and IMTA are briefly mentioned in policy and regulations as a means of diversifying commercial aquaculture. The diversification of the current suite of commercial aquaculture species is explicitly addressed in the Policy for the Development of a Sustainable Marine Aquaculture Sector in South Africa (DAFF, 2007), and the Aquaculture Research and Technology Development Programme for South Africa which seek to increase the number of candidate species for commercial aquaculture, including the culture of macroalgae and IMTA (DAFF, 2012). The research and technology development policy states that: 'increased emphasis needs to be placed on integrated use of water to improve environmental performance. Integrated Multi-Trophic Aquaculture incorporating the increased use of plants and animals for nutrient stripping should be encouraged".

IMTA is facilitated by the DEFF marine aquaculture permitting system which issues an 'integrated permit' for the culture of multiple species on the same site. For example, several farms possess permits for culturing abalone (*Haliotis midae*), macroalgae (*Gracilaria* and *Ulva*) and other species (e.g. fish, sea urchins and sea cucumber) on the same site. 'Research' permits may be obtained for investigating the culture of new species such as sea indigenous marine fish species, sea cucumbers, sea urchins and bloodworm.

3.5.2 Approach

An industry consultation workshop on policy and regulatory issues enabling or constraining the development of integrated multitrophic aquaculture (IMTA) was arranged by Rhodes University in partnership with AquaVitae industry partner, Marifeed (Pty.) Ltd.

This was complimented with telephone interviews with selected industry persons and the director of Aquaculture in government (Directorate of Aquaculture and Socio-economic Development, Department of Fisheries, Forestry and Environment).

The workshop was attended by 39 industry participants, comprising mainly producers (89%) from the abalone farming sub-sector (which is the biggest aquaculture sub-sector in South Africa), plus a few from the aquafeed and consulting sub-sectors. The participants represented approximately 10% of the management and supervisory level marine aquaculture industry target group.

The participants were asked to comment on two key questions based on their commercial aquaculture experience, visibly:

"In terms of existing policy and regulations, what 1) promotes and 2) constrains the development of IMTA in South Africa?"

Workshop participants at lunch

3.5.3 Outcomes

It was revealed that IMTA is under active development on abalone farms which are seeking to diversify their range of products to make more economic and sustainable use of the every large volumes of water they pump (2000-3000 M3/h). Macroalgae (*Ulva* and *Gracillaria*) is cultured on a commercial scale on four abalone farms, in the farm effluents steam as abalone feed and as a form of bioremediation and/or partial recirculation. Cultured macroalgae makes up 40-50% of the food requirement on these farms with the balance being pelleted food and wild harvested kelp (*Ecklonia maxima*). Some abalone farms have or are conducting research to diversify their IMTA mix to include other species such as sea urchins (*Trypneustes gratilla*), rock lobster (*Panulirus homarus*), sea cucumber (*Neostichopus grammatus),* bloodworm (*Arenicola capensis*) and marine finfish (*Argyrosomus japonicus*). The existing offshore mussel and oyster farms are not integrated with any form or offshore IMTA, although some experimentation with macroalgae is taking place as part of the present AquaVitae programme.

The workshop participants did not have any specific policy suggestions for promoting IMTA and felt that the existing policy framework accommodated IMTA. This finding resulted from select telephone calls to key industry players.

Several participants had experienced difficulties with cumbersome bureaucratic processes in obtaining IMTA research permits, particularly for new species which had not yet been trialed for aquaculture. Two participants commented:

'with applications on blood worm you are called in at the start and a study group is set up. The next moment the study group is referred to a new group and then to another group .... this causes difficulties to know where your application is and within the first 6 months your application is lost, and you have to restart the process.'

'It is very difficult to start a request to focus on a new species or work on a hybrid. It is frustrating to even try and apply as it feels like you are getting nowhere with any application.'

The problem highlighted by the industry members to what appears to be a structural organisational problem within the Department of Fisheries, Forestry and Environmental Affairs. Any industry application for a new permit goes to a scientific committee convened by the Departmental management. Scientists make anonymous comments, which are then forwarded by management back to the applicant. Each round of correspondence typically takes around 3 months. It would save a great deal of time if the permit applicant, DEFF management and scientists sat together to discuss the application to resolve any queries.

A further major hurdle to developing IMTA was the biosecurity regulations, as the transfer of IMTA species and products between farms could spread pathogens. For example, Marifeed is unable to use IMTA grown macroalgae in formulated feeds for abalone due to the risk of spreading pathogens between abalone farms. Case Study 3 in the AquaVitae project is undertaking some trials including IMTA algae in pelletised feed to test whether the algal drying and extrusion pelleting processes can eliminate the risk pathogen transfer.

A further constraint to developing IMTA, was that if macroalgae is to be cultured for human consumption, there is no regulatory provision for food safety monitoring and testing of macroalgae and waters it is grown in. The DEFF is aware of the issue and a policy maker indicated that an appropriate standard could be developed if requested by industry and gazetted as a regulation.

3.5.4 Main Findings

The consultation with the South African aquaculture industry revealed no major policy constraints to the development of IMTA.

Two possible regulatory constraints were identified:

1. Biosecurity. Under the present aquaculture biosecurity protocols, it is not allowed to use macroalgae grown on one abalone farm and transport it to another farm for feeding to abalone, or to incorporate it into a pelletised abalone feed. The reason is that abalone associated pathogens and parasites may be transferred between facilities. At present the

AquaVitae project is investigating a possible protocol for treating and using macroalgae grown on abalone farm effluent in pelleted feeds.

2. Food safety. If macroalgae is to be cultured for human consumption, there is no regulatory provision for food safety monitoring and testing of macroalgae and waters it is grown in. The DEFF has indicated a standard could be developed if requested by industry.

The main constraint experienced by commercial farms in developing IMTA was the slow bureaucratic process in obtaining research permits for new species. This could possibly be speeded up by active discussion of scientific queries about the proposed projects involving the industry applicant and DEFF managers and scientists.

3.6 Workshop on IMTA in Brazil

3.6.1 Introduction and scope

Following a worldwide goal and need for more sustainable aquaculture systems, there is growing interest in IMTA in Brazil over the last years, exemplified by research and production initiatives integrating freshwater fishes (*Colossoma macropomum*) with prawns (*Macrobrachium amazonicum*) (Dantas et al., 2020; Flickinger et al, 2020), prawns and Nile tilapia (*Oreochromis niloticus*) (Rodrigues et al., 2019a; Rodrigues et al., 2019b; Flickinger et al., 2020), the ornamental seahorse (*Hippocampus reidi*) in multitrophic organic farms with oysters and shrimps (Carvalho et al., 2019), combinations of the Nile tilapia, shrimps and halophyte plants (Poli et al., 2019), shrimps with different mullet species (Chamorro-Legarda, et al., 2019, 2020, Holanda et al., 2020), different combinations of shellfish, macroalgae (*Kappaphycus alvarezzi*) and cobia (*Rachycentron canadum)* in open sea (Rombenso et al., 2014; Santos et al., 2018), among other experiences in different realities of the continental-sized Brazil. Although IMTA systems are very promising, the reality of the aquaculture production in Brazil is fundamentally monoculture-based. Freshwater finfish production relies on the monoculture of the Nile tilapia, tambaqui and its hybrids (i.e. tambacu and tambatinga) (PEIXEBR, 2020). Mariculture is mainly represented by the farming of the Pacific White Shrimp (*Litopeaneus vannamei*) in the northeast region with around 90.000 t produced in 2019 (ABCC, 2020). Shellfish production plays also an important role being represented by the brown mussel (*Perna perna*), the Japanese oyster (*Crassostrea gigas*) and the lion's paw scallop (*Nodipecten nodosus*), whose overall production totalized 15.215 t in 2019 (IBGE, 2020).

As illustrated above, there is a scenario of different monoculture-based industries well-established in Brazil, but also a varied range of studies, pilot experiences, interests and potential regarding the production of those same species in different IMTA systems. On the other hand, there is also an apparent lack of incentives and appropriate policies to promote such a step change towards multitrophic production in the country. Not surprisingly, this monoculture reality is also reflected in the current aquaculture regulations. The only mentions to IMTA in the legislation are overall guidelines for organic aquaculture considering a scope and concept of integrated farming and polyculture (BRASIL, 2011). Also, the environmental regulations have become more rigorous over the past years, but the environmental benefits of IMTA is not accounted for in the licensing of aquaculture. As a result, there are only few IMTA commercial initiatives in Brazil, of which most have the Pacific White Shrimp as the main economic species, some at Rio Grande do Norte state, a traditional shrimp farming site in Brazil. With few exceptions, farmers tend to be reluctant to change their working economic model

(monoculture) to IMTA systems, which still lack research on applicability and scalability, opening the opportunity and need to advance on Research, Development and Commercialization (R&D&C) aspects. Indeed, this production changing process has been reported for other countries, where the conversion of traditional monoculture sites into IMTA sites required time, dedication, perseverance, and an interdisciplinary approach (Chopin, 2011). In Brazil, at this point in time, understanding the local factors that either promote or constraint a step change from monoculture to IMTA is key. This understanding needs to be developed in cooperation with the production sector so that future policies can be appropriately implemented. To do so, the AquaVitae project organized a workshop in Brazil aiming to raise governance perceptions from different stakeholders focusing on available technologies, current policies, and regulations.

3.6.2 Approach

Alongside the Brazilian National Shrimp Fair (FENACAM) at Natal-RN (northern Brazil), the Brazilian Agricultural Research Corporation (EMBRAPA) and the Federal University of Santa Catarina (UFSC) co-organized and promoted a workshop session gathering the different stakeholders involved with IMTA production in Brazil on 15th of November 2019.

Prior to the meeting, stakeholders were selected and invited to the workshop (contacted by email and phone). Aiming to raise their interest and increase participation, a banner and a summary of the workshop was sent to all participant candidates (Appendix 1). The workshop itself started with a general overview of AquaVitae project, an overall levelling of the workshop aims, the methodology/dynamics of the workshop and the questionnaire on policy and governance that would be discussed after dividing participants into four groups. The 25 participants were also informed about how and under which conditions the information to be collected would be used for, according to the GDPR requirements. The workshop on policy and regulation issues for IMTA in Brazil was developed to serve the task in AquaVitae project, of which this report is an outcome[24] .

The 25 participants of the workshop were all Brazilians, and included IMTA producers, researchers, and aquaculture students. The four groups were created in a way to equalize the diversity of experiences and background on the subject. Each group was oriented to select from themselves a coordinator and a rapporteur. Participants in each group were given an opportunity to make comments from their group followed by discussions of each topic. The same questions were discussed in each group and after that, a general discussion among all participants took place.

After the workshop, the outcomes from each of the four groups were summarized and e-mailed each one of the participants. To harness more perceptions about IMTA policy and governance in Brazil, the position paper from the round table of the International Industry Forum for the future of sustainable aquaculture in Brazil organized by the BlueEconet in June 2019 in Brazil was also considered.

[24] The workshop session on policy and regulation issues was designed and lead by Eric Routledge (Embrapa) and Felipe Vieira (UFSC).

3.6.3 Outcomes

The main outcomes from the workshop include either challenges faced by the IMTA sector in Brazil, or also opportunities that participants have identified regarding IMTA policy and governance, these have been grouped in specific topics as follows.

Policy and regulation

Although IMTA has a huge potential to tackle different economic and sustainability issues of aquaculture, the overall perception from stakeholders is that the Brazilian policies fails to support or help the development and adoption of IMTA in Brazil. The existent general regulations are indeed not applied to IMTA production systems, and development of specific regulations should be considered. Today, the environment licensing for IMTA can be even more difficult to be obtained when compared to the licensing of monoculture farming. The overall perception is that this discourages production system diversification, even though if IMTA could prove to the environmental agencies that these relatively new production systems can yield lower environmental impacts.

To overcome the lack of specific legislations for IMTA, it has been suggested that policy makers and staff from the environmental and regulation institutions can be trained within IMTA concepts of sustainability, so they can better understand the benefits of IMTA systems. It has also been suggested that policy makers consider actions and partnerships to acquire datasets from the few available IMTA farms, and thus establish appropriate specific IMTA licensing policies. This would facilitate practical learning, and consequently, help speed up the analysis of the licensing petitions. Also, such a new legislation would include and categorize IMTA farms as belonging to a “low” environmental impact activity (e.g. reduced or zero effluents), creating the opportunity for a green label that would add value to products coming from IMTA production systems.

The establishment of IMTA specific legislations would also open room for the improvement of other co-existing regulations to reduce operation costs. As an example, within the Brazilian Labour Ministry, all employees’ duties are classified by the Brazilian Occupation Classification (CBO) which recognize, nominate, and codify each job title, describing the characteristics of the different occupations (BRASIL, 2002). Considering this actual legislation, someone hired at a shrimp farm under the appropriate code CBO 6313 “Aquatic Animals Farming” would not be allowed to work with macroalgae at the same farm. A slight change in this classification code title to “Aquatic Organisms Farming” would permit the employer to hire one employee for both duties (shrimp + macroalgae farming) thus reducing labour costs.

Industry point of view

The development of the full potential of IMTA in Brazil depends on the willingness of the industry to invest in these systems, and the speed of implementation will depend on the market and the producers from each location. The processing of IMTA products has sustainability as a source of motivation and could support the creation of a "voluntary label" to use as a marketing tool for the acceptance of IMTA products on the market. Industry support would be vital to implement the idea of a voluntary label, as Brazilian consumer would not be automatically interested in a more expensive product only because it is sustainable. Also, to stimulate industry involvement, key questions should address how much could IMTA increase profit for their products for further development. Economics of IMTA are not well understood as the benefits of the lowered feed input and greater productivity stand against a higher

energy cost due to extra costs in some cases to maintain pumping and Recirculating Aquaculture Systems. In Brazil, power distribution is not stable at all regions and dependency on electricity might hinder a proper interest and spread of certain IMTA systems.

Another raised perception is that the existing lack of knowledge and information about the potential and application of IMTA restrict the interest to spread investments. Although many gaps are found to discourage investments, it has been raised that integrated actions between farmers, researchers and final consumers could be a strategy to increase the level of IMTA importance, and principally validate experimental data at commercial scales.

Nowadays, only three cases of commercial success of IMTA have been identified in Brazil. Two of them are located at Rio Grande do Norte state, northeast region. “Primar Orgânica” farm managed to convert its farm into IMTA with the mangrove oyster (*Crassostrea gasar*) and the Pacific White Shrimp, while “Camanor” shrimp farm changed their layout to IMTA system benefiting from the intensification advantages provided by biofloc systems. In Rio de Janeiro state (southern Brazil), “Maricultura Costa Verde” has started an IMTA system integrating the cultivation of cobia with scallop, mussel, and macroalgae.

Overall, participants pointed out that the participation of research institutions on these IMTA initiatives was fairly limited, with farmers taking most of the risk and costs, especially because the industry “timing” is not the same as the research “timing”, and validation of the IMTA systems need to be followed by production-profit numbers. To improve this framework, farmers and researchers would have to work more closely together so that new findings in science become more directly applied. The potential of research to develop new models and indicators to establish new and more stable functional systems for the industry standards should be recognized (Valenti et al., 2018). If not, the already existing enterprises will keep experimenting with different IMTA designs on their own accord.

Research and development

Overall, the Brazilian research applied to IMTA have been developed from different (mainly public) institutions, and applied to cover a wide range of species, even though R&D investments over the past 10 years have been problematic in many instances. The fact that there is no common conceptual model for IMTA makes it impossible to put all trophic level species into the same system, and challenges the researchers to establish focus on the technical and economic feasibility of different IMTA systems (Chopin, 2011).

Also, it has been identified different demands from various locations aiming to improve IMTA for different scales, considering the development of small shrimp production units, with possibility for these to be away from the sea by using biofloc systems, without huge investments, and with less vulnerability to environmental changes. Other needs for research pointed out during the workshop include the improvement of feed quality through the incorporation of macroalgae/microalgae for oil/fatty acids, tank engineering, design of systems to meet requirements of the different cultured species, evaluation of RAS technology and appropriate characterization of system effluents. The main target should be to start systems as simple as possible to be functional, attractive, and realistic for farmers.

Nevertheless, it has been recognized that universities and research institutions do their best, carrying out studies with scarce funding, but limitations at experimental scale normally poses more difficulties to achieve validated results that can be directly applied into commercial IMTA farms or production projects. On the other side, IMTA Brazilian cases still need data to refine farming protocols and include other species such macroalgae and molluscs. In the case of shrimp farm, there is interest to look for options other than tilapia to be combined into a more cost-effective approach.

Overall, it was a consensus that shrimp farming is driving IMTA development and research in Brazil, as the main species of the systems. Researchers are looking forward not only to reach efficiency, survival, growth, higher yield levels combining different species and strategies, but resilience against diseases outbreaks such as White Spot Syndrome Virus (WSSV) and Infectious Myonecrosis Virus (IMNV).

Brazil has huge inland aquaculture industry to be explored that can be used in IMTA. Many IMTA approaches have been adapted from other countries with different backgrounds and it is worthwhile to look more into the local regions for opportunities. Tilapia, tambaqui and other freshwater species have possibilities to build up and are worth to explore.

There is a perception IMTA could be also applied and be helpful to some extension as a strategy to prevent or mitigate other disease problems in the tilapia industry (Tilapia Lake Virus, TiLV), which is the main Brazilian aquaculture value chain. However, the best effective IMTA approach for tilapia farming developed in cages in big hydroelectric power dams around the country still need to be determined.

Besides all the demands, one important contribution from universities and research institutions would be to educate future professionals to fit a “hybrid” profile, with a multidisciplinary view with interests turned into both research and applied knowledge. The establishment of Technological Reference Units (TRUs) for research and training, especially in local communities could be a strategy to provide local qualified labour to the IMTA farms, usually not common at local communities. Partnerships between universities and research institutions are desirable to avoid duplicating efforts with similar scientific works.

Financial support

It was noted that only few Brazilian institutions such as farmers associations, development agencies and Brazilian public banks (e.g. Banco do Nordeste, BNB and National Bank for Economic and Social Development, BNDES) would be able to financially support and orient potential aquaculture investors. But when it comes to IMTA, there is no specific rule which offers funding with lower interest rates for investments and maintenance of production systems.

In fact, while these specific funding still need to be built, short-term investments from the private sector will be for brave and daring entrepreneurs, who will lay their hands on the masses and build a model based on their reality and needs. IMTA offers opportunities to apply CO_2 credits as a trigger and motivation for environmental compensation and business investment. In the same line, these credits can be the source of specific funding to support innovation and applied research into IMTA. This can also stimulate R&D institutions to work on technological packages with the private sector validating their experiments results and enabling scholarships and grants to build up future professionals for IMTA systems.

3.6.4 Main findings

Overall, participants shared congruent points of view regarding the different topics raised on the governance challenges, problems to develop and induce IMTA systems in Brazil. All of them asked for a special treatment claiming for lower taxes and a higher classification to get facilitated credit and increased investments. Also, suggestions to create a green label as a marketing strategy for IMTA products was also raised and debated.

Another common topic was the lack of specific legislation and/or public policies to facilitate and induce farmers to change their production systems from monoculture to IMTA. There was a consensus that the lack of appropriate specific regulations inhibits investments towards IMTA based farms. Other challenges to overcome are the distance between farmers and researchers and the IMTA farm need to hire a specific worker for each species farmed in the system, which increases the production costs.

In general, there are more bottlenecks and challenges than advantages when a farmer decides to go to an IMTA farm in Brazil. The lack of specific legislation, inadequate legislation applied to IMTA, and absence of a distinction between IMTA farmers and other farmers were the main issues presented and discussed. Specific policies for research funding should be considered to facilitate partnerships between researchers and the private sector and develop applied projects to increase yield and incorporate new species into the systems.

In conclusion, Brazil has an outstanding potential for the implementation of different IMTA systems, both in marine and freshwater environments. However, to-date there are only few enterprises that faced the challenges of these new technologies. To increase the adoption of IMTA, the maturation of these concepts within the sector becomes necessary. This maturation also needs to take place within public policies, standardization of environmental licensing, tax incentives and specific financing pathways. A higher interaction between research and productive sector was also seen as necessary to scale up IMTA in Brazil.

4 Discussion

The main findings of the information-gathering events reveal several similarities and differences. Despite methodological limitations discussed in the next subsection, the studies allow limited comparisons of aspects that workshop participants deemed to respectively promote or constrain a development of LTS aquaculture in the different countries and Atlantic regions. Following the methodological discussion, we present a few findings that seem to be of particular importance in several cases. What promotes or prevents a development of aquaculture is typically two sides of the same coin, depending on whether discussions revolve around a certain factor, such as funding for research development being present or absent. Accordingly, these findings are grouped thematically rather than being listed as issues that promote or prevent the development of LTS aquaculture.

4.1 Methodology

Although the general-purpose protocol (Annex1) was of necessity adapted to local circumstances in each of the 6 studies reported here, some common themes are apparent in the studies' findings. Before discussing them, however, we need to consider some of the methodological limitations (introduced in Section 2) that might have influenced the information collected during the workshops or by means of questionnaires or telephone interviews. Considering these information-collection events as Action Situations (McGinnis 2011) points to the need to describe participant-selection rules, discussion rules, and output-selection rules. We discuss the first under the heading of 'participant characteristics', the second and third under the heading of 'accuracy of reporting of opinions'.

Participant characteristics

The research question underlying these studies referred to "producers" opinions on the effect of regulation and policy on their companies. "Producers" are here understood as commercial organisations forming part of the relevant value chains, and so including farmers, equipment suppliers and processors of the farmed product. In most of the countries studied as part of AquaVitae T8.2, the LTS aquaculture and IMTA sector(s) are comparatively small – compared with (for example) salmonid aquaculture in Norway or Scotland, they consist of relatively small companies employing relatively few people. Thus, in most cases there was a relatively small population from which to recruit industry representatives. While this eased the challenge of identifying and recruiting participants, especially when drawing on meetings or workshops organised by the industry, it may also have resulted in 'stakeholder fatigue'. For example, the Scottish study used questionnaires, to avoid repeating a producer consultation workshop held one year before by another research project. Thus, those participating in the workshops etc. reported here, may have been more strongly motivated than those who did not participate. Nevertheless, there is no reason to think that industry participants, and their opinions, were unrepresentative of their sector.

Most events also included representatives of other sectors with an interest in the industry, especially researchers, regulators, and local government representatives. The effect of this heterogeneity remains to be examined.

Table 3 summarises information relevant to the representativeness and heterogeneity of the event participants.

Table 3: Characteristics of participants or respondents; the category 'producer' embraces all parts of the appropriate value chain (including farmers, equipment suppliers, and processors).

Study	**% producers amongst participants**	**How participants were identified and recruited; their estimated proportion of target population**
Offshore workshop, Sweden	27%	An open invitation was sent to the organisers networks and key actors networks, and industry representatives registered to participate in the workshop. Some industry representatives were engaged as presenters with offer of travel expenses to encourage attendance. An estimated 40-50% of the LTS offshore industry was represented.
Macroalgae workshop, Norway	26%	Open invitation sent to organisers networks, and industry representatives registered to participate in the workshop. The percentage of industry (macroalgae cultivation companies) represented could not be estimated reliably. However, representatives from several leading companies and from network organisations for macroalgae producers in Norway participated, potentially contributing to a broader basis for articulated industry perceptions.
Macroalgae cultivation, Scotland	~60%	By voluntary return of questionnaire distributed at a meeting organised by the Scottish Seaweed Industry Association; about 40% of meeting attendees responded
Macroalgae workshop, Portugal	45%	Open invitation sent to organisers networks, and industry representatives registered to participate in the workshop. The percentage of industry (macroalgae cultivation companies) represented could not be estimated reliably.
IMTA workshop, South Africa	89%	The participants represented approximately 10% of the management and supervisory level marine aquaculture industry target group. The workshop was attended by most South African abalone farmers (which had convened for another purpose).
IMTA workshop, Brazil	25%	Invitation provided to organisers networks, and industry representatives registered to participate in the workshop- The workshop was arranged as a session linked to the FENACAM conference, the largest conference for shrimp producers in Brazil. The percentage of target industry coverage (IMTA aquaculture companies) represented could not be estimated reliably.

Accuracy of participant expression of opinions

Considered instrumentally, the events reported here aimed to take information from participants to satisfy the requirements of the AquaVitae project's task 8.2. From this perspective, the key concern is with the accuracy of the reported opinions – does what is contained in this Deliverable D8.2 accurately depict the 'real' opinions of the LTS aquaculture or IMTA sector in each country studied?

Considered more broadly, however, the workshop events can be viewed as forums for 'communicative action' (Habermas, 1984) contributing to societal improvements (in this case to more socio-ecologically sustainable aquaculture). Such a perspective provides a framework that allows workshop characteristics to be assessed and criteria that, if satisfied, provide reassurance that workshop outputs are valid and collectively agreed expressions of the views of those who participated.

The requirements for a workshop to effective in this way are: that all participants are empowered to speak and to query by assigning them equal status and by use of a shared language; that participants are open about their position (e.g., representing an organisation, seeking a particular outcome); that statements may be challenged on the basis of evidence; and that creative discussion may lead to new questions and perspectives. Certain ethical issues are also important, including respect for local cultural norms, local laws relating to personal information (e.g. the GDPR), and the avoidance of risk to individuals because of their opinions. Table 4 assesses each workshop against a set of practical criteria based on these requirements.

Table 4: Workshop assessments as forums for communicative action. This table does not include the Scottish study, which used a questionnaire.

Criterion	Offshore workshop, Sweden	Macroalgae cultivation workshop, Norway	Macroalgae cultivation workshop, Portugal	IMTA workshop, S. Africa	IMTA workshop, Brazil
Provision of information about matters for discussion	Yes	Yes	Yes	No	Yes
Use of suitable language to allow participants to engage	Yes	Yes	Yes	Yes	Yes
Use of break-out groups, max 10 people, with facilitators	Yes	Yes	No	No	Yes
Steps taken to ensure that	Yes	Yes	Yes	Yes	Yes

facilitators skilled and neutral					
Steps taken to ensure that primary reports are unbiased by organisers, e.g. by election of rapporteurs	No Organisers were rapporteurs	No Organisers were rapporteurs	No Organisers were rapporteurs	No Organisers were rapporteurs	Yes
Opportunity for participants to review workshop outputs	Yes	Yes	No	No	Yes
Consideration given to ethical issues	Yes	Yes	Yes	Yes	Yes

In summary, it should be kept in mind that the perceptions expressed by stakeholders of a certain affiliation present at a workshop cannot be taken to express the view of all stakeholders of that affiliation, nor can it be taken as an accurate and unbiased description of an actual situation. As is often the case with qualitative information, the views expressed must be considered carefully, and be considered together with other available information sources.

4.2 Discussion of main findings

A time consuming and complicated application process was identified as an impediment to the development of LTS aquaculture in all cases and regions. Lengthy application processes may be difficult to avoid in practice, i.e. due to regulatory complexity, requirements to involve several administrative or expert agencies or uncertainties or lack of knowledge in cases involving new species or production methods. The workshops pointed to several measures considered to have a potential to improve this aspect. These include dedicated efforts to simplify the regulatory framework (Sweden, section 4.1), guidance in the form of a regulatory scout (Germany, section 3.1), guidance in the form of web resources (Norway, section 3.2), and industry networks facilitating knowledge sharing (Norway, section 3.2). For the case of IMTA in South Africa, it was proposed that more direct dialogues between the industry applicants, administrators and scientists could help to reduce the application time for licences for new species in research. Workshop participants in South Africa did not note major policy constraints for IMTA but pointed to specific deficiencies with the regulatory framework for this type of production. In turn, the overall perception from stakeholders in the workshop on IMTA in Brazil is that the Brazilian policies fail to support or help the development and adoption of IMTA. Timing of regulations is seen as a key factor, with macroalgae practitioners in Norway and Scotland being

reluctant to premature regulations, as having conservative regulations in place too early might hinder the sector development.

Regulatory deficiencies specific for novel LTS aquaculture systems

Workshop participants expressed that the development of IMTA in South Africa and in Brazil is impeded by regulatory deficiencies specific to IMTA as a novel type of aquaculture. In the case of South Africa, mentioned deficiencies concern a lack of regulatory provision for testing and monitoring, whereas regulatory deficiencies addressed in Brazil seem to be of a more general scope. Regulatory deficiencies were also identified as a barrier for the development of offshore aquaculture, as regulatory uncertainty will be seen to involve significant investment risks.

Food safety

In most cases addressed, workshop participants were concerned that novel LTS aquaculture production forms may be hampered by inadequacies in food safety procedures for the respective production forms and resulting products. Food safety concerns were brought up in relation to macroalgae cultivation in Norway, concerning harmful product components (iodine, allergens, and heavy metals) and the need to manage contamination risks in the production process. Biosecurity measures to prevent macroalgae or abalone diseases affect Scottish macroalgae producers as well as IMTA producers in South Africa. The need for arriving at scientifically well-founded food safety thresholds for iodine was identified in relation to macroalgae cultivation in both Norway and Portugal. For macroalgae cultivation in Norway, it was noted that there is a need for developing technological solutions for removing iodine, allergens and heavy metals. Lack of ability to handle these aspects of food safety, could limit market access, or undermine consumer trust. Moreover, concerns were raised that appropriate provisions for monitoring and testing of food safety were not developed for IMTA in South Africa, and that such provisions would prove problematic. Concerns about food safety provisions were also raised in relation to offshore aquaculture, where it could prove problematic to determine the responsibilities of local authorities, and where sampling to ensure food safety can be expected to raise logistical challenges and increase costs.

In some discussions, as those on macroalgae in Norway and Portugal, the food safety aspect was linked to the lack of quality standards for macroalgae products.

Financial Support

The importance of financial support for R&D, innovation and start-up was highlighted in nearly all cases. In the case of macroalgae farming in Scotland, the need for start-up advice and finance was listed as the most important aspect addressed. This is perhaps not surprising as most of the LTS aquaculture types addressed in this study have not yet developed to a mature commercial scale, and they will require further economic support to make this happen sooner rather than later. Sometimes, public and private funding sources are complementary. Participants in the Norwegian workshop on macroalgae remarked that public grants are a stepping stone towards private investment.

In the workshops on offshore aquaculture, Brazil, and Portugal, the role of market demand was outlined as an uncertain factor for companies. LTS aquaculture producers usually bear higher production costs (e.g., offshore production, pumping systems in IMTA) than those operating with a business-as-usual approach. Although there are positive market trends for algae consumption, as

mentioned in the Norwegian workshop, the sector has yet to achieve economies of scale. Being novel products, LTS species lack quality standards, information on nutritional values or analysis of certain food safety aspects. Some measures suggested in Norway or Brazil to reward the lower environmental impact were a voluntary “green” label for products or tax incentives for the companies.

Public support and positive impacts of LTS aquaculture

The importance of public support was highlighted as important in the cases of macroalgae cultivation in Portugal and in Norway, and in the case of offshore aquaculture. In discussions on offshore aquaculture, it was noted that LTS aquaculture suffers from public discourses that display a limited ability to distinguish between LTS aquaculture and less sustainable aquaculture forms, which often have a negative image in public discourses. Accordingly, efforts to clarify and nuance public discourses on LTS aquaculture may contribute to a shift towards more favourable public perception of LTS aquaculture. As such, outcomes from the workshop on macroalgae in Portugal highlighted the importance of assessing the wider benefits of macroalgae cultivation, and to communicate evidence-based findings to the general public (through the media) about the sector benefits. Sectoral associations and research networks are seen as the materialisation of a cooperative spirit and a possible way to support dialogue across LTS value chains and among the different actors in the sector: government, research and industry.

5 Conclusion

Six workshops were held to gather insights from aquaculture producers and other stakeholders on what has promoted or constrained the development of aquaculture with low trophic species (LTS). The discussions focused on issues relating to public policy and regulation, licenses, food safety, and support for research, development and start-up, market aspects and industry organization. The workshops addressed macroalgae cultivation in northern Europe (Norway and Scotland) and Southern Europe (Portugal), Integrated Multi-Trophic Aquaculture (IMTA) in Brazil and South Africa and the case of offshore aquaculture (involving macroalgae and shellfish species) in a Nordic and a global context.

The study does not permit wide ranging generalizations, and outcomes of each workshop will probably be mostly informative in their own right. Nevertheless, overarching findings can be summarized as follows:

- A time consuming and complicated application process was identified as an impediment to the development of LTS aquaculture in all cases and regions.

- In South Africa and in Brazil, the further development of IMTA was noted to be impeded by regulatory deficiencies specific for this novel type of aquaculture. Similarly, regulatory uncertainty specific for offshore aquaculture was noted to lead to significant investment risks, which consequently could constrain development of offshore aquaculture.

- In most cases addressed, workshop participants were concerned that novel LTS aquaculture production forms may be hampered by inadequacies in food safety procedures for the respective production forms and resulting products.

- The importance of financial support for R&D, innovation and start-up was highlighted in nearly all cases. Low trophic aquaculture has not developed to a mature and competitive industry segment, and its further development will depend on financial support.

- Public support was noted to be important for the development of LTS aquaculture in most cases. In some cases, it was noted to be important to analyse the positive effects of low trophic aquaculture. The findings from such analysis could help to inform public discourses on aquaculture. This is important as public discourses in some cases do not distinguish between low trophic aquaculture and less sustainable aquaculture forms.

Having workshops across the Atlantic has showed a certain common horizon of challenges for LTS aquaculture producers, policymakers or researchers. The outcomes indicate that complex, rigid and unbefitting regulations may hamper the development of novel LTS aquaculture systems. The findings of this study will provide inputs for the later AquaVitae deliverables entitled “Recommendations for LTS aquaculture policy framework” (AquaVitae D8.3) and “Report on good practice for policy development for low-tropic level aquaculture” (AquaVitae D8.5).

6 References

Alonso et al. 2021. A. A. Alonso, X. A. Álvarez-Salgado, L. T. Antelo. "Assessing the impact of bivalve aquaculture on the carbon circular economy". Journal of Cleaner Production 2021. Vol 279. https://doi.org/10.1016/j.jclepro.2020.123873

ABCC, 2020. Associação Brasileira de Criadores de Camarão. Produção Brasileira de Camarão Marinho por estado. Availab. at: https://abccam.com.br/2020/10/producao-brasileira-de-camarao-marinho-cultivado/. [Last accessed 13.10.2020]

Angus, S. (2017) "Modern Seaweed Harvesting and Gathering in Scotland: The Legal and Ecological Context", Scottish Geographical Journal, 133 (2): 101–114.

Bak et al. 2020. Urd G. Bak, Ólavur Gregersen and Javier Infante. "Technical challenges for offshore cultivation of kelp species: lessons learned and future directions". Botanica Marina 2020; 63(4): 341–353. https://doi.org/10.1515/bot-2019-0005

Barbier et al. 2019. Michèle Barbier, Bénédicte Charrier, Rita Araujo, Susan L. Holdt, Bertrand Jacquemin & Céline Rebours (2019). PEGASUS - PHYCOMORPH European Guidelines for a Sustainable Aquaculture of Seaweeds, COST Action FA1406 (M. Barbier and B. Charrier, Eds), Roscoff, France. https://doi.org/10.21411/2c3w-yc73

Bennett, NJ; Govan, H. and T. Satterfield (2015) Ocean grabbing. Marine Policy 57: 61-68

Billing, S.-L., Rostan, J., Tett, P. & Macleod, A. (in review) Is social license relevant for seaweed cultivation in Europe? submitted to Aquaculture.

BRASIL, 2002. Portaria nº 397, de 09 de outubro de 2002. Ministério do Trabalho e Emprego. Classificação Brasileira de Ocupações 2002. Brasília: MTE. Availab. at: http://www.mtecbo.gov.br/cbosite/pages/legislacao.jsf. [Last accessed 05.10.2020]

BRASIL, 2011. Instrução Normativa Interministerial nº 28 de 08 de Junho de 2011. Estabelecer Normas Técnicas para os Sistemas Orgânicos de Produção Aquícola a serem seguidos por toda pessoa física ou jurídica responsável por unidades de produção em conversão ou por sistemas orgânicos de produção. Diário Oficial da União, 09/06/2011, Brasília/DF, Seção 1. Availab. at: http://www.normaslegais.com.br/legislacao/in_mapa_mpa28_2011.htm [Last accessed 05.10.2020].

Buck BH, Troell MF, Krause G, Angel DL, Grote B and Chopin T. (2018) State of the Art and Challenges for Offshore Integrated Multi-Trophic Aquaculture (IMTA). Front. Mar. Sci. 5:165. doi: 10.3389/fmars.2018.00165

Bumstead, J.M. (2005) "The rise and fall of the kelping industry in the Western Isles", pp. 123–138 in From Clan to Clearance, K. Branigan, Oxford: Oxbow Books.

Campbell, I., Macleod, A., Sahlmann, C., Neves, L., Funderud, J., Øverland, M., Hughes, A.D. & Stanley. M. (2019) "The Environmental Risks Associated With the Development of Seaweed Farming in Europe - Prioritizing Key Knowledge Gaps," Frontiers in Marine Science, 6(107), pp 22. doi: 10.3389/fmars.2019.00107

Carvalho, T.L.; Cacho, J.C.; Souza, R.S.; Morais, J.A.; Wandeness, A.; Carlos, M.T.L.; Wainberg, A.A.; Souza-Santos, L.P. & F.A.S. Ribeiro. 2019. Integrating of the seahorse Hippocampus reidi in multitrophic organic farms of oysters and shrimp: Effects of density and diet. Revista de Biología Marina y Oceanografía 54(1): 43-50.

Chamorro-Legarda, E; Poli, M.A; Martins, M.A; Pereira, S.A; Martins, M.L; Machado, C; Lorenzo, M.A; Nascimento Vieira, F. 2019. Integrated recirculating aquaculture system for mullet and shrimp using biofloc technology. Aquaculture 512, 734308.

Chamorro-Legarda, E; Martins, M.A; Pereira, P.K.M; Carneiro, R.F.S; Machado, C; Lorenzo, M.A; Vieira, F.N. 2020. Shrimp rearing in biofloc integrated with different mullet stocking densities. Aquaculture Research 00, 1–11.

Chopin, 2011. Progression of The Integrated Multi-Trophic Aquaculture (IMTA) Concept and Upscaling of IMTA Systems Towards Commercialization. Aquaculture Europe, v. 36 (4). 5-12.

Costello, C., L. Cao, S. Gelcich et al. 2019. The Future of Food from the Sea. Washington, DC: World Resources Institute. Available online at www.oceanpanel.org/future-food-seaDAFF 2007. Policy for the Development of a Sustainable Marine Aquaculture Sector in South Africa. Department of Agriculture, Forestry and Fisheries, Cape Town.Government Gazette No. 30263 of 7 September 2007.

DAFF 2012. Aquaculture Research and Technology Development Programme for South Africa. Department of Agriculture, Forestry and Fisheries, Cape Town.

DAFF 2014. Aquaculture Yearbook 2014 South Africa. Department of Agriculture, Forestry and Fisheries, Cape Town.

DAFF 2018. Aquaculture Development Bill. Department of Agriculture, Forestry and Fisheries, Cape Town. Government Gazette No. 41632 of 18 May 2018.

Dantas, D.P.; Flickinger, D.L.; Costa, G.A.; Batlouni, S.R.; Moraes-Valenti, P. & W.C. Valenti. 2020. Technical feasibility of integrating Amazon river prawn culture during the first phase of tambaqui grow-out in stagnant ponds, using nutrient-rich water. Aquaculture 516, 734611

DEA 2014. Environmental Impact Assessment Regulations, 2014. Department of Environmental Affairs. Government Notice R982 in Government Gazette 38282 dated 4 December 2014

Drumm, A. (2010). Evaluation of the promotion of offshore aquaculture through a technology platform (OATP). Ireland, Marine Institute. 46 pp

Duarte CM, Wu J, Xiao X, Bruhn A and Krause-Jensen D (2017) Can Seaweed Farming Play a Role in Climate Change Mitigation and Adaptation? Front. Mar. Sci. 4:100. doi: 10.3389/fmars.2017.00100

European Commission 2016. Summary of the 27 Multiannual National Aquaculture Plans. https://ec.europa.eu/fisheries/sites/fisheries/files/docs/body/27-multiannual-national-aquaculture-plans-summary_en.pdf (last visited 18.10.20)

Flickinger, D.L.; Costa, G.A.; Dantas, D.P.; Proença, D.C.; David, F.S.; Durborow, R.M.; Moraes-Valenti, P & Valenti, W.C. 2020. The budget of carbon in the farming of the Amazon river prawn and tambaqui fish in earthen pond monoculture and integrated multitrophic systems. Aquaculture 17, 100340.

Froehlich, H. E., Afflerbach, J. C., Frazier, M. & Halpern, B. S. Blue Growth Potential to Mitigate Climate Change through Seaweed Offsetting. Curr. Biol. 29, 3087-3093.e3 (2019).

Galparsoro, I., Murillas, A., Pinarbasi, K., Sequeira, A. M. M., Stelzenmüller, V., Borja, Á., … Tett, P. (2020). ''Global stakeholder vision for ecosystem-based marine aquaculture expansion from coastal to offshore areas''. Reviews in Aquaculture, 19 pp. https://doi.org/10.1111/raq.12422.

Gattuso et al (2018). Ocean Solutions to Address Climate Change and Its Effects on Marine Ecosystems. Front. Mar. Sci. 5:337. doi: 10.3389/fmars.2018.00337

Habermas, Jürgen, 1984. The Theory of Communicative Action. Volume 1: Reason and the Rationalization of Society. Beacon Press/Polity Press, Boston, MA/Cambridge, England

Hoegh-Guldberg. O., et al. 2019. ''The Ocean as a Solution to Climate Change: Five Opportunities for Action.'' Report. Washington, DC: World Resources Institute. Available online at http://www.oceanpanel.org/climate

Holanda, M; Santana, G; Furtado, P; Rodrigues, R.V; Cerqueira, V.R; Sampaio, L.A; Wasielesky, W; Poersch, L.H. 2020. Evidence of total suspended solids control by Mugil liza reared in an integrated system with pacific white shrimp Litopenaeus vannamei using biofloc technology, Aquaculture Reports 18, 100479.

IBGE. 2020. Instituto Brasileiro de Geografia e Estatística. PPM - Pesquisa da Pecuária Municipal 2019, Dados do SIDRA. Availab. At: https://sidra.ibge.gov.br/pesquisa/ppm/quadros/brasil/2019 [Last accessed 19.10.2020]

Kapetsky, J.M., Aguilar-Manjarrez, J. & Jenness, J. 2013. A global assessment of potential for offshore mariculture development from a spatial perspective. FAO Fisheries and Aquaculture Technical Paper No. 549. Rome, FAO. 181 pp, November 12, 2020, 12:09 PM

Karlsson-Drangsholt, Anders et al 2017. Miljøkonsekvensanalyse: Integrert havbruk i Norge. Miljøstiftelsen Bellona, http://network.bellona.org/content/uploads/sites/2/2017/09/IMTA_2017_web.pdf

Makgill and Rennie, 2012. Robert A. Makgill and Hamish G. Rennie: A Model for Integrated Coastal Management Legislation: A Principled Analysis of New Zealand's Resource Management Act 1991. The International Journal of Marine and Coastal Law: 27 (I): 135-165

Marine Scotland. (2017). Seaweed cultivation policy statement. pp.7. Scottish Government, Edinburgh. Obtainable from: www.gov.scot/publications/seaweed-cultivation-policy-statement-2017/pages/2/

McGinnis, Michael D. 2011. An Introduction to IAD and the Language of the Ostrom Workshop: A Simple Guide to a Complex Framework. Policy Studies Journal, 39, 169 - 183. DOI: 10.1111/j.1541-0072.2010.00401.x

Monteiro, M.S., Sloth J, Holdt S. and Hansen M. (2019. Analysis and Risk Assessment of Seaweed. EFSA Journal2019;17(S2):e170915, 11 pp. https://doi.org/10.2903/j.efsa.2019.e170915

Norwegian Government, 2018. Havbruk til havs: Ny teknologi - nye områder» [Offshore aquaculture: new technolgy - new areas]. Available at: https://www.regjeringen.no/contentassets/e29cc668cbf54448a599c6da58cb1b9f/rapport-havbruk-til-havs.pdf

O'Connell, Tom (2018). Evaluation of U.S. Shellfish Aquaculture Permitting Systems: Recommendations to Improve Permitting Efficiencies and Industry Development. A Report to NOAA Fisheries Final Report Submission (June 2018).

PEIXEBR. 2020. Anuário Brasileiro da Piscicultura PEIXE BR. Peixe BR Associação Brasileira da Piscicultura, São Paulo, n. Texto Comunicação Corporativa.

Poli, M.A.; Legarda, E.C.; Lorenzo, M.A.; Pinheiro, I.; Martins, M.A.; Seiffert, W.Q. & F.N. Vieira. 2019. Integrated multitrophic aquaculture applied to shrimp rearing in a biofloc system. Aquaculture 511, 734274.

Rodrigues, C.G; Garcia, B.F; Verdegem, M; Santos, M.R; Amorim, R.V; Valenti, W.C. 2019a. Integrated culture of Nile tilapia and Amazon river prawn in stagnant ponds, using nutrient-rich water and substrates. Aquaculture 503, 111-117.

Rodrigues, C.G; Engle, C; Neto, B.F.G; Amorim R. V; Valenti, W.C. 2019b. The effect of choice of targeted market, production scale, and land tenure on the economics of integrated tilapia-prawn production. Aquaculture Economics & Management 23, 204-217.

Rombenso, A. N., Lisboa, V., Sampaio, L. A. 2014. MARICULTURE IN RIO DE JANEIRO, BRAZIL: AN APPROACH TO IMTA. World Aquaculture 2014 - Meeting Abstract. p.698-699.

Santos, A. A.; Dorow, R.; Araujo, L. A.; Hayashi, L. 2018. Socioeconomic analysis of the seaweed Kappaphycus alvarezii and mollusks (Crassostrea gigas and Perna perna) farming in Santa Catarina State, Southern Brazil. Cust. e Agrone. On Line, v. 14, 443-472.

SAPEA, Science Advice for Policy by European Academies. (2017). Food from the oceans: how can more food and biomass be obtained from the oceans in a way that does not deprive future generations of their benefits? Berlin: SAPEA. doi:10.26356/foodfromtheoceans

Stanley, M. S., Kerrison, P. K., Macleod, A. M., Rolin, C., Farley, I., Parker, A., Billing, S-L., Burrows, M. & Allen, C. (2019). Seaweed Farming Feasibility Study for Argyll & Bute. A report by SRSL for Argyll & Bute Council. SAMS Research Services Ltd., Oban, Scotland. Obtainable from /www.argyll-bute.gov.uk/sites/default/files/seaweed_farming_feasibility_study_for_argyll_and_bute_report_december_2019.pdf

Subasinghe, Rohana; Soto Doris; Jia, Jiansan. 2009. "Global aquaculture and its role in sustainable development". Reviews in Aquaculture (1) 2–9.

The Bellona Foundation 2020: Sustainable Aquaculture 2030 – Position Paper. The Bellona Foundation, Oslo. https://network.bellona.org/content/uploads/sites/2/2020/06/B%C3%A6rekraftig-Havbruk-2030.pdf

Torrissen et al 2018: Potential seafood production in Norwegian coast and fiords, Institute of Marine Research, https://www.hi.no/resources/publikasjoner/rapport-fra-havforskningen/2018/23-2018_framtidsrettet_mat_1408.pdf

UN 2019: United Nations, Department of Economic and Social Affairs, Population Division (2019). World Population Prospects 2019 Highlights (ST/ESA/SER.A/423)

Valenti, W.C., Kimpara, J.M., Preto, B.L., Moraes-Valenti, P. 2018. Indicators of sustainability to assess aquaculture systems. Ecol. Indicat. 88, 402–413.

van den Burg, S.W.K., H. Dagevos, and R. J. K. Helmes (2019) "Towards sustainable European seaweed value chains: a triple P perspective," *ICES Journal of Marine Science*, pp. 8, doi:10.1093/icesjms/fsz183.

7 Acknowledgement

The authors are grateful for the time, energy and knowledge invested in support of this work by the workshop participants. Adrianna Kochanska and Philip James are acknowledged for their support with reviewing and editing this report. The report is an outcome of the AquaVitae project, which has received funding from the European Union's Horizon 2020 Research and Innovation Programme under Grant Agreement No. 818173. This deliverable reflects the views only of the authors, and the European Union cannot be held responsible for any use which may be made of the information it contains.

8 Annexes

8.1 Annex1: Generic workshop questions and information letter

Generic list of workshop questions

How can policy and governance support or hinder macroalgae cultivation development?
In the case of [specify type of LTS aquaculture production and the regional scope, e.g. country where this type is addressed] how do regulation and policy support or hinder companies' start-up, growth, innovation and route to market? How can regulation and policy improve in these respects? Please consider the following aspects:

1. Policy and regulation as enablers

How can/does regulation and policy support a seaweed production company's start-up and growth stages, innovation and route to market?

- Which policies support(ed) this type of aquaculture production and how?
- Which regulations support(ed) this type of aquaculture production and how?
- Which stakeholder groups support(ed) the development this type of aquaculture production (e.g. agencies, associations, institutions, regulators, policymakers) and how?

2. Policy and governance as barriers
How have regulations and policy challenged or hindered this type of aquaculture production and in relation to startup and growth, innovation and route to market?
In your opinion what are the main challenges and hindrances for an expansion of this type of aquaculture production in terms of policy and regulation?

- At which level (i.e. international, national, regional, and local) are these challenges and hindrances concentrated?
- How significant do you consider the impact of these challenges and hindrances to be?
- Have you/your peers attempted to address these (i.e. proposing alterations to current frameworks, lobbying)?
- Are you familiar with cases/situations where these challenges/hindrances have been successfully addressed?

Generic Participant Information Sheet [August 2019]

Background and information about the group session on policy and regulation

[Date xx] there will be workshop group session lasting about xx in which we will discuss how policies and regulations respectively have supported or constrained the development of [specify LTS type and regional scope]. This session is led by [xxx, affiliation].

Outputs from the session will contribute to the AquaVitae project (https://aquavitaeproject.eu/) funded by European Commission's H2020 research program (Grant nr. 818173). The AquaVitae project carries our research and innovation to promote sustainable low trophic aquaculture in Europe, Brazil and South Africa. The project includes case studies on [specify LTS type].

In practice, we will divide the participants into X groups, which will discuss the questions sent to you earlier (see attachment to email from XX sentXX). We will take notes of the main points made and write up minutes from each group session. The minutes will not contain names or other information that can link individual participants to the points made in the session. You will be invited to check that points made in the minutes are correct after the workshop. A summary of the minutes will be included together with similar outputs from a number of other workshops in a public report.

Participation in this group session is entirely voluntary. You can decide to withdraw from the session and from the study at any time during the workshop. You can revise or delete the summary statement relating to the points you have until the report is made public (November 2020).

For any further information about this session or the research it contributes to, please contact [XXX, email]

8.2 Annex2: Information letter and questions for the offshore aquaculture workshop

How can policy and governance support or hinder off-shore aquaculture? (afternoon session 16.10.2019)

Background and information about the group session on policy and regulation

Wednesday afternoon there will be group session (lasting about 1 hour) in which we will discuss how policies and regulations respectively have supported or constrained the development of offshore aquaculture. This session is led by Kåre Nolde Nielsen from UiT – The Arctic University of Tromsø, Norway.

Outputs from the session will contribute to the AquaVitae project (https://aquavitaeproject.eu/) funded by European Commission's H2020 research program (Grant nr. 818173). The AquaVitae project carries our research and innovation to promote sustainable low trophic aquaculture in Europe, Brazil and South Africa. The project includes case studies on offshore production of macroalgae and mussels.

In practice, we will divide the participants into 3 groups, which will discuss the questions sent to you earlier (see attachment to email from Åsa Strand sent 19.09.19; see next page). We will take notes of the main points made, and write up minutes from each group session. The minutes will not contain names or other information that can link individual participants to the points made in the session. You will be invited to check that points made in the minutes are correct after the workshop. A summary of the minutes will be included together with similar outputs from a number of other workshops in a public report.

Participation in this group session is entirely voluntary. You can decide to withdraw from the session and from the study at any time during the workshop. You can revise or delete the summary statement relating to the points you have until the report is made public (November 2020).

For any further information about this session or the research it contributes to, please contact Kåre Nolde Nielsen (kare.nolde.nielsen@uit.no)

Workshop questions: how can policy and governance support or hinder off-shore aquaculture? (afternoon session 16.10.2019)

In the context of off-shore aquaculture in Europe and the US or elsewhere, how do regulation and policy support or hinder companies' start-up, growth, innovation and route to market? How could regulation and policy be improved in these respects?

Please consider the following aspects:

1. Policy and governance as enablers

1.1. How can/does regulation and policy support a company's start-up and growth stages, innovation and route to market?

1.1.1. Which policies support(ed) your business and how?

1.1.2. Which regulations support(ed) your business and how?

1.1.3. Which stakeholder groups support(ed) the development of your business (e.g. agencies, associations, institutions, regulators, policy-makers) and how?

2. Policy and governance as barriers

2.1. How have regulations and policy challenged or hindered a company's startup and growth phases, innovation and route to market?

2.1.1. In your opinion what are the main challenges and hindrances in terms of policy and regulation?

2.1.1.1. At which level (i.e. international, national, regional, local) are these challenges and hindrances are concentrated?

2.1.1.2. How significant do you consider to be the impact of these challenges and hindrances?

2.1.1.3. Have you/your peers attempted to address these (i.e. proposing alterations to current frameworks, lobbying)? [Follow up: How? Why or why not? Do you feel empowered to do this?]

2.1.1.4. Are you familiar with cases/situations when these challenges/hindrances have been successfully addressed?

8.3 Annex3: Information letter and questions for macroalgae cultivation workshop in Norway

SEAWEED AQUACULTURE IN NORWAY: SOCIO-ENVIRONMENTAL BENEFITS AND POLICY FRAMEWORKS - Information for participants

Purpose

The main purpose of this workshop is to gather information on perceptions of socio-environmental benefits, policy frameworks and regulation of seaweed aquaculture in Norway. Ultimately, it aims to contribute to the development of sustainable seaweed aquaculture.

The morning session involves focus groups, individual pools and plenary discussions. Participants are asked about their perceptions and perspectives on seaweed aquaculture. The session contributes to the GENIALG project, funded by Horizon 2020, the EU Framework Programme for Research and Innovation (grant number 727892, https://genialgproject.eu/). It is led by Itziar Burgués of CIIMAR - Interdisciplinary Centre of Marine and Environmental Research (https://www2.ciimar.up.pt/).
In the afternoon, participants are divided into groups to discuss how policies and regulations respectively have supported or constrained the development of seaweed aquaculture. The discussions will proceed from the questions placed on page two of this document. This session contributes to the AquaVitae project, funded by Horizon 2020, the EU Framework Programme for Research and Innovation (grant number 818173, https://aquavitaeproject.eu/). It is led by Kåre Nolde Nielsen from UiT – The Arctic University of Tromsø (https://uit.no/).

Use of information and confidentiality

Morning session: We will gather information through exercises and notes made during the discussions. No personal information will be recorded in forms or notes, nor used in further analysis of results. The gathered information will, combined with results from similar workshops in the GENIALG project, become part of a public report to be uploaded on the project website by December 2020. The material may be used in later research publications as well. Additionally, a summary of the session will be shared in form of a brief report, presentation or poster with all participants of the GENIALG stakeholder workshops by April/May 2020. For any further information about the afternoon session or the research it contributes to within the GENIALG project, please contact Itziar Burgués (iburgues@ciimar.up.pt).

Afternoon session: We will take notes of the main points made within each group and the plenary discussion. The resulting minutes will not contain names or other information that can link individual participants to the points made. You will be invited to check if points described in the minutes are correct after the workshop, and you can request that any point you have made be deleted. A summary of the minutes from the afternoon session will be included in a public report. The projects have received funding from the European Union's Horizon 2020 research and innovation programme under grant agreements number 727892 (GENIALG) and 818173 (AquaVitae).

A report from the AquaVitae project together with outputs from similar workshops, with deadline November 2020. Work from this report may be included in subsequent research publications. For any further information about the afternoon session or the research it contributes to within the AquaVitae project, please contact Kåre Nolde Nielsen (kare.nolde.nielsen@uit.no).
Participation in both sessions is entirely voluntary.

Questions for the afternoon session
How can policy and governance support or hinder seaweed aquaculture development?
In the case of seaweed aquaculture in Norway - and elsewhere more generally, if there are relevant examples to consider - how do regulation and policy support or hinder companies' start-up, growth, innovation and route to market? How can regulation and policy improve in these respects? Please consider the following aspects:

1. Policy and regulation as enablers

How can/does regulation and policy support a seaweed production company's start-up and growth stages, innovation and route to market?
For producers:

- Which policies support(ed) your business and how?
- Which regulations support(ed) your business and how?
- Which stakeholder groups support(ed) the development of your business (e.g. agencies, associations, institutions, regulators, policymakers) and how?

2. Policy and governance as barriers
How have regulations and policy challenged or hindered seaweed companies in relation to startup and growth, innovation and route to market?
In your opinion what are the main challenges and hindrances for an expansion of seaweed aquaculture in terms of policy and regulation?

- At which level (i.e. international, national, regional, and local) are these challenges and hindrances concentrated?
- How significant do you consider the impact of these challenges and hindrances to be?
- Have you/your peers attempted to address these (i.e. proposing alterations to current frameworks, lobbying)?
- Are you familiar with cases/situations where these challenges/hindrances have been successfully addressed?

8.4 Annex4: Information letter and questions for macroalgae cultivation workshop in Portugal

Stakeholder workshop draft protocol

Aquaculture policy and governance: The analysis of stakeholder perceptions will provide the basis for identifying policy constraints and suggest solutions to overcome them. Challenges or barriers might be local or common to several regions and production systems. Similarly, solutions might be found that have applicability in other contexts. The comparative study will therefore have a trans-regional scope

with the aim of identifying specific as well as common challenges and to offer good practices of policy frameworks for development of algal aquaculture

Examine producer perceptions on policy frameworks: workshops will be arranged with relevant producers to identify where regulation and policy have supported or inhibited innovation and route to market and to identify common inhibitory or supportive mechanisms.

Core research questions

- How do regulation and policy support or hinder companies' startup, growth, innovation and route to market? How could regulation and policy be improved?
- What is the balance between environment/societal protection and enabling development? In which cases is protection seen as helpful to development?
- What factors or mechanisms (and at which level) align public policy with stakeholder wishes? What are the channels by which producers communicate to government and what are the roles for key actors? Do some sub-sectors have higher leverage on policy?
- What is the role of marine spatial planning in the development of algal aquaculture?
- Is adaptive management/governance practiced and does it use DAPSIR or similar model? How does scale-dependent government Respond to State change? What are the time-scales of response? Do innovation licences aid development and adaptive management?
- How do policymakers, producers and public perceive the risks and benefits of algal aquaculture?

Discussion Guide

1. **Welcome**
   - Welcome the participants and thank them for their willingness to participate;
   - Briefly introduce the moderator/assistant;
   - Explain the workshop process: how results will be reported and commitment to confidentiality with participant responses anonymised.
   - General introductions beginning with the moderator going clockwise around the table.

2. **Introduction** (openers and ground-setting)
   - 2.1. We would like to begin by asking you to consider how your **company started** [i.e. development to start-up phase, including licencing, setting up].
     - 2.1.1. What was your company's goal?
     - 2.1.2. Which top challenges did your company face?
     - 2.1.3. How did your company navigate the regulatory framework?
     - 2.1.4. What has supported your company?
   - 2.2. We would be interested to know more about how your **company has developed and is expanding** [i.e. growth to expansion phases, including operation, innovation, new markets].
     - 2.2.1. What is your company's ambition (inc. new ventures)?
     - 2.2.2. Which challenges does your company currently face?
     - 2.2.3. What has supported or supports your company's development and expansion?

3. **Policy and governance as enablers**
   - 3.1. We are interested in your thoughts about.
     - 3.1.1. How and which **policies** support(ed) your business?
     - 3.1.2. How and which **regulations** support(ed) your business?

3.1.3. Which **stakeholder** groups support(ed) the development of your business (e.g. agencies, associations, institutions, regulators, policymakers)?

3.1.4. How has **society** supported the development your business (e.g. social licence)?

Prompts – word cues: Startup; Operation; Growth; Innovation; Route to market

4. Policy and governance as barriers

4.1. We are interested in your thoughts about how regulation and policy have challenged your company's startup and growth phases, innovation and route to market.

4.1.1. In your opinion what are the **main challenges in terms of policy and regulation**?

Prompts – word cues: Specific policies; Specific regulations

4.1.1.1. At **which level** (i.e. international, national, regional, local) do you feel these challenges are concentrated?

4.1.1.2. How significant do you consider to be the **impact of these challenges**?

4.1.1.3. Have **you/your peers attempted to address these** (i.e. proposing alterations to current frameworks, lobbying)? *[Follow up: How? Why or why not? Do you feel empowered to do this?*]

4.1.1.4. Are you familiar with **cases/situations** when these challenges have been successfully addressed?

4.1.2. Which **stakeholder groups** have constituted a barrier to the development of your business (e.g. agencies, associations, institutions, regulators, policymakers)?

4.1.3. How has **society** hindered the development of your business (e.g. social licence)?

Prompts – one word cues: Startup; Operation; Growth; Innovation; Route to market

5. Pathways to improving policy and governance

5.1. What are your thoughts on/ overall perception of the **level of support provided by current governance frameworks** applied to your business?

5.2. What is your overall perception of the level of **agreement/balance between policies for environment/societal protection and policies to enable business growth**?

5.2.1. In which cases has this protection been helpful or unhelpful to development?

5.3. Could you **identify improvements to regulation and policy?**

5.3.1. In your opinion what should be done/changed? *[Follow up: How and by who (at which level)?]*

5.3.2. What do you think would be the benefits of such changes?

5.3.3. What do you foresee as the challenges to making/implementing these changes?

Prompts – one word cues: Startup; Operation; Growth; Innovation; Route to market

6. Winding down

6.1. As we come to the end of the discussion, do you have any questions or comments or additional points that you would like to raise?

7. Debrief, Close and Thanks

- Close discussion and thank participants for their time and contribution;

- Inform participants about next steps and access to results.

Participant Information Sheet [June 2019]

We invite you to take part in a study to explore your thoughts on […]. This research is part of a project funded by […].

What is the purpose of this study?

This research aims to explore the […].

Why have I been approached?

We are interested in speaking to small groups of […] who […].

Do I have to take part?

Participation in the study is entirely voluntary. You have a right to decline the invitation or to withdraw from the study at any time without providing an explanation or incurring any penalty.

What will happen to me if I take part?

If you agree to take part in the study, you will be part of a group of approximately 5-8 participants who will be asked to discuss […]. This is not a test and there are no right or wrong answers, we are simply interested in your opinions on these topics. The discussion will take place at a location convenient to yourself. On arrival, you will be asked to provide some background details on an anonymous questionnaire, which takes about 5 minutes to complete. The group discussion will follow and with your permission it will be audio recorded. The discussion will last approximately […] hours in total.

How will the data be used and stored during and after the study?

The audio recordings will be transcribed (copied word for word) and analysed. Your contribution on the transcripts will be identified by a participant number to protect your anonymity therefore you will not be identifiable. The audio recordings will be stored anonymously on password-protected hardware and deleted within 6 months of completion of the study. Anonymised transcripts may be used by others for future research.

Are there any risks that could be incurred by taking part in this study?

The researchers have undergone training in the management of focus group discussions. Although no specific risks have been identified, there is always the possibility that discussion could become heated. In the unlikely event of this occurring, the researchers will ensure any disruptive and/or upset individuals are retired from the group and provided with appropriate after care.

Are there any potential benefits of taking part in the study?

Although we hope that focus group participants find the discussions enjoyable, there are no direct benefits to yourself of taking part in this study. The findings from this study will help our understanding of […].

What if something goes wrong?

It is extremely unlikely that something will go wrong during this study. However, you should know that the project partners have procedures in place for reporting, investigating, recording and handling adverse events and complaints from study volunteers. The project partners are insured for its staff to

carry out research involving people. The responsible project partner institution knows about this research project and has approved it. Any complaint should be made, in the first instance, to the researcher identified for this particular study. Any complaint you make will be treated seriously and reported to the appropriate authority.

Confidentiality

Any information you supply will be held in strict confidence, viewed only by the named researchers (see below) and then anonymised. Names will not be attached to audio recordings or questionnaires and respondents will be identified by a code number. Anonymised discussion transcripts and questionnaires will be stored in a locked password protected computer and controlled by the researchers below.

What will happen to the results of the study?

The results may be reported at conferences and meetings and published in academic journals. In all cases, anonymity and confidentiality will be maintained.

For further information, please contact a member of the research team:

[…]

Consent Form

Thank you for your interest in taking part in this research. Please complete this form after you have read the Participant Information Sheet and/or listened to an explanation about the research study. You will be given a copy of this Consent Form.

	Please tick boxes below to confirm consent	
1.	I confirm that I have read the information sheet dated […] for the above study, I have had the opportunity to consider the information, ask questions and I have had any questions answered satisfactorily.	
2.	I understand that my participation is voluntary and that I am free to withdraw at any time without giving any reason. I understand that if I decide to withdraw, any data that I have provided up to that point will be included in the study unless I request that it is omitted.	
3.	I consent to the processing of my personal information […] for the purposes of this research study, as described in the information sheet dated […].	
4.	I consent to my anonymised research data being stored and used by members of the research team and others for future research.	
5.	I understand that my research data may be published as a report, reported at conferences and meetings and published in academic journals.	
6.	I consent to being audio recorded and understand that the recordings will be stored anonymously on password-protected hardware and deleted within 6 months of completion of the study […].	
9.	I agree to take part in this research project.	

	Participant _____ _____ _____ Name of participant Signature Date	
	Researcher _____ _____ _____ Name of researcher Signature Date	