Access to Areas for Algae Cultivation in Norway

1. Introduction: Visions for increased algae cultivation

Marine macro algae may play a significant role in the transformation to more sustainable food production and energy systems (Roberts and Upham 2012). Ambitions related to the use of algae include a variety of applications; a source of fuel, fish and animal feed and speciality food (Fujiwara-Arasaki, Mino et al. 1984, Stévant, Rebours et al. 2017, Bay-Larsen, Risvoll et al. 2018, Broch, Alver et al. 2019). Furthermore, political ambitions for expansive growth in the aquaculture industry request circular systems, where left-overs from one production line may be a valuable resource for another. Algae's utilization of eutrophicating "waste" carbon and nitrate from other industrial productions or activities in e.g. integrated multi-trophic aquaculture (IMTA) has therefore been highlighted as promising for resolving major environmental challenges in the aquaculture industry (Rebours 2013, Alexander 2017, Stévant 2017, Ellis 2019, Fiskeridirektoratet, 2018).

The Norwegian coastline is 100 915 km, which makes it the second longest coastline in the world (after Canada), according to Norwegian authorities (Barents Watch, 2019). More than 80 percent of Norwegian population lives less than 10 km from the coastline. This reflects a huge potential for mariculture and exploitation of marine resources. Data from the Norwegian Fishery Agency (Figure 1) show that the number of applications for cultivating macroalgae in Norway from 2014-2017 has indeed increased significantly. Yet, there are many open questions related to the access and quality of potential sites in the coastal zone. In order to facilitate sustainable development of an algae industry, holistic planning and management that encompasses economic development, environmental resilience and socio-cultural aspects is needed (Bjørkan 2017, Bjørkhaug, Bay-Larsen et al. 2017)

This paper explores the premises for such an approach by asking: What are the main challenges to up-scaling cultivation of macro algae along the Norwegian coast in terms of access to areas, area conflicts as well as managerial knowledge and capacities? Based on statistics from the Norwegian Fisheries Directorate and a survey to Norwegian spatial managers, we explore the basis of knowledge and the local contexts for coastal municipalities, when prioritizing and allocating areas for industrial production of algae.

1.1. Identifying high-quality localities of macro algae

A 2012 report (Olafsen, et.al. 2012, 17) on value creation from sea-based productions stated that 'A sober assessment of the value creation potential of a comprehensive Norwegian aquaculture shows that this is off the same order of magnitude as the oil industry'. Hence, according to Olafsen, et.al (op.cit), development of aquaculture requires national efforts to the same extent as in the development of the country's petroleum industry.

Part of the growth will come in macro algae production, which holds a potential for becoming 'the next major coastal industry in Norway'. By 2030 the predicted production of macroalga is 4 million tonnes growing to 20 million tonnes in 2050 (Olafsen e. al. 2012). Seaweed and kelp farming are expected to demand more areas than current fish farming because algae depend on the upper water masses to obtain sufficient light (Rebours et al., 2013) and estimated need being one hectare per 150-200 tons produced in productive locations (Broch, et.al. 2019). In two reports on the potential for large-scale seaweed production, SINTEF points at the need for large areas, regulation and laws adapted to new knowledge on algae production and a need for allocation of (suitable) space for cultivation (Broch, Skjermo et al. 2016, Broch, Tiller et al. 2017)

Macro algae have several use potentials; food, feed, bio- chemistry and pharmaceutical industries, as well as energy. In the Government (Ministries, 2016) strategy for the Norwegian bio-economy main challenge to meet this potential is to develop regulations and management regimes, as well as strengthen the knowledge base, for cultivation, harvesting and utilization of macroalgae. Being an emerging growth industry in Norway, Government further point at the need for identifying potential area conflicts with other aquaculture activities, fisheries, maritime activities and leisure/tourism, and potential challenges for marine ecosystems.

Previous research shows that high expectations for future and large-scale algae cultivation in European and Norwegian waters are often attached to a wide range of challenges linked to the same development (Krause-Jensen, Lavery et al. 2018). Macroalgae includes a wide range of macroscopic and multicellular marine red, green and brown algae that we know as seaweed and kelp.

It is the combination of light, temperature and access to nutrient concentration and salination that define kelp growth. Water movement affects the flow of light (by moving the organisms), carbon footage, photosynthesis, nutrition etc. In addition, excessive water movement can damage or tear loose plants. Methodology has been developed to model and map kelp and other marine species, and there exists knowledge of the environmental conditions that determine the properties of kelp (op.cit). In a resent evaluation of the kelp cultivation potential in Norway, Broch, et. al (op.cit.) point at important differences between cultivation in northern, southern and coastal and off-shore locations in Norway. Differences are related to start and end of season and risks and opportunities connected to coastal and off-shore cultivations. Based on knowledge of these differences, Broch, et.al (p. 13-14) call for 'careful planning' to 'optimize value chains from deployment of seedlings, through harvest and processing, to the end market of the products based in the biomass', to best utilize opportunities given by the differences.

Thorough biological knowledge (breeding / life cycles) as well as documentation on environmental risks connected to large scale cultivation of macroalgae and surrounding marine environments, is currently lacking. Seaweed and kelp stocks are very important for many other marine species and ecosystems and provide habitats and food for many marine spices such as shells, snails and small fish and crabs. The kelp and seaweed forests are therefore important for fish populations and hence the fisheries, while itself being subject to climate change and ocean acidification (Dannevig, Groven et al. 2019). In addition, the development and upgrading of algae production require stable access to the right raw materials, cost-effective cultivation, harvest and processing methods (Broch, Tiller et al. 2017), product development, accessible markets, transport and logistics. Innovation is therefore needed in multiple stages and dimensions of the value chain (fig 1).

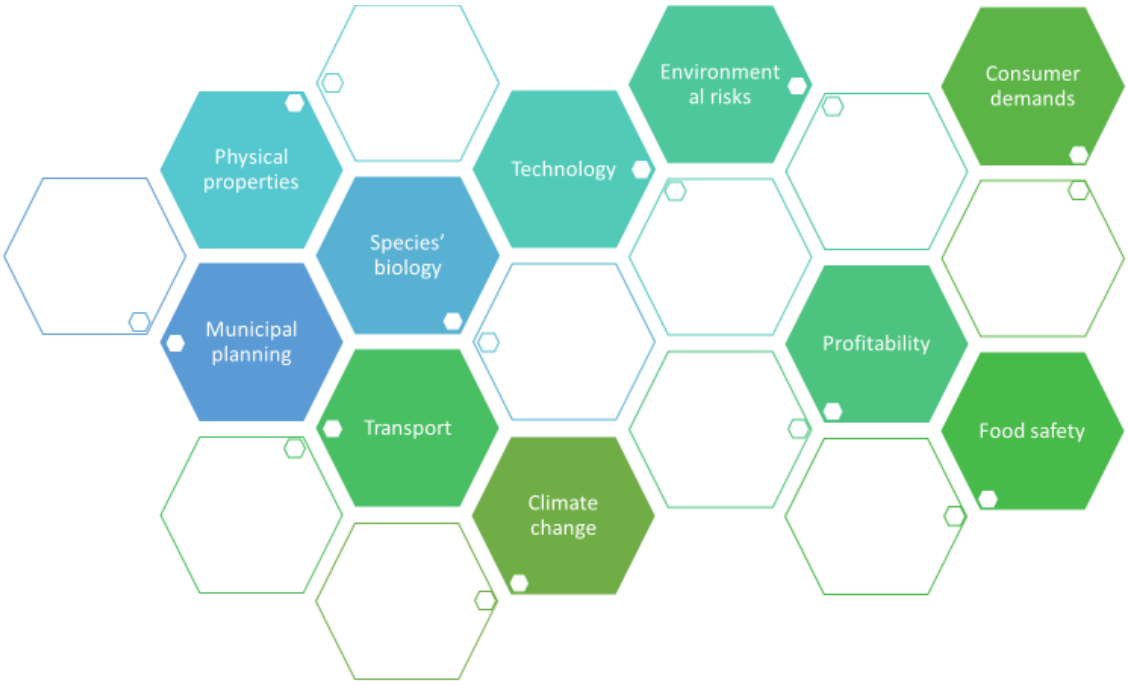

Figure 1: Puzzle/conceptual model illustrating parameters relevant for identifying high quality areas for upscaling macro-algae cultivation.

Consequently, multiple intertwined (and interdependent) parameters are in play, including available areas, physical properties of potential habitats (current, light, nutrients etc.), species' biology, food safety risks, environmental risks, technology development (cultivation, harvest and processing technology), transport and logistics, profitability and consumer demands, to mention some. One should also consider the possibility for numerous other non-identified premises/drivers for an upscaling in line with Olafsen, et.al's (2012) estimates (see above) (white hexagons in figure 1). In order to manage the coastal zone, tools that can assess the suitability of different locations for different purposes are necessary (Broch, 2019).

Finding the optimal spot that meets the relevant species' preferences, allows for easy processing and transport and enables the application of existing breeding and harvest technology, requires multi-criteria assessments. The 2016 SINTEF report state that there is currently no analysis of how social, political or management aspects related to such conflicts, neither valuation nor ranking of different social interests, financial values or governance positions. One of the issues highlighted in the reports is expectations of area conflicts (Broch, Skjermo et al. 2016). Hence, assessing the knowledge needs in management of areas available for use is urgent for policy and innovation in this emerging economic field.

As we will elaborate in the next section, local communities must decide to allocate areas for this instead of competing activities in the coastal zone. Moreover, municipal administration need competencies and capacities to address and encompass the complexities in coastal zone management (Bay-Larsen 2012, Bjørkan 2017).

For the area planners and the industry, it is therefore multiple economic and environmental risks associated to upscaling algae production. Lessons learned from shell farming indicate that infrastructure for industrial support were not sufficient in Norway, while the Norwegian producers have a small domestic market and greater difficulties gaining access to the well-established European market (Ytrøy 2008).

1.2. Integrated coastal zone planning – competencies and possible conflict of interest

Aarsæther (2012) emphasizes that public planning operates in the intersection between knowledge and politics and defines planning as "*an organized activity where actors design future goals and use knowledge and professional working methods to analyse, prioritize and coordinate actions to achieve these*" (authors translation) (Aarsæther 2012, p.15). Obtaining a permit to establish new aquaculture is a complex endeavour in bureaucratic and legal terms, involving two main steps. First, the political-bureaucratic leadership on both national, regional and local levels is involved in the process of allocating areas, although only the municipal plans are legally binding. More than 80 per cent of the Norwegian territory is subject to municipal plans and regulated according to the Plan and Building Act (PBA from 2008) while 17% is protected by national authorities according to the Nature Diversity Act (NDA from 2009). The PBA defines the planning processes relating to both terrestrial and marine environments, as well as the roles played by national, regional and local authorities and the rights and partaking of various stakeholders in the process. Municipal plans are processed within the respective municipality, and the plan proposal is made public among the local populace, with a four-week deadline for hearing replies. With increasing pressure on coastal areas from different user interests, it is an increasing pressure on municipalities to establish inter-municipal management of the coastal zone (Stokke, Lund Iversen et al. 2012, Kvalvik and Robertsen 2017). The municipalities are thus key actors for aquaculture industries and a future commercial algae cultivation along the Norwegian coast.

Second, the aquaculture companies must apply for concession (permit for industrial activity) from the County Municipality. Ministry of Fisheries and Coastal Affairs act as body of appeal (Directorate of Fisheries, 2019). Several other sectoral public authorities at different levels are involved assessing the application according to the laws pertinent to their area of responsibility. For instance, the County Governor will consider the application in terms of the Pollution Control Act, while the Norwegian Food Safety Authority, on a local level, will assess the application according to the Food Production and Safety Act.

The process of allocating areas and providing concessions points to the complexity in terms of balancing industrial development and nature protection, between the use and protection policies of the Norwegian government. These tensions are also reflected by conflicting private actors and interests in the coastal zone. Both fishing/harvesting, the maritime sector, farming and outdoor life are fighting for the same areas (Hersoug and Johnsen 2012, Bjørkan 2017). Finally, the coastal zone hosts a wide range of landscapes, seascapes and biodiversity hot spots that need stronger protection from risks imposed by industrial activities, including 485 red list species identified in the Norwegian coastal zone (Barents Watch, 2019).

At the same time, many challenges are yet to be resolved at the local level. Although most coastal municipalities have a coastal zone plan, many are old and out-dated (Robertsen, Kvalvik et al. 2014). The structure of aquaculture industries is changing rapidly, which emphasizes the importance of the municipalities having the capacity to keep the plans up to date (Robertsen, Kvalvik et al. 2014). At present (2019), many small municipalities in the outskirts do not hold the necessary skills required to create good, legitimate coastal zone plans. It may therefore be difficult for some municipalities to assess whether they have available areas, and if they have, whether these areas should be made available to the aquaculture industry (Sandersen and Kvalvik 2014, Sandersen and Kvalvik 2015, Tiller and Richards 2018).

While there is a considerable emphasis on stakeholder participation in planning at the municipal level generally (and thus potentially generating less conflict), a shortcoming regarding coastal zone management has been pointed to as being unable to create "the necessary common knowledge base and shared understanding […] namely, the [local] epistemic communities" (Tiller, Brekken et al. 2012ibid: 1090). Thus, municipalities remain lacking in the necessary planning expertise, with participatory structures that may fail to create the shared understanding needed for consensual decision-making.

Previous experiences from shellfish and cod farming have clearly demonstrated how expert knowledge is critical to meet challenges facing the multiple aspects and stages of businesses development and management. To develop an updated coastal zone plan, multiple forms of knowledge, competencies and capacities are needed. Municipality size may be a critical factor, however.

2. Data sources and statistical analyses

As outlined above, commercial activities in marine environments require permission based on application to the Norwegian Ministry of Trade, Industry and Fisheries. Based on data from the Norwegian Fishery Agency on we have developed maps and figures showing permissions to grow different species of seaweed along the Norwegian coast. The numbers reflect only permissions to produce in the sea. Permissions for producing in tanks onshore are not given. Several parameters are of importance when it comes to these figures on the production of seaweed. This includes whether permits are being used or not, for what purpose (research or industry) and prospects of products and markets. The following section discusses some of these factors.

We also present results from a survey directed at 227 coastal municipalities in Norway was conducted in December 2017. Municipal planners were asked a range of questions relating to aquaculture, macro algae and area use, potential areas of conflict between algae production and other interests pertaining to the coastal zone, and the need for knowledge relating to algae production. More specifically, the planners were asked whether the access to suitable areas for aquaculture (in general) was deemed satisfactory, as well as their perception of local industry actors' views on the matter.

An additive index of conflict has been constructed based on eight potential areas of conflict involving aquaculture activities (fisheries, other aquaculture, commercial sea freight, land owner's interests, areas of environmental protection, leisure activities, industry and other activities). The presence of aquaculture activities locally is measured by the reported gross municipal product related to aquaculture production.

3. Results

3.1. Allocation of areas

The most recent figures are 78 licenced locations granted in the period of 2010-2019 (fig 2). The larger fractions of permissions are given in the counties *Hordaland* (190 hectares/ha), *Sogn og Fjordane* (165 ha), while the counties of *Nordland* and *Trøndelag* counts for 154 ha and 117 ha respectively. The statistics also shows that as many as 33 different species have been allowed grown for commercial use. Atlantic wakame (No: Butare, Latin Alaria esculenta), Oarweed (No: Fingertare, Latin Laminaria digitata), Sugar kelp (No: Sukkertare, Latin: Saccharina latissima) and dulse (No: Søl, Latin Palmaria palmata) are the most common.

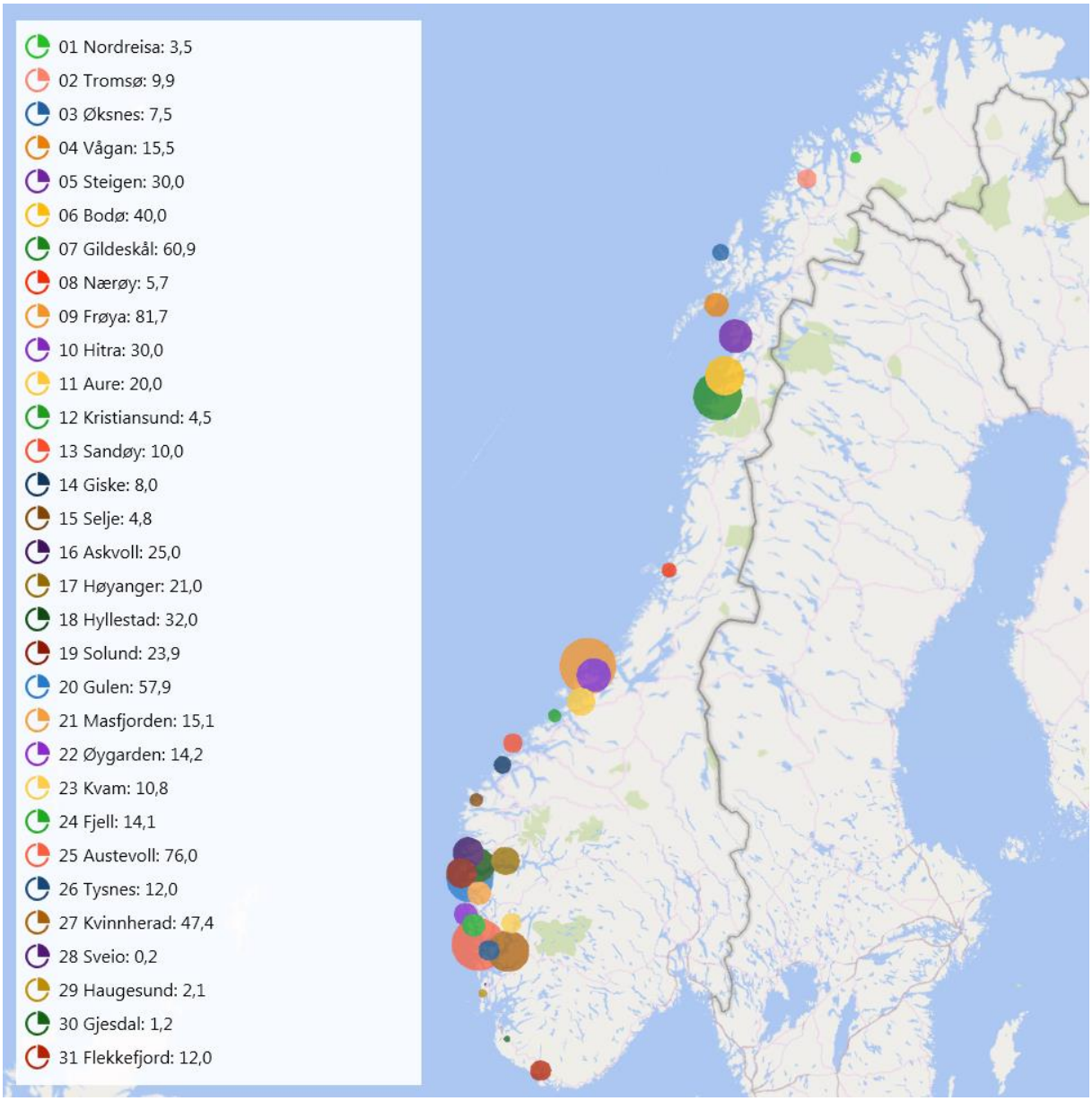

Figure 2 Geographical location (municipality) of permissions and size of permitted area (hectares) 2010-2019. Data source: Norwegian Fishery Agency

The majority of municipality planners view the access to suitable areas as somewhat or very satisfactory (60%). 70% of the respondents in the survey claim that the municipality has allocated less than a quarter of the total coastal/ocean areas to aquaculture. However, the *suitability* of the remaining available area for aquaculture in general, or algae production specifically, is unknown.

When it comes to coastal zone planning, 62% of the municipalities included in the survey report having an operative coastal zone plan in place, and slightly less than half of these are in the process of revising their plans (the average time to the completion of the revisions is reported to be 1,6 years). However, while 2 in 10 of the current plans are referencing algae production, 5 in 10 of the coming revisions will put algae on the agenda. The general impression from the survey is therefore that algae production is indeed very much an emerging field as viewed by the municipalities. Currently 1/3 of the municipalities participating in the survey claim to be hosts to industry actors interested in macro algae production.

3.2. Area conflicts

The survey material also shows how perceived issues of conflict relating to aquaculture in *general* differs considerably in strength. As figure 3 shows, conflicts regarding areas of environmental protection features most prominently, followed by fisheries and leisure activities. Interestingly, conflicts *between* aquaculture activities are not very prominent (7% of respondents answering, “to some degree” or “to a high degree”), possibly indicating that an introduction of algae production is less susceptible to conflicts with traditional aquaculture, but rather with already well-known issues.

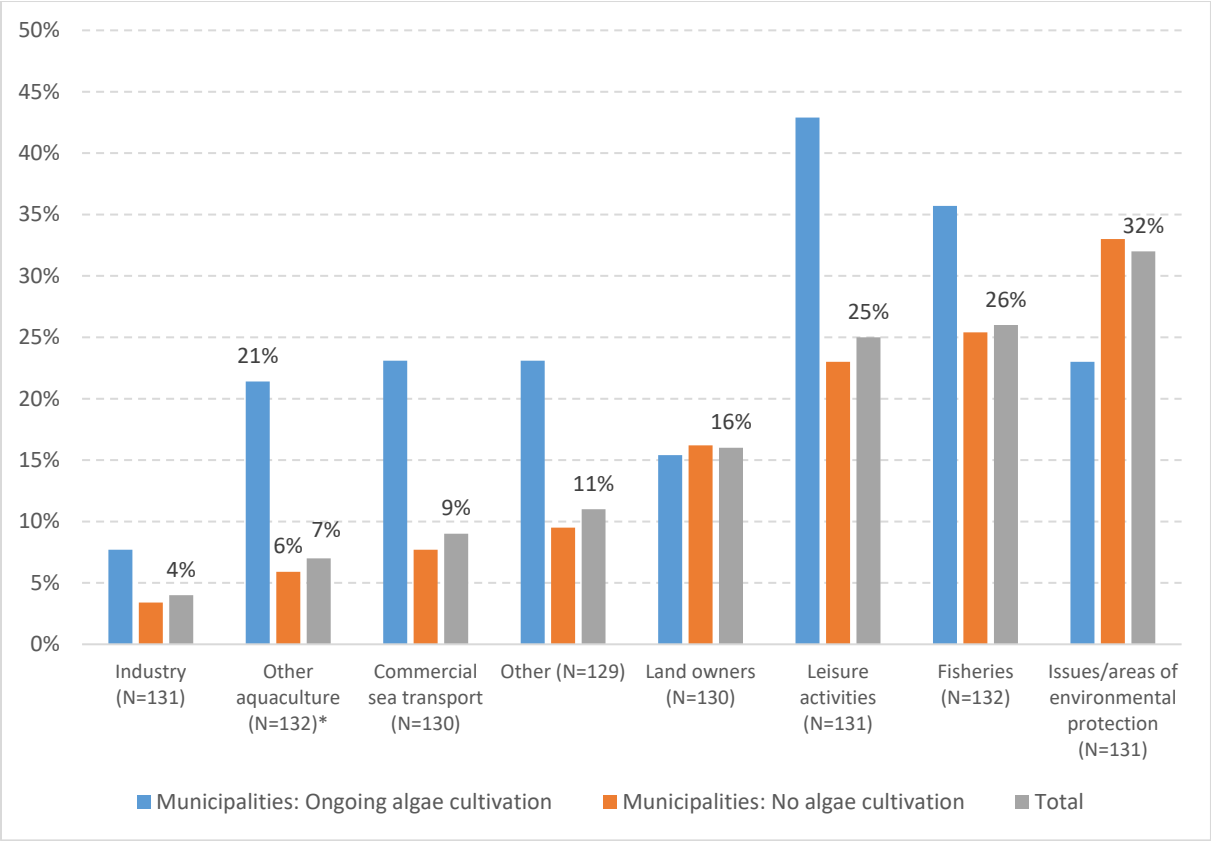

Figure 3: Issues of conflict involving aquaculture activities. Respondents answering, "to some degree" or "to a high degree". Percentage.

However, there are some notable differences between municipalities that are hosting ongoing algae cultivation, and those that are not. Generally, "algae-municipalities" report a higher level of conflict on all the variables included in the survey, except conflicts with environmental protection areas and land owners. The only statistically significant difference between the two types of municipalities relates to conflicts between aquaculture industry actors, however ("other aquaculture" in fig. 4). The data does not indicate whether the level of conflict on this item is a *consequence* of the introduction of algae cultivation. But generally exacerbated conflict levels in "algae-municipalities" could be expected to increase the local challenges related to such an introduction.

3.3. Competencies in municipal administration

Respondents were asked to what degree the municipality possesses the required knowledge on algae and algae production. Generally, the knowledge on algae production is deemed to be weak; 85% of municipalities claims to have an unsatisfactory level of knowledge regarding this. Moreover, the perceived need for knowledge on algae production relates to a broad

selection of issues, with knowledge relating to suitable locations for algae production and the effects of algae production on other activities at the top of the list.

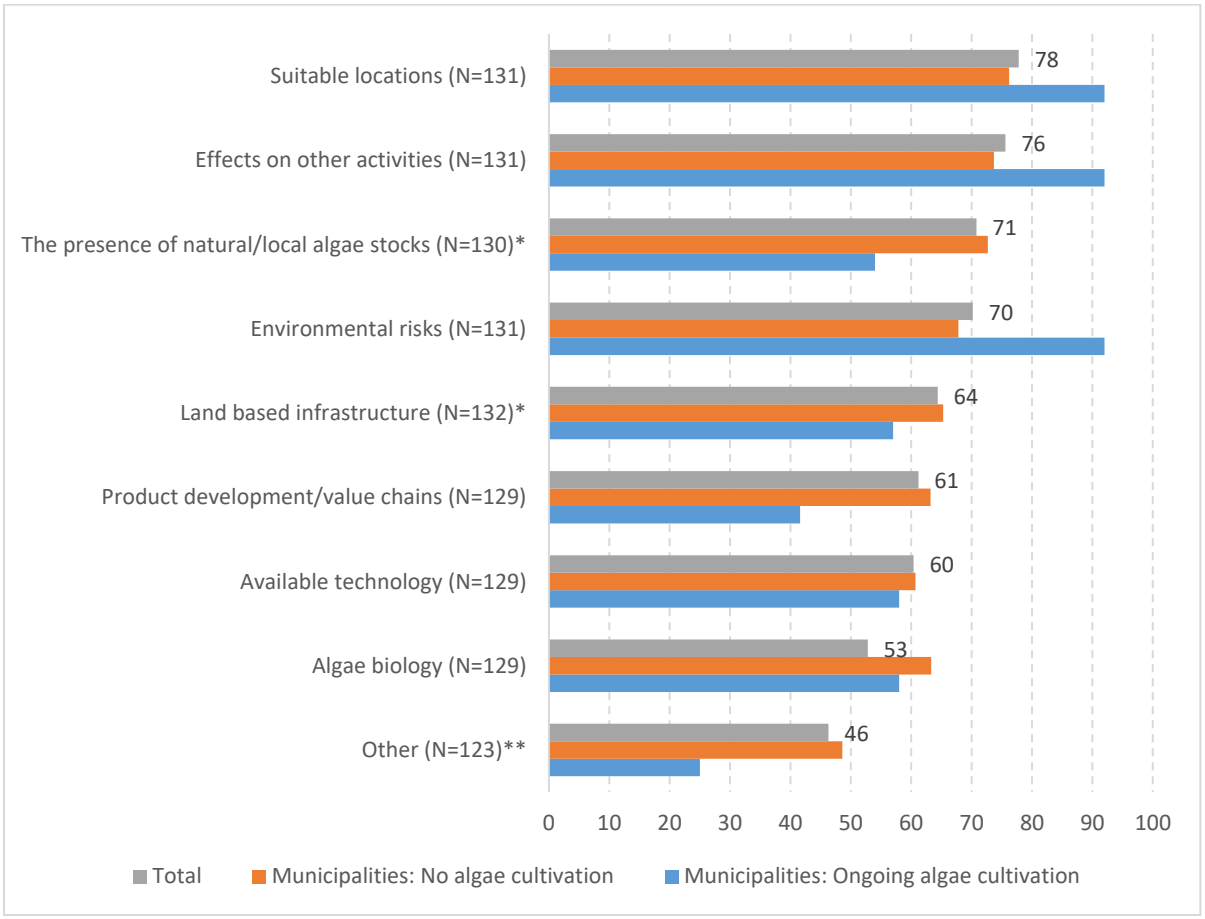

Figure 4: Perceived need for knowledge regarding algae production. Respondents answering, "to some degree" or "to a high degree". Percentage.

Considering the novelty of commercial algae production, the need for knowledge of the subject is hardly surprising. As such, a methodological caveat is warranted; the validity of the respondents' answers on any *specific* issues of algae cultivation (as referred to in figure 4.) could be questioned – respondents are of course relating to a topic on which they have generally little knowledge. The general lack of knowledge among municipalities are nevertheless well documented.

These responses do, however, also underscore the potential deficiencies in the local planning regime, and certainly illustrates the point of Tiller et.al. (2012) regarding a lack of local "epistemic communities", at least in terms of the local planners' participation in such

communities[1]. To the extent that local coastal zone governance is already deficient in this area (when looking at aquaculture in general), an upscaling of algae production could possibly exacerbate this problem, and potentially be conflict increasing[2]. The perceived need for knowledge on algae production and the general perceived level of conflict pertaining to the aquaculture sector shows a statistically significant positive correlation, i.e. municipalities with a need for expertise are also more often characterized by conflict. However, this does not translate to an *overall* statistically significant difference in perceived knowledge needs between "algae-municipalities" and municipalities not hosting algae cultivation (which is to be expected, considering the lack of statistically significant differences on conflict items in figure 3.). As figure 4. shows, there are nevertheless some significant differences between the two types of municipalities on three specific items (local algae stocks, land-based infrastructure and "other" topics). On these items the "algae-municipalities" report a lesser need for knowledge.

3.4. Local Context

All local contexts, municipalities and coastal zone plans are not created equal. Consequently, there are some differences between municipalities worth noting. A general find is that there is a conflation of certain municipality traits and their view on an upscaling of algae production, including, but not restricted to, local conflicts and the need for knowledge. There are significant variations in terms of municipality size, general aquaculture experience and general developmental prospects.

	V1	V2	P	N
1	Municipality size	Industry satisfaction (available areas)	,237**	141
2	Perceived need for algae expertise (index)	AQ Conflict level (index)	,267**	130
3	Industry satisfaction (available areas)	AQ Conflict level (index)	-,195*	133
4	Gross municipal product (AQ)	Presence of algae industry actors	-,210*	137
5	Gross municipal product (AQ)	Algae permit applications in process	-,246*	104
6	Gross municipal product (AQ)	Expertise on algae production	,317**	128

*Table 1: Pairwise correlations. Pearson coefficients. *p<0.5 **p<0.1.*

[1] The term "epistemic community" is defined as "a network of professionals with recognized expertise and competence in a particular domain and an authoritative claim to policy-relevant knowledge within that domain or area (Haas 1992).

[2] The perceived need for knowledge on algae production and the general perceived level of conflict pertaining to the aquaculture sector shows a statistically significant positive correlation, i.e. municipalities with a need for expertise are also more often characterized by conflict.

As the table above indicates, there is a positive correlation between municipality size and the perceived satisfaction of aquaculture industry actors pertaining to available areas for aquaculture (1). It should be noted that the industry actors' satisfaction has not been measured directly; rather it is the satisfaction as interpreted by local municipality planning officials. The municipalities with relatively more (expected) satisfied industry actors (comprising both general aquaculture actors and algae industry actors), are also less prone to experiencing conflicts[3] relating to the aquaculture industry (3). There is also a significant relationship between the level of conflict pertaining to aquaculture activities and the need for expertise on algae; conflicts seem to be more severe in municipalities with a higher perceived need for algae expertise (2). Initially, this seems puzzling; considering the scarcity of algae production on any industrial scale, one would not assume that a lack of expertise on the part of the municipalities would make a significant impact on the general level of aquaculture related conflicts. However, the lack of expertise on algae might be a signpost of a more general lack of expertise on aquaculture as such, and possibly also indicating deficiencies in the local planning regime – which would contribute to increased conflict levels.

Perhaps not surprisingly, the municipalities with a relative high presence of aquaculture activities in general[4] have a significantly higher score on expertise pertaining to algae (and, one would assume, aquaculture in general) (6). Nevertheless, the typical and traditional aquaculture municipalities are less inclined to report a presence of algae industry actors locally (4). Nor are the established aquaculture municipalities more likely to be hosts for industry actors *applying* for algae permits (5); thus, municipalities reporting a higher level of expertise on algae production, are not necessarily the principal target for the algae industry in its current form. While this might be explained by e.g. the availability of suitable areas for algae production (indeed, on could imagine a high level of traditional aquaculture as impeding on the possibilities for algae production), it also raises questions from a planning and governance perspective as to the suitability of the emerging "algae municipalities"– namely the less algae competent municipalities with lacking or outdated planning tools.

[3] An additive index of conflict has been constructed based on eight potential areas of conflict involving aquaculture activities (fisheries, other aquaculture, commercial sea freight, land owner's interests, areas of environmental protection, leisure activities, industry and other activities).
[4] The presence of aquaculture activities locally is measured by the reported gross municipal product related to aquaculture production.

4. Summarising discussion

This paper has addressed complexities connected to upscaling the cultivation of macroalgae along the Norwegian coast. In particular we have focused on the process of allocating areas for algae cultivation. Although the Norwegian coastline is among the longest worldwide, and contains wide shallow and nutrient rich areas, there are numerous reasons for why the access to areas is a scarce resource for Norwegian aquaculture. The point of departure is how integrated coastal zone management at the local level is municipalities is a key explanatory factor in this respect, and therefore a critical dimension to further expansion and up-scaling of macro algae cultivation.

The survey to the coastal municipalities in Norway reveals a number of salient aspects to the prospects for algae farming expansion. Although being one of the dominating actors in the coastal zone, the aquaculture industry in total occupies less than 25% of the coastal zone today in most municipalities, according to the municipal planners. At the same time, little space is left in the coastal zone to meet the growing need for areas in aquaculture. Data from the Norwegian Fishery Agency (Figure 1) show that the number of applications for cultivating macroalgae in Norway from 2014-2017 has six-folded, with the strongest increase in the counties of *Nordland* and *Møre og Romsdal*. Current algae farms are mostly small scale, and hold experimental, rather than commercial, ambitions in most cases. If the algae industry becomes attractive for investments, fish farmers may allocate their areas from fish to algae cultivation. Another possibility is to gain access to aquaculture-areas not in use, which refers to approximately 25% of areas allocated to aquaculture along the Norwegian coast. While there might be a higher probability that upscaling efforts would face area-related conflict scenarios involving non-aquaculture related activities, the possible encroachment on already established aquaculture should not be underestimated. This factor might be strengthened by favorable funding to municipalities with fish-farming through an aquaculture fund set up by the state (Directorate of Fisheries 2019b). Inclusion of macroalgae production in this funding arrangement might change this.

Uncertainty is also related to the suitability of areas for algae production combined with a generally more area demanding activity (compared to traditional aquaculture). This uncertainty points to the documented general knowledge gap on the part of local planners. Addressing this

would likely be central to avoiding potential conflicts in the Norwegian coastal zone related to algae production.

Another feature appearing from the survey indicate that the planners express a significant lack of competencies, capacities and abilities to deal with an expected increase in algae cultivation applications for the next years. In fact, more than 70 percent of the planners claim some/large need for knowledge on suitable locations, impact on other activities, wild macroalgae stocks and environmental risks to mention some. Although not surprising, these findings indicate a large need for increasing competencies as planners must consider both the distribution of surface area to different activities and how these activities affect the actual water and resources under water. The survey indicate that competencies are expected to increase at the local level, as the municipal planners indicate that more the 50% of new plans will include algae cultivation (against 20% of current plans).

Over the years, fish farming companies have increasingly been struggling to achieve local legitimacy and area access. The reason for this is claims of imposing environmental risks on marine ecosystems on the one hand, while contributing little to local communities' economic income and development on the other (Bay-Larsen 2012, Aasetre and Vik 2013, Olaussen 2018, Bjørkan and Rybråten 2019). Tiller, Brekken et al. (2012) have suggested that there is a high potential for conflict within the Norwegian coastal zone, even if it is not surfacing as open antagonism. They have also predicted an increased future pressure as the aquaculture sector in Norway expands, and not just in terms of tying up available areas for other activities, but also in terms of negative impacts on other common resources, e.g. stocks of wild salmon. Over time, the transformation of the aquaculture industry into a highly capitalized sector dominated by a handful of multinational companies (Liu, et.al. 2011), also puts a strain on the relationship between the industry and local communities.

Keeping in mind that this nexus of conflict potential and local planning expertise relates to challenges facing aquaculture in general, an obvious question would be if an upscaling of algae production as a relatively new and untried field would differ significantly. The more area intensive nature of algae production (compared to to salmon farming) may be considered as a potentially stronger conflict-driver – there is quite simply larger areas, and consequently interests, to encroach on. Likewise, the untried nature of algae production (relatively speaking)

would likely amount to less expertise on the part of local governing institutions in terms of the specific needs of algae production and the adherent need for planning.

An upscaling of algae production nevertheless needs to be sensitive to local contexts. The data suggest that a lack of expertise on aquaculture in general is linked to both lower industry satisfaction, higher levels of conflict, less experience with aquaculture in general, and small municipalities. Any notion of algae production becoming the next big thing for the small and inexperienced municipalities may not be substantiated. Consequently, an upscaling may have better conditions in some local contexts than others. However, expectations of licensed growers and other related actors in the community, requires good coastal zone planning and achieving sustainable resource utilization to avoid destructive conflicts that might limit or slow a green transformation in Norway. Sound coastal zone planning is a complicated exercise that requires expert knowledge and the right managerial tools. New industries are often developed before sufficient knowledge exists about its effects which may cause a challenging balance between use and protection interests. Social aspects and impacts are less investigated in development of macroalgae and growth in seaweed farming. Hence also social impact analysis is warranted for a successful planning of industrial activities in coastal zones. Addressing these issues, several measures aiming to improve the scientific basis of coastal management, enhancing the expertise of planning bodies, as well as addressing the issue of lacking planning competence is needed. Moreover, guidelines and incentives from national authorities for revising local plans, as well as increasing the focus on regional and inter-municipal planning should be strengthened. This could to some extent mitigate the planning challenges facing the smaller municipalities in terms of available knowledge and resources.

Nevertheless, while the scarcity of a commodity (here: marine acreage) could easily be envisioned as the driving factor behind conflicts, the empirical evidence for such an assumption is not necessarily strong. On the contrary, some suggest that the scarcity of resources can spur *cooperative* behavior (Wolf 1998) since collaboration bears the potential of shared competencies, more efficient and optimized resource use. One promising trend in coastal planning is the evolving digital databases and maps in Norwegian environmental governance and municipal planning according to PBL and NDA. The most important functions of digital maps are to compile geodata from multiple knowledge bases and platforms, encompassing natural resources, biodiversity, habitats, climate change, land-use planning and the like (Bay-Larsen et al in press). In general maps are highly suitable for translating or packing knowledge,

as they can be moved in time and space, they can be edited in terms of scale and information can be easily combined, recombined and compared (Hersoug and Johnsen, 2012). It is an effective means of providing the best available information for decision-makers since visual representations can communicate complex natural and landscape assets in a way which written documentation and scientific reports cannot. A map forms a basis for prioritizing between a broad spectrum of natural, economic and social assets within a specific area. This may be valuable tools and reasons to be optimistic in terms of developing the adequate governance and planning tools, that also may enable inter-municipal collaboration between small and large municipalities. What is a less than an ideal situation in terms of algae expertise and area planning today (fig 1.) might therefore change in the future.

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