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Shared waters—shared problems: The role of self-governance in managing common pool resources

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ABSTRACT

Seafood production governance, primarily and traditionally a governmental activity, is increasingly designed and performed by private actors, such as business organizations and/or Non-Governmental Organization. This is often seen as complementary to public regulation in handling collective problems, but there are few studies within the aquaculture sector which investigate the extent and potential of such arrangements. The aim of this paper is to study self-regulation among groups of fish farmers as a means to solve collective challenges in the commons and to derive lessons for future cooperative arrangements. Using data from the Norwegian salmon industry, we investigate the extent of private self-regulated collaborations, the motivation for collaboration, and the self-reported obstacles. We further elucidate the strengths and weaknesses of such arrangements, both regarding day-to-day operations and in times of crisis. The findings show that private self-regulation plays an important role in increasing available resources in addressing common challenges and coordinating the production to limit negative externalities. However, such arrangements cannot work in isolation and need to be aligned with the role and functioning of public authorities. In fact, the looming shadow of the state is an important prerequisite for the successful role of such arrangements.

KEYWORDS

Aquaculture; collaboration; fish farmers; governance; self-regulation

Introduction

The aquaculture industry currently contributes 47% of the total global seafood production and has already overtaken fishing as a source of seafood for human consumption (FAO, 2018). Moreover, globally foreseen to strengthen its importance as production is expected to continue to increase (Anderson et al., 2019; Kobayashi et al., 2015). The production of carp and tilapia represents the highest volumes globally, but salmon is the second largest species by value after shrimp, and as the largest salmon producer Norway is in the top

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ten aquaculture producing countries in the world, by both volume and value (Garlock et al., 2020). Salmon farming in Norway benefits from favorable physical conditions such as a lengthy and sheltered shoreline, and optimal sea temperatures, but equally important are the biological and technological innovations that have made the aquaculture industry in Norway one of the most advanced globally (Asche, 2008; Bergesen & Tveterås, 2019). This has been made possible due to a good governance regime stemming from both the government and the industry itself. In Norway and elsewhere, creating a good and predictable system for regulating aquaculture production is crucial for limiting environmental externalities and to allow future sustainable growth of the industry (Young et al., 2019), even though this is not always straightforward (Osmundsen et al., 2017, 2020). Hersoug et al. (2019) provide an overview of the development of the formal Norwegian regulatory system. The current governance system for the aquaculture sector, both in Norway and elsewhere, consists of national public regulations (Abate et al., 2018; Osmundsen et al., 2017; Robertsen et al., 2016; Solås et al., 2015), supplemented by private certification schemes (Amundsen, 2020; Bush et al., 2013; Osmundsen et al., 2020; Washington & Ababouch, 2011), and self-regulation arrangements initiated by individual companies, groups of companies and industry associations. Self-regulation is often organized either within an individual company as guidelines or company standards, or as cooperative arrangements between several companies. It is the latter which is the subject of this paper.

Area cooperation, zone management, beyond-farm cooperation, spatial management and area-based management are just some of the terms that depict different organizational models for mitigating shared production risks in aquaculture (Bottema, 2019; Bottema et al., 2019; Bush et al., 2019; Joffre et al., 2019; Murray & Gubbins, 2016), which are alternatives to larger integrated firms (Asche et al., 2013; Oglend & Tveterås, 2009). The combined effort of multiple actors in a given area is often seen as a useful way of reducing the cumulative and combined impacts of aquaculture practices. Such arrangements range from self-regulating cooperative models initiated by and between fish farmers to governmentally induced zoning of aquaculture activities in a given area. The common motivation of these arrangements is that there are benefits to collective action, especially because open net-pen fish farming shares the same waters, and the externalities associated with this production process cannot be handled by one actor alone, but need to be addressed in unison.

Cooperation has always been central to the aquaculture industry in Norway. The Norwegian aquaculture industry (Hovland et al., 2014) has since the beginning been characterized by trial and error, and extensive collaboration. The pioneers tried, failed and learned from each other.

The Grøntvedt brothers at Hitra, who were the first to introduce salmon net-pens in the sea, were for years engaged in knowledge dissemination to other potential fish farmers. Even when the industry became more institutionalized, the free flow of information and experience was considered important and was safeguarded, both in the Norwegian Fish Farmers' Association (NFF) and in the Fish Farmer's Sales Organization (FOS). Aquaculture research, financed directly by the government (The Research Council of Norway) or by an export fee (Norwegian Seafood Research Fund), has consistently pursued an open knowledge policy where new discoveries have been made available to all interested fish farmers. This is in contrast to many other countries, where research results have been much more privatized and unavailable (Hersoug et al., 2014). This has contributed to the rapid development of everything from technological solutions to the use of feed and vaccines, where the Norwegian aquaculture industry is considered a world leader (Aarset & Borgen, 2015) and probably significantly enhanced the effect of private research among suppliers (Asche, 2008; Tveterås & Heshmati, 2002).

Although the industrialization of the industry has led to a stronger presence of large multinational companies who are less likely to share the details of their knowledge and (bio-)technological solutions (Aarset & Borgen, 2015; Borgen & Aarset, 2016), and an increased focus on proprietary knowledge, collaboration still appears to play a central role in Norwegian aquaculture industry. On the other hand, there has been little research into the extent and degree of such cooperation beyond demonstrating the presence of agglomeration effects (Asche et al., 2016; Tveterås, 2002). Currently, there exists a number of different types of collaborative arrangements. Some fish farmers operate and produce their fish in cooperation, others share a common location, some operate joint set-up facilities, or organize joint procurement, such as the Norwegian collaborative organization "Salmon Group." According to traditional economic theory, these are solutions chosen to gain access to more resources and better information, and are alternatives to horizontal integration (Parmigiani & Rivera-Santos, 2011).

Cooperation in the aquaculture industry is also driven by other considerations, as fish farming is an activity with significant environmental externalities (Osmundsen et al., 2017). The fish farmers operate in the commons, and the use of open net-pens influence the surrounding marine environment where ocean currents carry feed residues, fecal and metabolic products, diseases and parasites. These externalities do not only affect other fish farms, but may also impact on the environment, and other resources and activities in the area. Closed systems are being developed but are not used to any large extent so far (Bjørndal & Tusvik, 2019). Cooperation is

one approach to handle and limit environmental impact like escapes of farmed fish, and spread of diseases and parasites.

There is virtually no research as to the effectiveness and practical implications of these arrangements, a paucity this article will address. Furthermore, outside of the aquaculture domain and in general, the question of regulatory effectiveness and impact is particularly underresearched when it comes to private and self-regulation (Thomann, 2017). Do private arrangements regulate common-pool resources as efficiently as the state would have done? The current state of research suggests that the delegation of regulatory tasks often does not live up to its promise—in fact causing worse outcomes than public regulation (Overman, 2016; Overman & van Thiel, 2016).

In this paper, we investigate, through empirical data from Norwegian fish farmers and public authorities, the extent of private self-regulated collaboration between fish farmers, the motivation for collaboration, and the self-reported obstacles to collaboration. These insights are used to discuss the actual problem-solving capacity of these arrangements, which appears to be common flaws and weaknesses, and the potential of such arrangements.

Theory

In nature-based production, producers often rely on common-pool resources that cannot easily be privatized, such as grazing land, waterways or marine fish stocks. When such resources are to be utilized by many actors who individually maximize their own profits, the outcome may be significantly worse for all parties than if it had been possible to enter into binding cooperation. Both publicly induced cooperation, where a regulator mandate cooperation and sanction noncompliance, and private collaboration arrangements are seen as solutions to what is often referred to as “the tragedy of the commons” (Kragestein et al., 2019). Collaboration is often defined as relationships that develop between two or more formally independent organizations as a result of a mutual agreement on the future exchange of resources, joint activities or joint decision-making. There is a large body of research on collaboration, both on benefits and drawbacks, and how collaboration can succeed (Ostrom, 1990; Ostrom et al., 1999, 2007; Parmigiani & Rivera-Santos, 2011). It is often emphasized that through cooperation one has the opportunity to solve problems that individuals cannot solve alone. In other words, the basis for the cooperation is mutual dependence between the actors. In fish farming with open nets, this interdependence is very evident.

Benefits to collective action

Research shows that there are many potential benefits of working together. Collaboration is seen as a means to access resources that individual farmers have limited control over on his own. Such resources include the possibility of increased control over what affects the individual facilities, access to technology and physical resources, providing increased capacity and competence and access to markets. Collaboration can lead to increased profitability for each partner through the spread of risk and cost, resource sharing, expanded flexibility, increased access to technology and knowledge, or new markets (Phillips et al., 2000). Cooperation between different actors can thus contribute to economies of scale that a single actor alone cannot achieve, so-called external economies of scale or agglomeration. Other benefits of collaboration are to gain access to legitimacy and reputation, as well as a stronger political position (Parmigiani & Rivera-Santos, 2011). The fact that several actors stand together and show that they are working together to solve common problems can give increased power and influence, and may ensure stakeholders that the industry is taking responsibility for addressing important challenges.

Collaborative models in aquaculture have been found to increase the financial and technical capacity of small-scale producers (Ha et al., 2013; Kassam et al., 2011; Mohan & De Silva, 2010), facilitate knowledge transfer (Srinath et al., 2000), and support horizontal coordination to mitigate disease risk in wider areas (Pettersen et al., 2015; World Bank, 2014). Joffre et al. (2019) finds that cluster formation is positive in order to mitigate production and market risks, integrate small-holders in the value chain, and enhance adoption of new technologies and practices (Kilelu et al., 2017). Tveterås (2002) show that productivity is higher, and Asche et al. (2016) that profitability is higher in industry clusters in Norwegian salmon farming. Oglend and Tveterås (2009) argue that collaboration between regions can spread risk, and Bottema et al. (2019) find that area-based management must be based on homogenous interpretation of risks. That means that joint interest and shared experience is the best starting point for establishing and developing area-based management. Socio-spatial areas should also be seen as building blocks for the management of wider areas. Further research is needed to provide better understanding of the extent to which external actors can stimulate collaboration between farmers to collectively manage environmental risks.

Regulation

Regulation is the controlling of an activity or process, often by means of rules, and may take many different shapes and forms. While regulation was

earlier seen as primarily a governmental activity, modern notions of regulation also includes hybrid forms of regulation based on social control (for an overview see Thomann, 2017). When we speak about regulation—it is thus not something that only the public authorities do—in fact “*regulation is occurring within and between other social actors, for example large organizations, collective associations, technical committees, professions etc., all without the government’s involvement or indeed formal approval*” (Black, 2001, p. 103). In this paper, self-regulation among a group of fish farmers is seen as a regulatory instrument and process that aims to regulate *behavior and performance* in a given area. Such modes of regulation are often private and voluntary, yet they occur in “the shadow of the state.” The shadow of the state refers to the threat of state intervention if voluntary regulation fails to take place (Héritier & Eckert, 2008). Héritier and Eckert (2008) also argue that not only is the shadow of the state a precondition for self-regulation to develop, but also that a looming shadow of control needs to be continuously in place to sustain self-regulatory efforts and obtain satisfactory results.

To be willing to participate in collaboration, the actors must acknowledge that they are mutually dependent, that cooperation is necessary and can have a positive effect on solving common challenges. If the actors do not cooperate, the shadow of the state looms as a threat that may impose collaboration through top-down regulation. However, according to Ostrom (1990), imposed cooperation is considered unsuccessful and is seen as rarely sufficient for effective cooperation to take place. She shows that voluntary cooperation on common natural resources is a good way to build trust and create effective solutions, and she warns against too much regulation by public authorities. However, there are some factors that must be present for collaboration to be successful. Such factors include that the members of the collaborative group are clearly defined and recognizable, that everyone’s actions are observable, that there are opportunities for graded sanctions against those who may violate the rules of cooperation, and that the benefits of collaboration are clear, reasonably distributed, and not subject to excessive uncertainty. If these conditions are met, then there are good opportunities for voluntary cooperation to be kept stable over time, so that the resource is managed in a good way by those who are financially dependent on it, and who often know it best.

Material and methods

This study draws its finding from multiple sources of data. These can broadly be categorized as two main studies. The first is concerned with cooperation between fish farmers regarding day-to-day operations, while

the second is concerned with cooperation in a time of crisis. These are described below.

Investigating cooperation in day-to-day operations

Firstly, an initial survey charting the type of cooperation existent in the Norwegian aquaculture industry was carried out. The survey was conducted by e-mail and phone to representatives from the aquaculture industry. It contained five questions concerning the topic of the cooperation, the geographical area, whether the cooperation was mandated by law or voluntary, and who the respondents cooperated with (fish farmers, authorities, and/or suppliers). In total 22 respondents participated in this initial study, 16 from the aquaculture industry and 6 from public authorities. The respondents came from different geographical areas in Norway and represented both small, medium and large fish farming companies and public authorities relevant for aquaculture regulation.

Based on these initial results, cooperation regarding operation activities and emergency preparedness was identified as the most common type of cooperation. Focusing on these two categories of cooperation, a more in-depth study was undertaken. Results have been summarized in Karlsen et al. (2019). The study was administered by a surveying company and was conducted by phone interviews and web-survey. The study was initially carried out as a web survey, but due to a low response rate, phone interviews were initiated to increase the number of responses. The questions asked were the same for both settings. The number of respondents was 37 Norwegian fish farmers. This represents approximately 35–40% of salmon and trout farmers in Norway, the total in 2019 being approximately 100 (NOU, 2019). Both small, medium and large companies were included in the study. The study was based on an interview guide, with the following main categories:

- a. The topic of cooperation with industry, public authorities and/or suppliers within a defined geographical area
- b. Whether the cooperation is required by law or voluntary
- c. Challenges and opportunities of cooperation

In addition, an in-depth interview was conducted with representatives from the Norwegian Food Safety Authority, as they control and supervise fish farmers' compliance with the aquaculture management regulations and are responsible for approving the operation plans. Two respondents from the Food Safety Authority were interviewed in the fall of 2018. This was recorded on tape and transcribed.

Investigating cooperation in a time of crisis

A toxic algae bloom in the northern part of Norway (in the counties of Nordland and Troms) occurred during the spring of 2019, and represented an opportunity to gain knowledge on how collaboration between fish farmers unfolds in a time of crisis. To chart the course of events and the level of emergency preparedness during the algae bloom, three of the authors conducted 17 interviews with fish farmers, industry representatives, researchers and public authorities. These results have earlier been summarized in Norwegian (Hersoug et al., 2019; Karlsen et al., 2019). Interviews were conducted by phone or face-to-face. An interview guide was prepared for each group of respondents. The interviews focused on the perception of the respondents as to the course of events of the algae bloom, what actions their organizations had taken, who they communicated and collaborated with, and the potential improvements they wanted to recommend for similar events in the future. Interviews were recorded and transcribed.

Findings

We present a finding which elucidates the extent of private self-regulated collaboration in Norwegian fish farming, the motivation for collaboration, and the self-reported obstacles to collaboration, both during day-to-day operations and a time of crisis.

The extent of collaboration

An initial charting of the area based cooperation existent in Norwegian aquaculture industry revealed that (neighboring) fish farmers cooperate on a range of different issues (Karlsen et al., 2019). The respondents reported that their collaboration was mainly in areas such as “operating activity,” “emergency preparedness,” “area governance/planning” and “strategical cooperation,” where the two first categories appeared to be most common, as shown in [Figure 1](#). A few of these collaborations are mandated by law, below illustrated with the § character in the figure.

As [Figure 1](#) illustrates, the study showed great diversity in the topics the fish farmers cooperated on. In the continuation of the study, we looked specifically at cooperation related to operation activity and emergency preparedness, the first two categories in [Figure 1](#). This is where we find most of the existent cooperation. According to the in-depth survey, all of the respondents cooperate with other fish farmers in their areas concerning operation activity and emergency preparedness ($N = 37$). Operation activity concerned sharing resources, equipment and facilities, information and knowledge, and coordinating the timing of certain actions, such as fallowing. And while operation activity is the



Figure 1. Topics for collaboration in the Norwegian aquaculture industry.

most common theme for the respondent in the initial survey, emergency preparedness is the second most used category for cooperation identified in the initial study. According to findings from the initial study and the study of the algae bloom, such preparedness is related to emergency plan, surveillance, warning systems, crisis teams, list of resources available in times of emergency, coordination between fish farms and authorities, media relations, fire drills, recapture of escapees, fish health, outbreak of contagious diseases, acute pollution, and access to fresh water resources.

On some of these topics, the Norwegian Food Safety Authority is increasingly mandating neighboring fish farmers to cooperate through coordinated fallowing of sites. This is accomplished by evaluating the sum of the operation plans from different fish farmers in an area and approving them if they satisfy fish health and welfare considerations.

Incentives to cooperate

The incentive for most of the respondents to cooperate with others about operation activities and emergency preparedness is to be able to reduce the risk for diseases and parasites, secondly to reduce negative environmental impacts and thirdly to improve the profitability of operation activities, as shown in [Figure 2](#).

Most of the respondents find that cooperating with others on topics such as the time of sea transfer of fish, and fallowing of geographical areas are important for optimizing their own production. As seen in [Figure 3](#), cooperation regarding coordinated delousing is regarded as less important than the other two topics. One of the reasons might be that fish farmers expose the fish to delousing treatments to a lesser extent than earlier, but rather have continuous control with salmon lice through the use of cleaner fish or other means. The coordination of such treatments is therefore not as important as before.

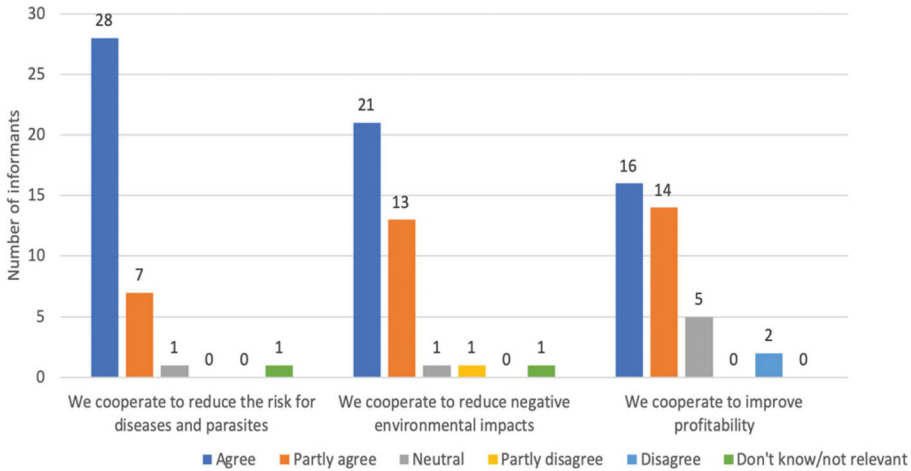


Figure 2. The informants' responses to why they choose to cooperate with others measured on questions "we cooperate to reduce the risk for diseases and parasites," "we cooperate to reduce negative environmental impacts," and "we cooperate to improve profitability." Numbers shown as frequencies, $N = 37$.

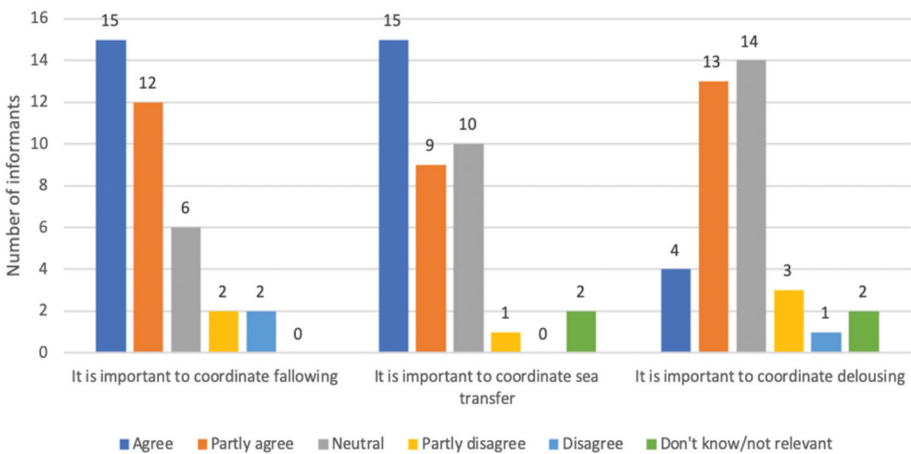


Figure 3. The informants' responses as to what they consider important to coordinate in order to optimize sea production, measured on statements "it is important to coordinate fallowing," "it is important to coordinate sea transfer," and "it is important to coordinate delousing." Numbers shown as frequencies, $N = 37$.

In comments to the survey, a different incentive brought forward by the informants is that the authorities may instruct them to cooperate if they fail to establish cooperation themselves. One of the informants also state that if the cooperation only involves fish farmers, and not public authorities, cooperation can be established faster. Another informant suggests that having shared problems is an important incentive for establishing cooperation.

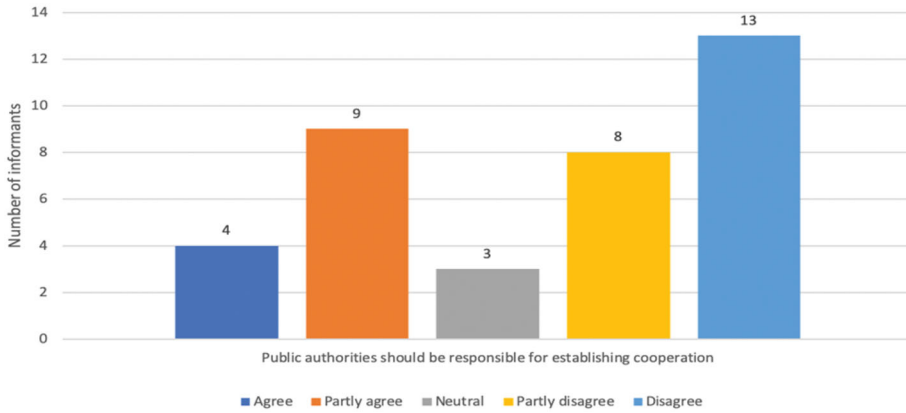


Figure 4. Informants' responses to the statement "public authorities should be responsible for establishing cooperation." Numbers shown as frequencies, $N = 37$.

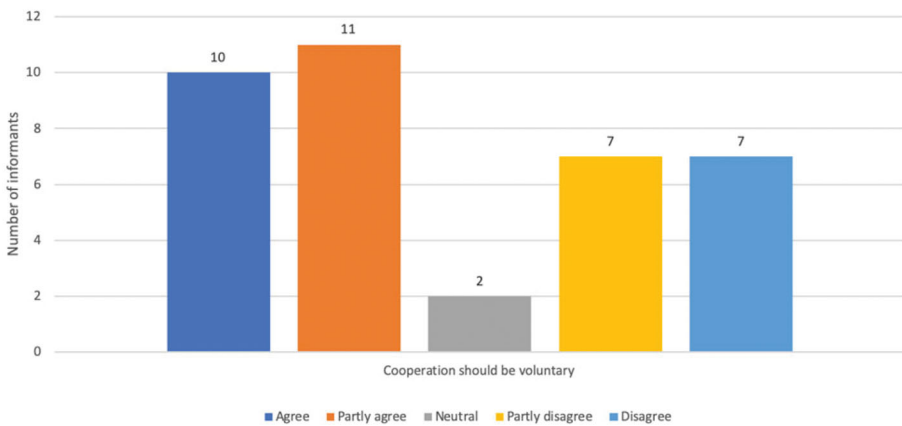


Figure 5. Informants' responses to the statement "cooperation should be voluntary." Numbers shown as frequencies, $N = 37$.

The informants were also asked whether it should be the industry or the public authorities who initiates cooperation (Figure 4).

When asked who should be responsible for initiating and establishing cooperation between fish farmers the respondent's responses diverge. Only 13 (of 37) of the respondents state they agree this should be a responsibility for the public authorities. Also, on the question whether such cooperation should be voluntary or mandatory, 21 respondents respond that this should be voluntary (Figure 5).

On the other hand, we find disagreement among the respondents as to the extent to which universal or more "tailor-made" solutions to challenges are considered suitable for issues that may vary widely from one area to another. This also reflects the disagreements as to whether it should be the authorities or the industry who is responsible for cooperation.

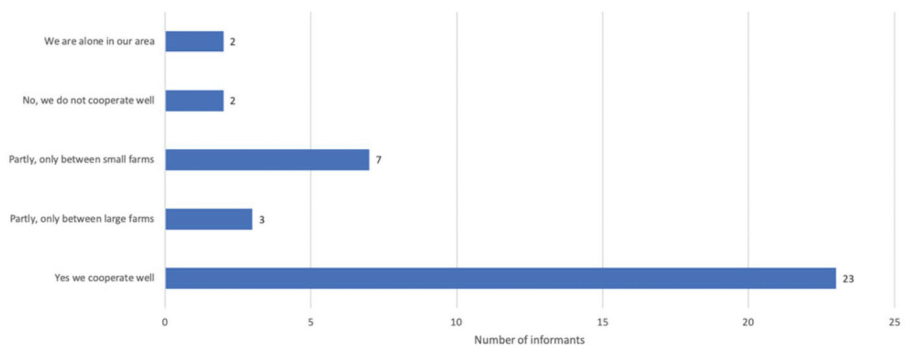


Figure 6. Informants' responses to the question "How well do you cooperate with other fish farms in your area?." Numbers shown as frequencies, $N = 37$.

Experiences with cooperation

The majority (23 of 37) of the informants report that they cooperate well with other fish farmers in their area, as shown in Figure 5. However, some of the informants state this is just partly true, and that cooperation only includes either just the small companies (7 informants) or the large companies (3 informants). Two of the informants state that they do not have good cooperation in their area, and two reports that they are all alone in their geographical area, and therefore do not see the need to cooperate with others.

While the majority state they have good cooperation, conflicts can arise. The informants report that cooperation in areas where many fish farmers are located, and where there is a high density of sites are most prone to conflict, as shown in Figure 6. Such conflicts may arise when new fish farmers attempt to establish themselves in areas where others have been for a long time, and where there is already a well-established cooperation structure.

According to the respondents from the Food Safety Authority, the main challenge toward establishing good cooperation between fish farmers is access to sites. According to a couple of the fish farmers (commenting on the survey) there is an unwritten rule between the farmers about not competing with each other on access to sites. However, there is reason to believe that this does not apply everywhere and between all farmers, see also Figure 7.

The fish farmers are reluctant to give up sites they have gained access to, and this limits the possibilities for restructuring. To be able to design new and improved following zones¹ fish farmers may be required to swap sites or agree to close sites. A consequence already seen in certain areas, is that due to lack of cooperation, some of the following zones becomes too small. The distance between the zone and adjacent sites outside of the zone becomes too small, and the following becomes less effective. According to

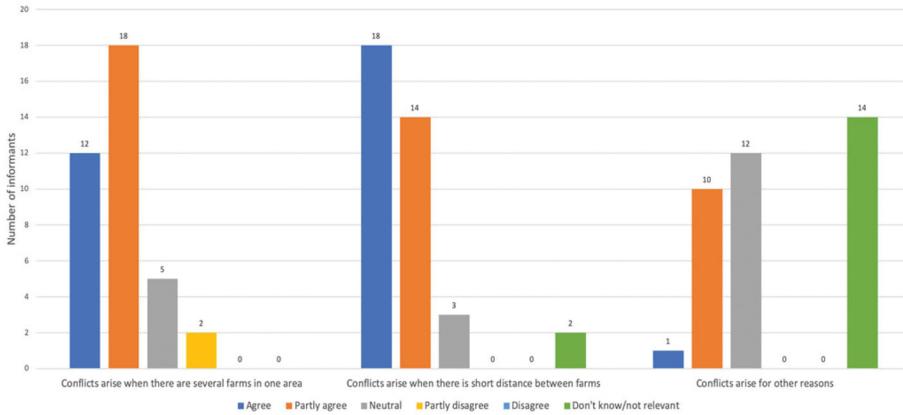


Figure 7. Informants' responses as to why they think conflicts arise between fish farmers, measured on statements "conflicts arise when there are several farms in one area," "conflicts arise when there is short distance between farms," and "conflicts arise for other reasons." Numbers shown as frequencies, $N = 37$.

respondents from the Food Safety Authority, the incentives for the fish farmers to cooperate should be stronger. In the current regulatory system, cooperation and willingness to share resources and coordinate with others is not rewarded. According to these respondents, perhaps one would see stronger cooperation if the incentives were stronger (Figure 8).

The findings show that all the respondents acknowledge that cooperation is necessary and important on a number of different topics. Even though the fish farmers willingly enter into a binding cooperation, they appear to be uncertain whether the cooperation is strong enough to handle difficult challenges. One respondent state that "*it is easier to agree on a plan, but harder when something happens.*" The respondents express a concern, regarding the strength of the cooperation in a situation where participants are challenged to prioritize the collective good over the benefit of their own company. Cooperating farmers may disagree on how to solve difficult situations, in particular regarding who will have to bear the burden if a situation can be alleviated by actions taken at one farm, and not the others. According to the respondents, it appears that the rules governing the cooperation are perhaps not clear or specific enough for all participants. Whether or not the cooperation is able to function when things becomes challenging is especially visible in a time of crisis, and as we will see below, the findings of this study also shed light on such situations.

Cooperation in a time of crisis

The study of the toxic algae bloom reveals the problem-solving capacity of collaboration between fish farmers in the affected area during a time of

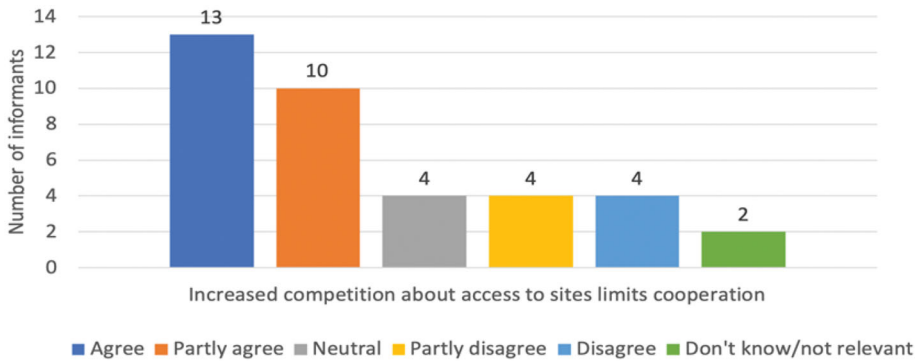


Figure 8. Informants' responses to the statement "increased competition about access to sites limits cooperation." Numbers shown as frequencies, $N = 37$.

crisis. The findings also expose the status of the area's emergency preparedness. These findings have earlier been presented in Karlsen et al. (2019).

In the spring of 2019, 14 Norwegian salmon farms in the northern part of Nordland County and the southern part of Troms County were hit by a toxic algae bloom² (*Chrysochromulina leadbeaterii*). In less than three weeks, the farmers lost 8 million salmon (*Salmon salar*), a total of 14,000 tons. While this had relatively little impact on the national total production of salmon, the bloom hit the farmers hard, some losing up to 85% of the total fish they had in the net pens. The toxic algae bloom hit small, medium sized as well as large-scale producers. Due to extraordinary profits the preceding five years, none were threatened by bankruptcy, but the loss means reduced deliveries to processing plants over the next two years, leaving many workers unemployed, with economic repercussions in many coastal communities. The collaboration to handle the crisis was extensive, it was run by the farmers themselves with support from governmental agencies and research institutions, and it included all the farms hit by the bloom, irrespective of size, ownership and command of internal resources.

The findings reveal that, regardless of size and capacity, all fish farmers in the affected area were engaged in solving the crisis. Not only did they cooperate during the warning period (to notify everybody and to attain knowledge about the algae bloom), but also in the practical handling of the crisis. The majority of those interviewed explained that all helped each other with equipment, personnel, and other resources, also fish farmers outside the affected area joined in to offer help. Respondents from the public authorities confirm the shared efforts and cooperation undertaken by the fish farmers. There was continuous dialogue and coordination between the fish farmers, and as emphasized by one respondent, no one disagreed. One of the respondents, however, stated that they had not received direct assistance from other farmers because all the farms in their

areas was hit simultaneously, and there was no one that could assist on their farm.

However, according to most of those interviewed, all of the fish farmers offered to share their resources, prioritizing the farm and area where the algae attack was most imminent. Such priorities were decided through daily and continuous contact between fish farmers, and authorities in the area. The algae caused dead fish in large numbers, which is a practical challenge for any fish farmer. Respondents emphasized that the amounts of dead fish were also a psychological challenge for the employees, dealing with an animal tragedy.

When the algae hit, the fish had to be removed quickly, in order to prevent escapes and/or to avoid sinking the entire net pens. Capacity was used across the various farm sites, and the ordinary collectors of dead fish for silage had to be assisted by fishing vessels (purse seiners) with a higher capacity to pump dead fish. The same applied to grinding capacity and delivery to silage companies.

Improvisation and informal contact appear to have been central to solving the challenges the fish farmers were faced with. While the respondents report to have followed the emergency preparedness plans at each farm, they also had to improvise. The farmers had daily meetings, coordinating their actions, and directing capacity where the situation was worst. Because so many farms were hit at the same time, there was a scarcity of many of the resources, mainly well boats, pumps, grinders and storage for the dead fish. All the fish farmers had emergency preparedness plans that involved the same suppliers of the area and these did not have the capacity to serve all at the same time. The algae bloom caused mortality to such an extent that the existent emergency preparedness plans did not suffice. The emergency resources mostly referred to in such plans are those that are in use on a daily basis, and their capacity meets the normal operational needs, but not those arising in a time of crisis. The fish farmers had to improvise to access additional resources and acquired these mainly from the wild catch fisheries.

There was also a need to quickly analyze water samples in order to know where the alga was moving. Based on an initiative from the industry, the Coast Guard was brought in, as they had test material onboard and could function as a lab on sea. Informants state that a lesson for the future is to increase the available capacity to analyze water samples in the area, and to be aware that water samples should be taken at different depths, not only on surface water. Also, a system of real time measurements should be in place.

Early on, it also became clear that there was a need for emergency sites, so that fish could be evacuated out of the area. Some of the fish farmers had access to such sites, because they have sites that were not in use. This

was, however, not the case for some of the smaller farmers, who needed to rely on the authorities to make such sites available. A lesson for future emergencies is to have empty areas and sites that can be made available to farmers, a resource the public authorities should have command of.

While the fish farmers took the main actions in attempting to salvage the fish and handle the crisis, there was a strong dependency on local authorities. The authorities have access to resources, informational oversight, knowledge, and can grant permits for some of the actions that need to be done in such a crisis. The findings demonstrate that collaboration between private actors and public authorities is decisive in solving the crisis.

Discussion and conclusions

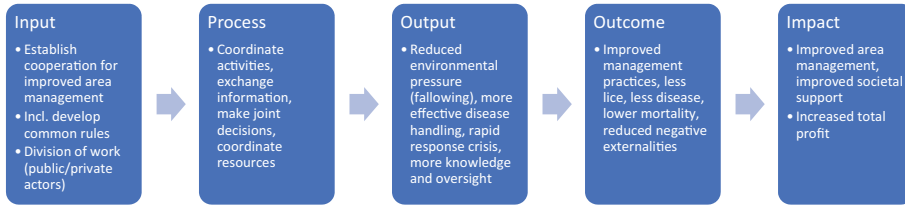
The general motivation as reported by the fish farmers is that cooperation with other fish farmers is important on a range of different topics, but especially for daily operations and emergency preparedness. Cooperation is important to be able to reduce the risk for diseases and negative externalities in an area. They also see that cooperation can improve the profitability of operations, but this is an incentive which is considered less important in our survey.

Based on this study, the main motivations for area cooperation in Norwegian aquaculture can be deduced to concern increased access to resources (equipment, personnel, knowledge, processing) and coordination of production (transfer to sea, slaughtering, following), both in daily operations and emergencies.

Most of the informants in this study have experience with cooperative arrangements, and most report this to be positive. Conflicts may arise though, especially when there are many fish farmers within the same area, and the sites are a short distance apart. Also, new-comers to an area with an established cooperative arrangement may cause conflict and be difficult to handle. The informants themselves identify a number of measures that can increase the problem-solving capacity of self-governance models.

These lessons are summarized in [Model 1](#), a simple performance model (Norad, 1999), here applied to self-governance arrangements.

The model highlights the input factors that should be in place for such arrangements, including the specific rules that apply to the cooperation, and awareness of the division of work between private industry and public authorities. Informants explain that while day-to-day cooperation appears to work just fine, they are unsure whether arrangements are strong enough, and rules clear enough when cooperation is challenged. Cooperation can for instance be challenged if one fish farmer needs to slaughter his fish



Model 1. A simple performance model for self-governance arrangements in area collaboration.

earlier than scheduled, but the processing plant is fully booked with fish from other farms. These farms will have to yield, but may suffer fines from authorities, or have difficulties meeting their orders if they do so.

Cooperation should be clearly defined through agreements, where actions of the parties involved are visible to all, and where there are sanctions for those who violate cooperation agreements. Furthermore, both the costs and benefits of the cooperation should be clear, they should be reasonably distributed and not associated with excessive uncertainty. One example is the need to improve the cooperation between fish farmers and well boat companies to ensure clear rules for the division of responsibilities and costs in the transport of sick fish. The same applies to agreements with fishing boat companies for the transport of dead fish.

Based on this study, we see that there is a need for more knowledge about the formal agreements that are established between fish farmers, and between fish farmers and their suppliers. Such knowledge could be used to provide advice on how such agreements should be designed; what elements should be included, what rules should be used including for shared decision-making, and how sanctions should be specified.

The findings also point to the division of work between private industry and public authorities. This study shows, both in daily operations and in a time of crisis that there is a need to be more explicit on how private self-regulating arrangements are dependent on public authorities, both in terms of access to resources and formal approval of activities. These input factors are decisive in creating pathways that lead to outcomes and higher-level impacts of an economic, ecological and social character. The interstices between different types of governance therefore merit more attention in future work to strengthen the potential of self-governance arrangements.

Area cooperation in the Norwegian aquaculture industry should as far as possible be initiated by the industry itself, and be voluntary. To ensure that both responsibility and accountability for how the industry handles its cumulative externalities remain with the industry, it is important that the industry is able to steer how such cooperative arrangements within an area are established and developed. Ostrom (1990) warns against imposed

cooperation, as it is rarely sufficient to achieve effective cooperation. This is supported by the Norwegian fish farmers, who believe that cooperation is more efficient if the industry can cooperate without involvement by the public authorities. This is also in line with the current recommendations from The Norwegian Food Safety Authority. On the other hand, the findings of this study also point to the central role that public authorities have in incentivizing the industry, either directly through regulatory mandates, or as a looming shadow of control.

In our study, we find that public authorities are important as a purveyor of resources and legislative approval. It is the combination of efforts from both private and public actors in sustaining and further improving collaboration which can be seen as an efficient mean to regulate behavior and performance in specific areas. Heeding the advice of Ostrom et al. (2007), there is no such thing as a panacea for how the governance of aquaculture should be designed. On the other hand, the findings presented above, demonstrate that in the context of Norwegian aquaculture, there are some lessons to be learned both for the industry itself, and for public authorities.

Improvement potential for cooperative arrangements

Conflicts between fish farmers in a limited geographical area during daily operation can be a significant challenge. Consideration should be given to establishing a mechanism to deal with such conflicts. This assessment should include who is responsible and whether there is a need to adjust the regulations.

Increased competition for sites in the same area limits cooperation on daily operations and emergency preparedness. Although the main rule should be that cooperation is voluntary, there will be considerations that cannot be solved by the companies alone. This applies, for example, to a shared good such as ancillary emergency sites, which were urgently in need during the algae attack in the spring of 2019. The counties in collaboration with the municipalities, the Norwegian Food Safety Authority and the Directorate of Fisheries should jointly develop a minimum of ancillary emergency sites in each production area.

The toxic algae bloom raised new issues both with regard to how an alert service should be organized and what resources should be in place when the disaster takes the form of emergency (well boats, slaughter capacity, transport of dead fish, harvesting and alternative sites). The weakness of the emergency preparedness plans during the toxic algae bloom was that all fish farmers in an area had plans which involved the same local suppliers and resources. When all fish farms in an area were hit by the algae bloom, this quickly exceeded the capacity of these suppliers and resources.

Emergency preparedness plans in the Norwegian aquaculture industry are developed for each individual site and have to be approved by the Food Safety Authority when a new site is to be established, or an existent site is sought amplified. Such plans can be difficult to assess for two main reasons. Firstly, they are often based on resources, equipment and suppliers in the local area that are in use on a daily basis, and not on supplementary resources reserved for emergencies. Secondly, to predict the amount of resources that needs to be available when multiple farms and sites are hit simultaneously by an emergency is difficult. The findings of this study show that fish farmers hit by the toxic algae were able to improvise and draw on resources from other industries, such as wild-catch fisheries. A lesson for future emergencies could be to have supplementary stand-by resources stored away and available on short notice, or that formal agreements about access to additional resources are established beforehand. Furthermore, collective emergency preparedness plans have in some areas been established for several fish farms and sites, but not in all regions. Also, practical emergency exercises that could demonstrate flaws in existent plans appear to be very rare.

Emergency preparedness thus appears to be an area where public authorities should have a stronger presence—a looming shadow of control—in terms of pushing for improvements in the industry's actual and practical capacity to handle emergencies in larger areas.

The importance of cooperation

Although cooperation in sum can be profitable for the Norwegian aquaculture industry, also in a more general sense as increased social support and legitimacy, several factors can prevent such cooperation from being established. The following conditions affect the possibilities for area cooperation and its design, and can be deduced from this study:

- *Knowledge*: Aquaculture companies' knowledge of hydrodynamic, biological and epidemiological factors affecting externalities.
- *Information*: Information technologies and systems for harvesting, analysis and sharing of relevant information on factors affecting aquaculture production, contamination pressures and effects in and outside aquaculture (e.g., wild salmonids).
- *Trust*: The aquaculture companies' trust in each other and attitudes toward cooperation.
- *Institutional framework conditions* in the region affecting opportunities for cooperation.
- *Public regulations* that directly or indirectly provide incentives or mandate cooperation.

Focusing on these factors in future efforts to improve the regulation of the aquaculture industry may prove fruitful toward strengthening the industry's capacity to self-regulate.

Notes

1. Fallowing zones means that aquaculture operations such as stocking, fallowing, treatments and harvesting are synchronized at all sites in the coordinated area.
2. Algae blooms are experienced by salmon and their farmers globally. In 2016, Chile was hit by a severe algae bloom, and there has been recurrent ones in Eastern Canada.

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