This is the authors' version of a paper with reference: Ellis, John; Tiller, Rachel (2019) Conceptualizing future scenarios of integrated multi-trophic aquaculture (IMTA) in the Norwegian salmon industry in Journal of Marine Policy. 201, 104, 198-209
The version of record is available at: https://doi.org/10.1016/j.marpol.2019.02.049

Conceptualizing future scenarios of integrated multi-trophic aquaculture (IMTA) in the Norwegian salmon industry

Abstract
Norway is the largest global producer and exporter of farmed salmon, however the growth of the industry has coincided with environmental impacts to the marine ecosystem and negative perceptions of salmon farming. Integrated multi-trophic aquaculture (IMTA) is one a solution, and scientists in Norway have researched salmon-driven IMTA for over a decade. Their research suggests that IMTA can mitigate some of the negative environmental impacts of salmon farming through waste recycling, however regulations in Norway do not allow IMTA. A participatory workshop was conducted to assess the future of IMTA in Norway, and participants were experts with a comprehensive understanding of the biological and technological processes of IMTA or salmon farming. Two group exercises gave participants the opportunity to conceptualize IMTA in the Norwegian salmon industry, and results indicate that IMTA would improve perceptions of the industry, create skilled jobs in coastal communities, and provide the industry with new sustainable sources of marine ingredients for feed. Participants identified that advocates of IMTA have a difficult task in advancing their agenda because of other stakeholders, such as policymakers and the public concerned with the environmental impacts from salmon farming, communities that regulate access to their coastal zone, and a powerful industry focused on producing salmon. This article explores how advocates could advance IMTA regulations in Norway using agenda building to influence policymakers and agenda setting to sway public opinion. This is the first interdisciplinary article on IMTA in the Norwegian salmon industry using a social science approach.

1. Introduction
The Norwegian salmon industry is a political priority, yet the sustainability of aquaculture in Norway is a public concern (Tiller, Svalestuen, et al. 2015, Tiller, Brekken, and Bailey 2012, Amberg and Hall 2008, Price et al. 2015, Richardsen, Bull-Berg, and Grindvoll 2016, Olafsen et al. 2012, Christiansen and Jakobsen 2017). Atlantic Salmon (*Salmo salar*) is the dominant species farmed in Norway, with respect to value of production, tonnage, farm sites, number of companies, employment, and value to the economy (Richardsen, Bull-Berg, and Grindvoll 2016, Olafsen et al. 2012). Norway is also the largest global producer of farmed salmon, and the annual production volume of over 1.2 million tonnes in 2016 is expected to reach values of 3 and 5 million tonnes by 2030 and 2050 respectively (Fiskeridirektoratet 2017, Olafsen et al. 2012, FAO 2016). However salmon farms also negatively impact the marine environment due to the release of excess nutrients from uneaten feed and fecal matter. It is estimated that over 60% of the feed for salmon farming is uneaten, with most of this waste settling on the seafloor (Mente et al. 2006, Wang et al. 2012, Braaten and Bergheim 2007). With the expected growth in production, solutions are needed to address the environmental impacts from nutrient loading and other environmental stressors.

Integrated multi-trophic aquaculture (IMTA) is one solution to the environmental impacts from excess nutrients (Soto 2009, Troell et al. 2009, Wang et al. 2012), and has the potential to improve perceptions and reduce public concern of salmon farming (Barrington et al. 2010, Alexandera, Freeman, and Potts 2016). The principles of IMTA are based on nutrient recycling, whereby complimentary (non-competing) marine species at different trophic levels are grown in proximity to each other, allowing the waste from one species to become the feed for another. Although poly-culture[1] and IMTA have been used for centuries in Asia and other parts of the world, salmon-driven IMTA research has primarily taken place in Canada, Chile, and Norway, focused on using seaweeds and mussels (Troell et al. 2009, Chopin et al. 2001, Handå et al. 2012, Broch et al. 2013, Leonczek 2013, Buschmann et al. 2009, Buschmann, Troell, and Kautsky 2001). Research has shown that IMTA improves the sustainability of the aquaculture production by reducing the negative environmental impacts from excess nutrients (Neori et al. 2007, Troell et al. 2009, Troell et al. 2003, Holdt and Edwards 2014, Wang et al. 2012). Despite the commercial success of IMTA at some salmon farms in Canada, Chile has not adopted IMTA because of economic considerations, and Norwegian regulations do not allow IMTA (Soto 2009, Leonczek 2013, Buschmann et al. 2014).

[1] "…the co-culture of different aquatic species from the same trophic level…" (Soto 2009)

Over a decade of salmon-driven IMTA research in Norway has emphasized the biological functions of the marine system[2] (Wang et al. 2014, Handå A et al. 2013, Broch et al. 2013, Handå A et al. 2012), however there is no literature from social science on IMTA in the Norwegian salmon industry. Recent publications from social scientists in Norway on salmon farming includes economic consequences of escaped farmed salmon (Olaussen and Liu 2011, Liu, Olaussen, and Skonhoft 2014), workshops to understand the impacts on stakeholders from the predicted growth of the Norwegian salmon industry (Tiller, Svalestuen, et al. 2015, Tiller, Hansen, et al. 2015, Tiller et al. 2014, Tiller and Richards 2015, Tiller, Brekken, and Bailey 2012), in-depth interviews with individuals from public agencies and the aquaculture industry to understand their perceptions of the challenges in governing aquaculture (Osmundsen, Almklov, and Tveterås 2017), the role of media in framing public opinion (Olsen and Osmundsen 2017), the role of media in allowing a forum for public debate (Osmundsen and Olsen 2017), and understanding the new 'light green', 'dark green' and 'development' license scheme (Christiansen and Jakobsen 2017). The European IDREEM project (Increasing Industrial Resource Efficiency in European Mariculture) used a web-based survey across 5 countries (Ireland, Israel, Italy, Norway, and the UK) and investigated public understanding of IMTA (Alexandera, Freeman, and Potts 2016), however it was not specific to Norway or salmon farming. Canadian researchers have published on social issues of IMTA in the salmon industry, including the social acceptance of IMTA at a pilot project in the Bay of Fundy, Canada (Ridler et al. 2007, Barrington et al. 2010). Although the future of IMTA regulations in Norway remains uncertain, this literature establishes the importance of the social science approach.

This article explores how advocates could advance IMTA regulations in Norway using agenda building to influence policymakers and agenda setting to sway public opinion. The article first introduces the Norwegian salmon industry, followed by the theoretical and methodological framework. A participatory workshop conducted in Trondheim, Norway in 2014 gave participants the opportunity to assess the future of IMTA in Norway. The article introduces the results of the workshop and a discussion of the results.

This article does not offer insight into the economic growth of the industry or an analysis on the potential rebound effect of more salmon production at a farm site due to using IMTA. We also do not discuss IMTA within the framework of offshore aquaculture or other challenges to the industry, such as escapes or sea lice. Finally, there is no discussion on the aesthetics of salmon farms or IMTA structures.

1.1 The Norwegian Salmon Industry

Salmon farming was originally developed along the extensive Norwegian coast and fjord systems, which are ideal for salmon aquaculture due to sheltered locations, consistent water temperature, and strong currents. As the salmon farming industry began to emerge in the 1970s in Norway, Chile, US, Scotland and Canada, the Norwegian government saw the potential to stabilize struggling rural coastal communities, which were losing jobs and population. The government was instrumental in the early success of the salmon industry, providing substantial resources and support such as research and development, educational programs, and investments in infrastructure.

Although salmon farming in Norway has changed dramatically since the 1970s, salmon are still grown in monocultures, where only one species is being farmed. Salmon farms now utilize high tech automation for production and harvesting, which allows more intensive farming at one location. For example, in 1978 the entire Norwegian production from 116 farms totaled 3540 tonnes, whereas one farm site is currently allowed to hold up to 3900 tonnes of salmon at any time (Statistics Norway 2008, Marine Harvest 2017). The intensive farming produces a high volume of nutrients from feces and excess feed, impacting the marine ecosystems around the salmon farms (Buschmann et al. 2009). While nutrients are essential for plants and animals in a marine ecosystem, excess nutrients may negatively impact benthic communities (sediment), pelagic organisms (water column), and the whole ecosystem (eutrophication) (Handå et al. 2012, Wang et al. 2014, Wang et al. 2013). An ecosystem has an inherent capacity to persist in the face of some perturbations in the form of increased nutrient input, however at some level the disturbance may be too great for the system. Two forms of eutrophication that can kill plants and animals in a marine ecosystem are oxygen depletion and toxic algae blooms (National Academy of Sciences 1969).

As the Norwegian salmon industry sets its sites on increasing production levels, and with the potential for even more intensive farming, the environmental impact from excess nutrients needs to be addressed. IMTA could reduce the environmental impact while simultaneously creating positive perceptions of salmon farming. In an IMTA system, different extractive species, such as seaweed and mussels, are grown at various trophic (water)

[2] Research Council of Norway projects: POLYCULT (2004-2006), INTEGRATE (2006-2011), MARCROBIOMASS (2010-2012), MAXIMTA (2012-2016), and EXPLOIT (2012-2016).

This is the authors' version of a paper with reference: Ellis, John; Tiller, Rachel (2019) Conceptualizing future scenarios of integrated multi-trophic aquaculture (IMTA) in the Norwegian salmon industry in Journal of Marine Policy. 201, 104, 198-209
The version of record is available at: https://doi.org/10.1016/j.marpol.2019.02.049

levels and in close proximity with the fish. The main purpose of IMTA is to mitigate some of the environmental impact from excess nutrients from fish farming, and species are chosen with complimentary environmental functions so that the waste from one is the food for the other. Integrating different species in aquaculture has been used for centuries, and many countries currently use IMTA for a range of species. An example from Norway is Ocean Forest, an ongoing joint venture between the Norwegian corporation Lerøy and the environmental NGO Bellona. Ocean Forest is a full-scale salmon farm conducting IMTA research under a development license, and with the stated goal of using excess nutrients to produce raw materials for fish feed (Lerøy Seafood Group 2015).

2. Theoretical framework

There has been over a decade of salmon-driven IMTA research in Norway, and scientists have answered many questions about IMTA under different conditions and marine ecosystems. Although the research is ongoing, regulations do not allow IMTA in Norway[3]. The formation of public policy is initiated through a political process whereby elected officials introduce policy items to a formal agenda, which then allows those items to be considered for public policy (Cobb, Ross, and Ross 1976). The public does not have direct access to the formal agenda, however stakeholders and other interest groups have the ability to shape public policy by influencing public opinion and decision makers (Olsen and Osmundsen 2017, McCombs 2013, Kepplinger 2008).

Norway's salmon industry is highly regulated, and there are many actors and stakeholders with different levels of influence throughout the process of creating policy, issuing a farming license, and the placement and operation of an individual farm. In order to change regulations, advocates of IMTA in Norway need to persuade policymakers, the public, and the salmon industry that IMTA is one solution to mitigate the environmental impact from salmon farming. Using agenda building and agenda setting is one way to develop coalitions of advocates at different levels of influence. An academic distinction exists between agenda building and agenda setting, although both are used to advance an issue. Agenda building is part of the formal political process and applies to policy makers, and agenda setting is when the media sets the public agenda by informing the public on an issue and shaping public opinion.

Agenda Building works through anticipating resistance and building coalitions, and has been applied to various fields of study to understand the politics of policymaking, such as drug policy in Major League Baseball (Denham 2004), 'big science' (Madison 2000), and social movements (Smith et al. 2001). Agenda building has also been used for environmental issues, such as ecosystem management (Haeuber 1996, Braat and Groot 2012), international environmental policy (Kamieniecki 1991, Ross 1992, Hardoy, Mitlin, and Satterthwaite 1992), food policy (Mendes 2008), water policy (Smith 2009), and climate change (Vogel and Henstra 2015). The salmon industry uses agenda building to advocate for production growth, and the Norwegian Seafood Federation builds coalitions with stakeholders to promote policies and legislation that benefits the industry (Norwegian Seafood Federation 2018). Similarly, Lerøy Seafood Group and the environmental NGO Bellona, collaborate on IMTA research and advocate for using IMTA at farms in Norway (Lerøy Seafood Group 2015). IMTA advocates could benefit from using agenda building to navigate the many levels of potential stakeholder resistance, and build coalitions with stakeholders interested in improving the environmental impact of the industry and developing new markets for Norwegian seafood.

Agenda setting has been applied to the environment (Curtin and Rhodenbaugh 2001), greenhouse gas (Lodhia and Martin 2011), and after natural and manmade disasters (Birkland 1998, Barnes et al. 2008). It has also been a focus of recent articles on the Norwegian salmon industry, such as the media framing the aquaculture debate on escapes and sea lice (Olsen and Osmundsen 2017), increased media coverage on environment issues (Tiller, Brekken, and Bailey 2012, Olsen and Osmundsen 2017), and as a forum for public debate (Osmundsen and Olsen 2017). Increased media attention is believed to result in increased concern for a particular issue, influencing public opinion and policymakers (Brown and Deegan 1998, Cobb, Ross, and Ross 1976). During 1984-2010 approximately half of the news articles on the Norwegian aquaculture were related to conflict, which affected the social discourse to the point where industry growth was limited and then stopped in 2012, even though there was political will for aquaculture expansion (Olsen and Osmundsen 2017, Hersoug 2015, Osmundsen, Almklov, and Tveterås 2017, Tiller, Brekken, and Bailey 2012). Industry growth resumed in 2013 when the government announced they would award 45 'green' licenses, which linked growth to improving the

[3] IMTA is allowed using a research or development licenses, which restricts IMTA products for research and not commercial sale.

environmental impact at salmon farms (Hersoug 2015, Marine Harvest 2017). Additionally, the new regulations finalized in 2017 divided the coast into 13 production areas, allowing growth if sea lice is kept below a certain level in a production area (Hersoug 2015, Marine Harvest 2017). While this is further evidence of the need to improve the environmental impacts of salmon farming and the political priority of the industry, it also shows the power of stakeholders with an agenda.

3. Methodology

A participatory workshop was conducted to assess the future of IMTA in Norway, and participants were experts with a comprehensive understanding of the biological and technological processes of IMTA or salmon farming. The collaboration of researchers from different fields made use of the institutional memory of the experts and shed light on how IMTA could technically work in Norway. Two complimentary methods, Systems Thinking and Bayesian Belief Networks (BBNs), enabled researchers the ability to assess the perceptions of experts, as has been used for modeling climate change adaptations (Richards et al. 2013), and stakeholder perceptions of salmon farming in Chile (Salgado et al. 2015) and Norway (Tiller et al. 2014, Tiller and Richards 2015). Primarily used to represent causal relationships in a system with a lack of quantitative data, the mix of methods creates a model of a complex system based on the knowledge and expertise of the participants, and identifies probability of key scenarios.

The snowball method (Biernacki and Waldorf 1981) was used to recruit participants to the workshop. IMTA has been researched for over a decade in Norway, and we began by inviting IMTA researchers as well as other experts on salmon farming in Norway. Participants were selected based on their portfolio of peer-reviewed articles, followed by experts recommended by the first group, and followed by PhD and master students working on IMTA or salmon farming. A benefit of using this approach is that it allows exploration of a complex system based on the broad knowledge and expertise of the participants.

Literature in the use of expert opinion includes the most knowledgeable person (Yetton and Bottger 1982), aggregating opinion (Hogarth 1978), wisdom of the crowd (Surowiecki 2004), and select-crowd strategy (Mannes, Soll, and Larrick 2014). Hogarth (1978) wrote that “groups containing 8-12 members have a predictive ability close to ‘optimum’ under a wide range of circumstances”, and Mannes et al (2014) stated “that select crowds of 5 knowledgeable judges” from a larger crowd were more accurate than the crowd. Thus the small sample size of Norwegian experts used for this research is in agreement with the select-crowd strategy, which is a rigorous and robust strategy for obtaining data from a group of knowledgeable experts.

3.1 System Thinking

The System Thinking exercise uses a participatory framework (Forrester, 1961) that relies on an open dialogue of the group to conceptualize the dominant components of the system being explored. The exercise lasts between one and two hours and it is designed to have participants discuss a research question, create a shared conceptual model of the system, and come up with ‘Priority Issues’ of the system. Participants are first given instructions about the system thinking exercise. They are told a series of ‘drivers’ of the system will be introduced to the group to stimulate the discussion, that the moderator will introduce a research question to frame the discussion, and that the conversation begins with someone in the group selecting a driver to discuss. The drivers, which are pre-selected by the researchers, are variables that describe something in the system that can change. Participants are allowed to choose additional drivers to discuss and to dismiss a driver if it is not important to the group. Thus the participants ultimately decide the drivers and the depth that each driver is discussed.

Using VENSIM® software[4], the drivers are shown on a video screen for the group to see. During the discussion a second moderator inputs the comments from participants into VENSIM® in real time. Each comment becomes a new variable and is connected (by a line) to the corresponding driver(s) or variable(s) being discussed. The participants can see comments and connections on the screen as they are added, and can comment if something was not added correctly. Each line connects a variable with an arrow in the direction of causality, therefore if the arrow goes from A to B, then A affects or influences B. Causality may be circular, and a second arrow would also go from B to A indicating that B also influences A. Causality may also occur between multiple variables, such as an arrow from A to B, C, and D. At the end of the exercise all of the drivers, variables and connections combine to form a conceptual map of the system, showing which variables have influence over others. In addition, the dialogue is recorded and transcribed to provide the researchers with qualitative data to be used to better understand the thought process behind the connections.

[4] VENSIM® is a simulation software that creates a graphic representation of qualitative data in real time, and organizes complex data into easily accessible causal diagrams.

This is the authors' version of a paper with reference: Ellis, John; Tiller, Rachel (2019) Conceptualizing future scenarios of integrated multi-trophic aquaculture (IMTA) in the Norwegian salmon industry in Journal of Marine Policy. 201, 104, 198-209
The version of record is available at: https://doi.org/10.1016/j.marpol.2019.02.049

The system thinking exercise begins with the declarative statement: “Let us assume that XYZ will happen”, then the moderator poses a question: “What is going to happen to the current system?” Any participant is able to begin the discussion by selecting a driver and answering the question posed, and other participants follow in an open dialogue. When necessary, the moderator can refocus participants by asking, “how is that going to affect the current system?” The moderator may also ask individual participants their opinion to make sure that everyone shares their thoughts and ideas.

Once the system thinking exercise is completed, the moderator runs the VENSIM® software to identify all of the variables that have influence over other variables. The variables with the most influence are identified and prioritized to represent the issues most affected by the research question. The next step is a group discussion to determine the Priority Issue(s) that the participants will use for the BBN exercise. The final step of the system thinking exercise is to decide if the participants should work on one Priority Issue or if the group should be split up to discuss multiple issues.

3.2 Bayesian Belief Network

Bayesian Belief Networks (BBNs) are built upon the robust mathematical framework of Bayes theory, and incorporates qualitative data into the model[5], which traditional statistical testing methods cannot do. Through participatory engagement workshops, BBN modeling represents causal relationships by eliciting qualitative variables from participants, specifically in context to variability, uncertainty and subjectivity (Aguilera et al. 2011, Richards et al. 2013). BBNs use discrete variables, which is useful in coalescing knowledge from expert opinion and stakeholder experience (Tiller and Richards 2018, Aguilera et al. 2011).

There are two parts of the BBN exercise. The first part is a group exercise to develop the conditional probability table (CPT), which requires participants to discuss and agree on everything included in the table. The second part of the exercise is for each participant to fill in the CPT, providing individual parameterization that is then combined into a single model for the group. The CPT (see Figure 1) begins with the Priority Issue, next are 3 Primary Level variables, followed by 9 Secondary Level variables – 3 for each of the Primary Level variables. In addition, all variables have a discrete outcome, which are 2 mutually exclusive states that include a preferred and an undesirable outcome.

Figure 1 here

To create the CPT, the group must first decide on a preferred and an undesirable outcome for the priority issues. The group then determines the 3 primary level variables, which are the 3 most important factors that can lead to the preferred outcome of the priority issue. The group then repeats the process of assigning a preferred and undesirable outcome for each of the primary level variables. The next step is to determine the 9 secondary level variables, which are the 3 most important factors for each of the 3 primary level variables. The last step in creating the CPT is assigning a preferred and undesirable outcome for each of the secondary level variables.

The second part of the BBN exercise is for each participant to fill in the CPT, which is a series of 32 ‘scenarios’ automatically created by an excel spreadsheet. Beginning with the 8 scenarios pairing the priority issue with the 3 primary level variables, the first scenario would look as such: “What is the probability of a preferred outcome of the priority issue occurring given the preferred outcome of primary level variable 1, 2, and 3 has already occurred?” The subsequent scenarios for the priority issue are a combination of preferred and undesirable outcomes, ending with the scenario: “What is the probability of an undesirable outcome of the priority issue occurring given the undesired outcome of primary level variable 1, 2, and 3 has already occurred?” The process continues with the 8 scenarios for each of the 3 primary level variable paired with their 3 corresponding secondary level variables. When the CPTs are completed, each participant will have viewed 32 unique scenarios and assigned each scenario a probability of occurring.

[5] For more information on how BBNs are used in qualitative studies, see:
Richards, R., *et al.* 2013. "Bayesian belief modeling of climate change impacts for informing regional adaptation options." *Environmental Modelling & Software* 44:113-121.
Tiller, R. and Richards, R. 2018. "Ocean futures: Exploring stakeholders' perceptions of adaptive capacity to changing marine environments in Northern Norway." *Marine Policy*:12.

4. Results

Using the snowball method (Biernacki and Waldorf 1981) to recruit participants, the workshop consisted of 8 Norwegian experts with a comprehensive understanding of the biological and technological processes of IMTA or salmon farming. A common argument against qualitative studies with a low number of participants is that it is not statistically valid, however Hogarth (1978) wrote that "groups containing 8-12 members have a predictive ability close to 'optimum' under a wide range of circumstances", and Mannes et al (2014) stated "that select crowds of 5 knowledgeable judges" from a larger crowd were more accurate than the crowd. Further, sample size does not negate the validity of the perceptions of the expert participants, the scientific validity of the methods, and the results presented. Thus, having 8 Norwegian experts at the workshop is in agreement with the select-crowd strategy, which is a rigorous and robust strategy for obtaining data from a group of knowledgeable experts.

4.1 System Thinking Exercise

This section will highlight the topics discussed during the System Thinking exercise, and the conceptual model from VENSIM® (see Figure 2). The participatory framework of the exercise relies on an open dialogue of the group to conceptualize the dominant components of the system being explored, and takes between one and two hours. To stimulate an in depth discussion between participants, researchers used 8 drivers (see Table 1) that were chosen at a separate workshop by experts in biology, microbiology, environmental modeling, political science and oceanography (Salgado et al. 2015). The drivers are based on a broad set of stressors related to salmon farming and describe something in the system that can change. Participants were told they had control over the drivers and could add, change, or dismiss each one.

Table 1 here

The exercise began with the premise that IMTA was "feasible and scalable, and that regulations in Norway have been changed to allow IMTA at salmon farms". This was used as the starting point to understand how participants would conceptualize future scenarios of IMTA in the Norwegian salmon industry. The discussion began with one participant commenting, *"Escapes should be a separate driver"*[6], and expanding on that idea. The following section details the main issues discussed by the participants, and highlights the ways that advocates of IMTA could anticipate resistance and build coalitions in order to influence public opinion and policymakers.

Participants discussed the decades long regulatory process that some suggested would delay IMTA from moving forward, and a reluctant salmon industry accepting it. *"If it's within the next 1 or 2 decades, we should talk about regional multi-trophic aquaculture (RMTA) systems and not integrated ones because I think that is where we will start. We will have a balanced ecosystem approach within an area - fjord system - but not at the farm level."* In a regional system the production of seaweed and mussels will take place within an area of many salmon farms (1.5 km from the farms) and not in close proximity of a specific salmon farm (100-200 m from a farm). Regulatory changes in Norway are necessary to allow seaweed and mussel deployment in close proximity to salmon farms, however a balanced regional ecosystem approach may be the necessary first step for generating political support (Vogel and Henstra 2015). Giving lawmakers a way to show benefits to multiple stakeholder groups has proven successful for policy implementation in Norway (Aall 2012). While a regional system means slower growths rates for the seaweed and mussels (they have the fastest growth within 100-200 m from salmon farms), a balanced ecosystem approach will benefit the region by improving the overall environmental impact from salmon farming.

In Norway "*salmon is going to be the driver for IMTA, so whatever we discuss or how we approach it or what we think about it 10 or 20 years from now, it will still be the salmon that is the driver for the system*." Norway has a large stake in having a successful farmed salmon industry, however the salmon industry is not ready to drive IMTA. It was a complicated discussion about who will produce the products within an IMTA system. Participants believed that salmon farmers would not want to make changes to their production process, and when IMTA begins it will be a collaboration between the individual producers of salmon, seaweed, and mussels - perhaps subsidiaries of existing companies. Agenda building works through anticipating resistance and building coalitions, and policy makers could secure the commitment of the industry to use IMTA by tying it to something the industry wants, such as access to more farming locations (Madison 2000, Christiansen and Jakobsen 2017). The Lerøy-Bellona project Ocean Forest is currently producing salmon, seaweed and mussels at a large-scale research site, however it may take years before an industrial system is feasible (Lerøy Seafood Group 2015).

[6] *"Italic print in quotation marks"* indicates a quote from a participant during the system thinking exercise.

This is the authors' version of a paper with reference: Ellis, John; Tiller, Rachel (2019) Conceptualizing future scenarios of integrated multi-trophic aquaculture (IMTA) in the Norwegian salmon industry in Journal of Marine Policy. 201, 104, 198-209
The version of record is available at: https://doi.org/10.1016/j.marpol.2019.02.049

Escaped farmed salmon cause both environmental damage and give the industry a bad reputation, and participants discussed that IMTA could lead to an increase in human caused escape due to increased traffic to check on seaweed and mussels installations. Conversely, it was suggested that large-scale seaweed production could decrease salmon escapes because *the "seaweed could reduce the physical stress on the salmon cages"* due to a change in the current. An IMTA installation would use native (local) cultures of seaweed and mussels, which naturally exist along the entire Norwegian coast and persist at salmon farms, reducing the risk of causing new problems to the marine ecosystem. The increased media coverage of the industry, especially on environment issues, has given the media a powerful role in agenda setting (Tiller, Brekken, and Bailey 2012, Olsen and Osmundsen 2017), by affecting public opinion through "the stimulation of critical voices" (Birkland 1998). Advocates could promote IMTA when negative media coverage of salmon farming occurs, using the opportunity to create a positive narrative about IMTA as an environmental solution.

The salmon industry will need more marine space to accommodate their expected growth and participants discussed the issue of the coastal zone among competing users and stakeholders. Coastal communities and the salmon industry would benefit by allowing growth only after a region has controlled lice, disease, pesticide use, and escapes; essentially, growth only comes after the region is 'fixed', which forces all farms in a region to work together to secure their region. The challenges of the marine space in Norway, especially the additional space requirements of IMTA, can be addressed by both agenda building and setting, as local policy makers make decisions for the coastal zone, and multiple stakeholder groups participate in the process. From an agenda building perspective, the marine space fits into the model of an outside initiative (Cobb, Ross, and Ross 1976), and from an agenda setting perspective it fits into the interest group mobilization (Birkland 1998).

In Norway the local government approves salmon farm locations, not the federal government, therefore the local community and local politicians are extremely important for the aquaculture industry. The industry has been focusing on gaining access to space that they will need in the future, and IMTA could make local stakeholders and politicians happy by growing seaweed and mussels in areas that are not suitable for salmon farms. "*The big salmon producers understand that to be able to grow and have more production they need to have public acceptance and a better reputation with stakeholders - decision makers, authorities, politicians*." As a condition for the growth, farms could be required to maintain certain production volumes of IMTA products.

Participants discussed IMTA as a benefit to communities with new jobs, increased business activity, and an improved environment. While feeding salmon is the most labor intensive, IMTA products need seasonal workers to deploy, maintain, harvest and process. As in the early days of the salmon industry, fishermen could be employed for these seasonal jobs. Participants also identified the indirect values to the community, such as using seaweeds and mussels to decrease waste and increase the sustainability of the salmon harvest, and deploying IMTA in areas unsuitable for salmon.

"*Canadian salmon farms also have commercial IMTA, and seaweed grown in the IMTA system has a higher value than other seaweed. They also get a higher price for the salmon*." However, the participants believe that in Norway food safety will be a concern, and the slow growth rate of mussels will be another. One potential is harvesting small mussels for fish feed, "*something that should actually be explored more*." While the assumption at the beginning of the system thinking exercise was that IMTA products are for human consumption, by the end of the exercise the discussion was about using them to supply sustainable marine ingredients for fish feed.

"If we want to triple salmon production, we need new sources to produce feed. The fisheries that produce the fish oil and fishmeal are regulated and cannot harvest more, regardless of economic interest." Salmon feed is the largest cost in salmon production by a large factor, and it would be a sustainable solution *"for the Norwegian salmon industry if they created a new feed source, or at least part of it. It is possible to get up to 5% of the fatty acids from mussels cultivated from IMTA, and small mussels could be cultivated in 3 months instead of 3 years."* Also, aquatic plants grown in IMTA could replace all of the agriculture plants. That will not solve the fishmeal and fish oil problem but it will help. On the other hand salmon producers will generally use the cheapest acceptable resources to make feed, and IMTA products may be more expensive than alternative products. Additionally, there are other industrial uses for IMTA products, such as biofuels, pharmaceuticals, cosmetics, plastics, textiles, and fertilizers (Leonczek 2013), however the participants were focused on items for human consumption and fish feed alternatives.

Figure 2 here

4.2 Bayesian Belief Network Exercise

After the system thinking exercise the moderators used the VENSIM® software to analyze the variables, looking at concentrations of causal relationships to find where issues could exist. The participants were presented with all of the identified issues, and together with the moderators the group chose two priority issues to further explore, 'addressing stakeholder conflicts' and 'environmental impacts from salmon farming'. For the Bayesian Belief Network (BBN) exercise, the moderators split the participants into 2 groups, with 4 participants in each group.

With the moderators assisting the first part of the exercise, participants in each group created a conditional probability table (CPT) for their priority issue. As described in the Methodology section (see section 3.2), that process required the participants discuss and agree on everything to be included in the CPT. It began with participants choosing the discrete outcomes for the priority issue, followed by the 3 primary level variables, and then the 9 secondary level variables. In addition, all primary and secondary level variables have a discrete outcome, one preferred and the other undesirable. The second part of the exercise was for each participant to fill in the CPT, providing individual parameterization that was then combined into a single model for the group.

4.2.1 Group 1 – Addressing stakeholder conflicts

IMTA development will create new challenges for communities and the industry, and there will be a need to understand how IMTA will affect existing conflicts as well as new ones that will arise. For the BBN exercise Group 1 asked the question: "As the salmon industry develops with IMTA, how will conflict be managed?" The participants believe there could be an increased acceptance of all aquaculture if conflicts from IMTA development are well managed, and the three main factors they determined were Reputation of IMTA, Public Acceptance of IMTA, and Consumer Demand. While agenda setting is ultimately about the media influencing public opinion, two principles of agenda setting are Reputation and Public Acceptance, which are two factors chosen by Group 1 (Birkland 1998). The third factor, Consumer Demand, could also be influenced by media attention. The following section will provide details from the discussion and how they define those factors.

The first factor was Reputation of IMTA, and the discussion addressed the willingness of the industry to improve their reputation, and included the secondary level variables: open dialogues, meeting performance indicators, and sharing information. Creating a forum for open dialogue was considered a necessity because the "*information process is something that is ongoing*". It doesn't get solved. Meeting performance indicators meant measuring quantifiable indicators from all aspects of performance – productivity, efficiency, environmental, fish health, profitability, reduction of lice and escapes. That was a very important point and easy to validate. Finally, they see the need for the industry to be transparent by sharing information before stakeholders ask for it. Stakeholders will reward an open and honest industry with their trust and an improved perception. While the industry would not want companies to provide information that could benefit their competitors, data sharing, even from inefficient farms, will improve efficiency and performance for all farms.

The second factor was Public Acceptance of IMTA, and it related to both the farm level and the larger idea of society accepting IMTA production and the products from IMTA, and included the secondary level variables: coastal zone use, job creation, and environmentally friendly IMTA products. Coastal Zone Use would involve the need for additional space to produce IMTA products, potential conflict with existing users, and issues of the public not wanting to see more fish farms from their property. It was agreed that conflict about space could be described as whether stakeholders even wanted aquaculture on their coastline. There will always be a need for seafood from coastal communities, so there will be a need for stakeholders to agree to the overall use of the coastal zone – regardless if there will be IMTA or monocultures. Participants believe that the public would be more willing to accept an industry that increased local jobs. Finally, IMTA products must be produced in an environmentally friendly manner, which addresses the environmental impact from the salmon industry and IMTA production.

The final factor was Consumer Demand, and the discussion primarily focused on the global market for seafood, and included the secondary level variables: desirability, market need, and safe products. Norwegian seafood producers currently sell seaweed and mussels into the large international market, however participants are unsure whether the same products produced in IMTA would be desired. It was also unknown whether Norwegian laws would allow products from IMTA to be sold for human consumption. Regarding market need, there may be a market for seaweed and mussels, but that doesn't mean the IMTA products are needed. Finally, consumers will want IMTA products if they are healthy and safe to eat. Although the discussion focused on IMTA products for human consumption, it was noted that there are industrial uses for some IMTA products, and that the issues of food safety would be of less concern. Figure 3 is the CPT for Group 1.

This is the authors' version of a paper with reference: Ellis, John; Tiller, Rachel (2019) Conceptualizing future scenarios of integrated multi-trophic aquaculture (IMTA) in the Norwegian salmon industry in Journal of Marine Policy. 201, 104, 198-209
The version of record is available at: https://doi.org/10.1016/j.marpol.2019.02.049

4.2.2 Group 2 – Environmental impacts from salmon farming
IMTA could improve the environmental impacts from salmon farming, however there are over 1000 salmon farms throughout Norway, which are owned by approximately 100 companies including a few very large corporations (Fiskeridirektoratet 2017). Group 2 believes that sustainable production practices such as IMTA must take place at a high percentage of those farms and be a priority of salmon producers. For the BBN exercise Group 2 asked the question, "What does it take to have a sustainable industry?" The three main factors they determined were IMTA, Cultivated Fish Feed, and Environmentally Driven Rules and Regulations. Agenda building and setting are concerned with the public policy process that creates Rules and Regulations. Also, policy makers and public opinion could be influenced by the development of Cultivated Fish Feed. The following section provides details from the discussion on how they define those factors.

The first factor was IMTA, which must be financially sustainable for firms to want to invest resources, included the secondary level variables: research based concessions, species selection for site, economically viable market. Participants said that a majority of farms must use IMTA, especially at farms and with nutrient loading over a specific threshold. The participants also said farm licenses needed to be transferable from a research license to a commercial license[7]. The idea was that a site must first be suitable for IMTA before it is transferred, which would reduce the financial risk. In addition, not all species are suitable for industrial scale at each farm site. Species selection is the process of choosing complimentary species for IMTA that are adapted to the unique conditions of each farm site. Finally, a viable market should already exist for the IMTA products because companies will want to make money on IMTA products, not try to create demand.

The second factor was finding new sustainable sources of marine ingredients for fish feed, which included the secondary level variables: industry interest, research funding, and competence. Fish feed is already a challenge because traditional marine resources, such as fishmeal and fish oil, are in high demand and costs continue to rise. Low cost soybean oil and low value wild caught fish are currently being used for feed, and that is not sustainable. Soy production competes with agriculture land that could be used for humans, and uses a lot of fertilizers and water. It is also not sustainable to fish low value fish to feed high value fish. Group 2 stated that "*you should not fish fish to feed fish*", and they believe that new sustainable sources for marine ingredient are needed. Their solution was cultivated non-fed aquaculture from lower trophic levels. Industry involvement and funding will come after basic research, not during product development. Funding from the RCN (Norwegian research council) on new fish feed usually begins with government funding. Companies are also willing to invest, however feed companies do not share results to protect their business interests. Finally, it requires specific competence and expertise to determine the species that can be cultivated at each site.

The final factor was developing rules and regulations that are environmentally driven instead of profit driven, which included the secondary level variables: consumer demand, environmental based research, and an environmental need. Environmentally driven rules and regulations will define government priorities for the salmon industry, such as the recently issued green concessions focused on reducing sea lice and escapes. The participants referred to consumer demand in terms of consumers wanting the government to push the industry to be more sustainable. Decision makers creating rules and regulations need knowledge and advice about salmon farming, which is why environmental research is needed. Finally, rules and regulations are needed to manage the environmental impacts from excess nutrients coming from salmon farms. Figure 4 is the CPT for Group 2.

5. Discussion

We performed a sensitivity analysis (using Netica® software[8] for Bayesian Belief Networks) to understand the results from the conditional probability tables (CPTs). The sensitivity analysis is run for each group, and it is used to determine where the participants were in agreement (or disagreement). It also helps to understand the most influential variables, as well as which variables have influence over others.

5.1 Group 1 Sensitivity Analysis:

---

[7] The workshop predates 2015 legislation in Norway that added a 'development' license to encourage innovation and investment into new technology. Participants called it a 'research' license. After meeting specific criteria, a development license can be converted into a commercial license (Christiansen and Jakobsen 2017).

[8] Netica® software is used for working with belief networks and influence diagrams, and produces a graphic display of the Bayesian belief network.

Agenda building works through anticipating resistance and building coalitions, and this is illustrated by the results from the CPTs (see Figure 3), which show that there is a 54% probability that IMTA related conflict would be well managed. In addition, results also show that IMTA will improve the perception of salmon farming through job creation, mitigated environmental impacts, and stakeholder engagement. Advocates of IMTA could focus on two principles of agenda setting, reputation and public acceptance, to build coalitions and mobilize interest groups. There is a 56% probability that the reputation of IMTA will be good, and a 51% probability that the public will accept IMTA. Also, there is a 46% probability that consumer demand for IMTA products will be high, and the industry could support IMTA products as a new sustainable source of marine ingredients for feed.

Figure 3 here

The sensitivity analysis shows a balance between variables in the primary level, and also in the secondary level (see Table 2). The most sensitive are the primary level variables: Public Opinion of IMTA, Consumer Demand, and Reputation of IMTA. In a BBN sensitivity analysis that is considered a 'normal' state because the three primary level variables directly influence the priority issue, IMTA Related Conflict. The three primary level variables also have a similar amount of influence on the priority issue because the 'variance of belief' between those variables is so close. The next most sensitive variable is Participants, the auxiliary variable, which shows that the participants are in agreement about the importance of the primary level variables. It also means that the results are balanced, and that each of the participants in Group 1 has a similar amount of influence.

Table 2 here

At the secondary level, Job Creation (through Public Opinion of IMTA) has the highest level of influence. In addition, the variance of belief for Job Creation is double the influence of the next variable, which means it will be easier to manage IMTA related conflicts by creating jobs. That is understandable since the system thinking exercise brought to light the control that local government has over aquaculture development in their communities, and the need for jobs to create stability in rural communities.

The results for the sensitivity analysis on the remaining variables are more nuanced. The next pathway of influence is through Consumer Demand, although there is much less influence than Job Creation. Market Need and Desirability have strong influence on Consumer Demand, however Product has low influence because its variance of belief is almost half that of Market Need. That is in line with the conversation from the workshop on fish feed, and using the IMTA products as new sustainable sources of marine ingredients for feed. Similarly, during the exercise to create the CPT the group discussion focused on Performance of IMTA and Open Dialogues, which have a strong influence on Reputation of IMTA.

5.2 Group 2 Sensitivity Analysis:

Increased media attention is believed to result in increased concern for a particular issue, influencing public opinion and policymakers. The environmental impacts from salmon farming have caused negative perceptions of the industry, and results from the CPTs (see Figure 4) illustrate that there is a 48% probability that the development of the Norwegian salmon industry will be sustainable. Agenda building and setting are concerned with the public policy process that creates rules and regulations, and regulatory changes are necessary to allow IMTA in Norway. Creating a regional ecosystem approach could build coalitions by giving lawmakers a way to show benefits to multiple stakeholder groups, and there is a 69% probability that new rules and regulations will be environmentally driven. Agenda setting influences public opinion, and IMTA advocates could work with the media to improve the perception of salmon farming. Although there is a 46% probability that IMTA will be financially sustainable, and a 43% probability that fish feed will use cultivated non-fed ingredients, these are valuable to the industry if it improves public perception.

Figure 4 here

In contrast to Group 1, the sensitivity analysis for Group 2 (see Table 3) shows significant differences, beginning with the influence of the primary level variables, IMTA, Fish Feed and Rules and Regulations. Their influence is 'unbalanced' because the primary level variables are not ranked together at the top, which shows a divergence in beliefs of the participants. The rank shows that the most influential variable is IMTA at the primary level, followed by Market, which is a secondary level variable (through IMTA). The next most influential variable is Participant, the auxiliary variable, which means that participants do not agree about the influence of the three primary level variables. With the exception of IMTA and Market, the results from the CPTs show that participants disagreed in most cases.

This is the authors' version of a paper with reference: Ellis, John; Tiller, Rachel (2019) Conceptualizing future scenarios of integrated multi-trophic aquaculture (IMTA) in the Norwegian salmon industry in Journal of Marine Policy. 201, 104, 198-209
The version of record is available at: https://doi.org/10.1016/j.marpol.2019.02.049

Table 3 here

At the primary level there are significant difference between variables, which means that the primary level variables do not have similar influence over the priority issue. Although the variance of belief for IMTA is 3x more than Fish Feed, Fish Feed nevertheless has the 3rd highest rank of all variables and therefore a high level of influence. However Rules And Regulation, the 3rd primary level variable, has little influence, which is consistent with the system thinking exercise and the discussion that IMTA regulations would take decades. Each primary level variable has more influence than their 3 respective secondary level variables, which is a 'normal' state and means that the participants agreed on the variables of influence. However, that does not mean that the Participants were in agreement on the amount of influence.

During the system thinking and BBN exercises participants reiterated that without a market there would be no IMTA, so it makes sense that at the secondary level the Market variable has a higher influence than the other two primary level variables, Fish Feed and Rules and Regulations. The other secondary level variable with influence on IMTA is Research Based Concessions, however the variance of belief of Market is significantly higher because selling IMTA products is paramount. Also at the secondary level, Research Funding and Industry Interest have a high influence on Fish Feed, which is consistent with the discussion in both the system thinking and BBN exercises about the need to develop new sustainable sources of marine ingredients for fish feed.

5.2.1 Group 2 Second Sensitivity Analysis: each individual participant
A second sensitivity analysis was performed for Group 2 because of the significant differences in influences at the primary and secondary level, and the significant divergence in beliefs of the participants. The second analysis tested the CPTs of each individual participant, and only allowed an observation of changes within a primary level variable and the corresponding secondary level variables. Our interest in the analysis was the convergence and divergence of the RMS (root mean square) of each participant.

The results of the second sensitivity analysis validate the importance of the Market variable (through IMTA at the primary level). Although individual participants converged for the Market variable, there was also a significant divergence between two groups of participants. These results highlight the debate during the exercises regarding the need for a financially sustainable market despite the high production costs. Participants also converged on Feed at the primary level and its 3 corresponding secondary level variables (Research Funding, Industry Interest, and Competence), which means participants agreed on their importance.

6. Conclusion

The Norwegian salmon industry is a political priority, however the growth of the industry has coincided with increased impacts to the marine environment and negative perceptions of salmon farming. Over a decade of research in Norway suggests that integrated multi-trophic aquaculture (IMTA) can mitigate some of the environmental impacts through waste recycling. While IMTA is one solution to the environmental challenges of the salmon aquaculture industry, namely those from excess nutrients (Soto 2009, Troell et al. 2009, Wang et al. 2012), and it can also be used as a strategy to counter negative perceptions (Barrington et al. 2010, Alexandera, Freeman, and Potts 2016), Norwegian regulations do not allow IMTA.

This article explored how advocates could advance IMTA regulations in Norway using agenda building to influence policymakers and agenda setting to sway public opinion. A participatory workshop was conducted to assess the future of IMTA in Norway, and participants were experts with a comprehensive understanding of the biological and technological processes of IMTA or salmon farming. The collaboration of researchers from different fields made use of the institutional memory of the experts and shed light on how IMTA could technically work in Norway. Two group exercises gave participants the opportunity to conceptualize IMTA in the Norwegian salmon industry, and results indicate that IMTA would improve perceptions of the industry, create skilled jobs in coastal communities, and provide the industry with new sustainable sources of marine ingredients for feed.

Agenda Building works through anticipating resistance and building coalitions, and advocates of IMTA could use the benefits of a regional system to build coalitions and appeal to industry as producers gain expertise in IMTA (Madison 2000). Although participants foresee a decades long process for regulating IMTA, regulations already exist for mussel and seaweed farms to be in the same region as salmon farms. In regional multi-trophic aquaculture (RMTA), the production of seaweed and mussels will take place within an area of many salmon farms, not at a specific farm site. While RMTA means reduced growths rates for seaweed and mussels compared to IMTA, it is a balanced ecosystem approach that will benefit a geographic region by improving the overall environmental impact from salmon farming. In addition, mussel and seaweed farms could be placed in areas that are not suitable for salmon farms. This approach may be the necessary first step in creating positive perceptions of multi-trophic aquaculture while generating political support (Vogel and Henstra 2015), which has proven successful for policy implementation in Norway (Aall 2012).

Participants identified developing new sustainable sources of marine ingredients for fish feed as another way to gain support for IMTA. Fish feed is already a challenge because traditional marine ingredients, such as fishmeal and fish oil, are in high demand and costs continue to rise. As a result, it has become standard to substitute some marine ingredients with lower cost agricultural products, such as soy. Feed is the largest cost in salmon farming by a significant factor, and access to feed may limit Norway's ability to reach production goals of 3 and 5 million tonnes by 2030 and 2050 respectively (Fiskeridirektoratet 2017, Olafsen et al. 2012, FAO 2016). IMTA farms could provide part of the solution to the feed issue by producing cultivated non-fed marine ingredients, such as aquatic plants and small mussels. The benefits to Norway would include the ability to produce new sustainable sources of marine ingredients for fish feed and creating new jobs in coastal communities that require specific competence and expertise.

IMTA is one solution that Norwegian farms will use in the future, and advocates of IMTA in Norway have a better chance of advancing their agenda through agenda building and agenda setting. While decision makers have their own agenda, improving environmental impacts from salmon farming is a challenge for all stakeholders. By changing regulations to allow IMTA in Norway, policy makers could create overlapping benefits for Norway, coastal communities, and the salmon industry. Norway and coastal communities would see an increase in jobs and business opportunities, and an improved marine environment. Norway and the salmon industry would benefit from producing marine ingredients for fish feed and increasing exports. Finally, coastal communities and the salmon industry would benefit by allowing growth only after a region maintains production levels of IMTA products and has fixed the region by controlling sea lice, disease, pesticide use, and escapes. Future research on IMTA in Norway should include a cross-sectional survey of the Norwegian public to understand their attitudes toward the salmon industry, and how allowing IMTA affects their attitudes.

7. Acknowledgements

This research was funded by the Norwegian Research Council through the EXPLOIT project (RCN 216201). Special thanks to Aleksander Handå, Project Leader of EXPLOIT, and Jennifer Bailey, Advisor SINTEF Ocean AS for the opportunity to work on the EXPLOIT project.
The Gemini Center for Sustainable Fisheries (NTNU/SINTEF) is also acknowledged for funding the workshop.

8. REFERENCES

Aall, Carlo. 2012. "The early experiences of local climate change adaptation in Norwegian compared with that of local environmental policy, Local Agenda 21 and local climate change mitigation." *Local Environment* 17 (6-7):579-595.

Aarset, Bernt. 1997. "Norwegian salmon-farming industry in transition: dislocation of decision control." *Ocean & Coastal Management* 38:187-206.

Aarset, Bernt, and Stig-Erik Jakobsen. 2009. "Political regulation and radical institutional change: The case of aquaculture in Norway." *Marine Policy* 33:280-287.

Aguilera, P.A., A. Fernández, R. Fernández, R. Rumí, and A. Salmerón. 2011. "Bayesian networks in environmental modelling." *Environmental Modelling & Software* 26:1376-1388.

Alexandera, K.A., S. Freeman, and T. Potts. 2016. "Navigating uncertain waters: European public perceptions of integrated multi trophic aquaculture (IMTA)." *Environmental Science & Policy* 61:230-237.

Amberg, Shannon M., and Troy E. Hall. 2008. "Communicating Risks and Benefits of Aquaculture: A Content Analysis of US Newsprint Representations of Farmed Salmon." *Journal of the World Aquaculture Society* 39 (2):143–157.

Asche, Frank, and Trond Bjørndal. 2011. *The Economics of Salmon Aquaculture*: Wiley-Blackwell.

Barnes, Michael D., Carl L. Hanson, Len MB Novilla, Aaron T. Meacham, Emily McIntyre, and Brittany C. Erickson. 2008. "Analysis of media agenda setting during and after Hurricane Katrina: Implications for emergency preparedness, disaster response, and disaster policy." *American Journal of Public Health* 98 (4):604-610.

Barrington, K., N. Ridler, T. Chopin, S. Robinson, and B Robinson. 2010. "Social aspects of the sustainability of integrated multi-trophic aquaculture." *Aquaculture international* 18:201-211.

Biernacki, Patrick, and Dan Waldorf. 1981. "Snowball Sampling: Problems and Techniques of Chain Referral Sampling." *Sociological Methods & Research* 10 (2):141-163. doi: 10.1177/004912418101000205.

Birkland, Thomas A. 1998. "Focusing Events, Mobilization, and Agenda Setting." *Journal of public policy* 18 (01):53-74.

Braat, Leon C., and Rudolf de Groot. 2012. "The ecosystem services agenda:bridging the worlds of natural science and economics, conservation and development, and public and private policy." *Ecosystem Services* 1 (1):4-15.

Braaten, Bjørn R., and Asbjørn Bergheim. 2007. "Cage aquaculture and environmental impacts." *Aquacultural Engineering and Environment*:49-91.

Broch, OJ, Ellingsen I, Forbord S, Wang X, Volent Z, Alver MO, Handå A, Andresen K, Slagstad D, KI Reita, Olsen Y, and Skjermo J. 2013. "Modelling the cultivation and bioremediation potential of the kelp Saccharina latissima in close proximity to an exposed salmon farm in Norway." *Aquaculture Environment Interactions* 4:187-206.

Brown, Noel, and Craig Deegan. 1998. "The public disclosure of environmental performance information—a dual test of media agenda setting theory and legitimacy theory." *Accounting and business research* 29 (1):21-41.

Buschmann, A. H., S. Prescott, P. Potin, S. Faugeron, J. A. Vásquez, C. Camus, J. Infante, M. C. Hernández-González, A. Gutíerrez, and D. A. Varela. 2014. "The Status of Kelp Exploitation and Marine Agronomy, with Emphasis on Macrocystis pyrifera, in Chile." In *Advances in Botanical Research: Sea Plants*, edited by Nathalie Bourgougnon, 161-188. Academic Press, Elsevier Ltd.

Buschmann, A.H., M. Troell, and N Kautsky. 2001. "Integrated algal farming: a review." *Cahiers De Biologie Marine* 42 (1):83-90.

Buschmann, Alejandro H, Felipe Cabello, Kyle Young, Juan Carvajal, Daniel A Varela, and Luis Henríquez. 2009. "Salmon aquaculture and coastal ecosystem health in Chile: analysis of regulations, environmental impacts and bioremediation systems." *Ocean & Coastal Management* 52 (5):243-249.

Chopin, T., A.H. Buschmann, C. Halling, M. Troell, N. Kautsky, A. Neori, G.P. Kraemer, J.A. Zertuche-Gonzalez, C. Yarish, and C Neefus. 2001. "Integrating seaweeds into marine aquaculture systems: A key toward sustainability." *Journal of Phycology* 39:975-986.

Christiansen, Erling A.N., and Stig-Erik Jakobsen. 2017. "Diversity in narratives to green the Norwegian salmon farming industry." *Marine Policy* 75:156-164.

Cobb, Roger, Jennie-Keith Ross, and Marc Howard Ross. 1976. "Agenda Building as a Comparative Political Process." *The American Political Science Review* 70 (1):126-138.

Curtin, Patricia A., and Eric Rhodenbaugh. 2001. "Building the news media agenda on the environment: a comparison of public relations and journalistic sources." *Public Relations Review* 27 ( ):179-195.

Denham, Bryan E. 2004. "Sports Illustrated, the mainstream press and the enactment of drug policy in Major League Baseball A study in agenda-building theory." *Journalism* 5 (1):51-68.

FAO. 2016. The State of the World Fisheries and Aquaculture 2016. edited by Food and Agriculture Organization of the United Nations FAO Fisheries and Aquaculture Department, Rome.

Fiskeridirektoratet. 2017. Key figures from the Norwegian aquaculture industry 2016.

Haeuber, Richard. 1996. "Setting the environmental policy agenda: The case of ecosystem management." *Natural Resources Journal* 36 (1):1-28.

Handå A, Forbord S, Wang X, Broch OJ, Dahle SW, Størseth TR, Reitan KI, Olsen Y, and Skjermo J. 2013. "Seasonal- and depth-dependent growth of cultivated kelp (Saccharina latissima) in close proximity to salmon (Salmo salar) aquaculture in Norway." *Aquaculture* 414-415:191-201.

Handå A, Ranheim A, Olsen AJ, Altin D, Reitan KI, Olsen Y, and Reinertsen H. 2012. "Incorporation of salmon fish feed and faeces components in mussels (Mytilus edulis): implications for integrated multi-trophic aquaculture in cool-temperate North Atlantic waters." *Aquaculture* 370-371:40-53.

Handå, Aleksander., Hojune Min, Xinxin Wang, Ole Jacob Broch, Kjell Inge Reitan, Helge Reinertsen, and Yngvar Olsen. 2012. "Incorporation of fish feed and growth of blue mussels (Mytilus edulis) in close proximity to salmon (Salmo salar) aquaculture: Implications for integrated multi-trophic aquaculture in Norwegian coastal waters." *Aquaculture* 356-357:328-341.

Hardoy, Jorge Enrique, Diana Mitlin, and David Satterthwaite. 1992. *Environmental problems in Third World cities*.

Hersoug, Bjørn. 2015. "The greening of Norwegian salmon production." *Maritime Studies* 14:16:19. doi: 10.1186/s40152-015-0034-9.

Hogarth, Robin M. 1978. "A Note on Aggregating Opinions." *Organizational Behavior and Human Performance* 21:40-46.

Holdt, Susan L., and Maeve D. Edwards. 2014. "Cost-effective IMTA: a comparison of the production efficiencies of mussels and seaweed." *Journal of Applied Phycology* 26:933-945.

Kamieniecki, Sheldon. 1991. "Political Mobilization, Agenda Building and International Environmental Policy." *Journal of International Affairs* 44 (2):339-358.

Kepplinger, Hans Mathias. 2008. *18 Effects of the News Media on Public Opinion. The SAGE Handbook of Public Opinion Research. SAGE Publications Ltd*. London: SAGE Publications Ltd.

Leonczek, Annelise. 2013. Traditional and Integrated Aquaculture. Bellona Foundation.

Lerøy Seafood Group. 2015. Environmental Report 2015.

Liu, Y., J. O. Olaussen, and A. Skonhoft. 2014. "Fishy fish? The economic impacts of escaped farmed fish." *Aquaculture Economics & Management* 18 (3):273-302.

Liu, Yajie, Jon Olaf Olaussen, and Anders Skonhoft. 2011. "Wild and farmed salmon in Norway—A review." *Marine Policy* 35 (3):413-418.

Lodhia, Sumit, and Nigel Martin. 2011. "Stakeholder responses to the National Greenhouse and Energy Reporting Act: An agenda setting perspective." *Accounting, Auditing & Accountability Journal* 25 (1):126-145.

Madison, John. 2000. "Agenda-Building and Big Science." *Policy Sciences* 33:31-53.

Mannes, Albert E., Jack B. Soll, and Richard P. Larrick. 2014. "The Wisdom of Select Crowds." *Journal of Personality and Social Psychology* 107 (2):276-299.

Marine Harvest. 2017. "Salmon Farming Industry Handbook 2017."

McCombs, M. 2013. *Setting the Agenda: The Mass Media and Public Opinion*: Wiley.

Mendes, Wendy. 2008. "Implementing Social and Environmental Policies in Cities: The Case of Food Policy in Vancouver, Canada." *International Journal of Urban and Regional Research*:942-967.

Mente, Eleni, Graham J. Pierce, Maria Begoña Santos, and Christos Neofitou. 2006. "Effect of feed and feeding in the culture of salmonids on the marine aquatic environment: a synthesis for European aquaculture." *Aquaculture International* 14 (5):499-522.

National Academy of Sciences. 1969. "Introduction, summary, and recommendations." In *Eutrophication--Causes, consequences, correctives*, edited by National Academy of Sciences. Washington, D.C.

Neori, Amir, Max Troell, Thierry Chopin, Charles Yarish, Alan Critchley, and Alejandro H. Buschmann. 2007. "The need for a balanced ecosystem approach to blue revolution aquaculture." *Environment* 49 (3):37-43.

Norwegian Seafood Federation. 2018. accessed October 4. https://sjomatnorge.no/norwegian-seafood-federation/.

Olafsen, Trude, Ulf Winther, Yngvar Olsen, and Jorunn Skjermo. 2012. Value created from productive oceans in 2050. edited by Trude Olafsen: SINTEF Fisheries and Aquaculture.

Olaussen, Jon Olaf, and Yajie Liu. 2011. "On the willingness-to-pay for recreational fishing - escaped farmed versus wild Atlantic salmon." *Aquaculture Economics & Management* 15 (4):245–261.

Olsen, Marit Schei, and Tonje Cecilie Osmundsen. 2017. "Media framing of aquaculture." *Marine Policy* 76:19-27.

Osmundsen, Tonje C., Petter Almklov, and Ragnar Tveterås. 2017. "Fish farmers and regulators coping with the wickedness of aquaculture." *Aquaculture Economics & Management*:21.

Osmundsen, Tonje C., and Marit Schei. Olsen. 2017. "The imperishable controversy over aquaculture." *Marine Policy* 76:136-142.

Porter, Michael. 1990. "The Competitive Advantage of Nations." *Harvard Business Review* March-April.

Price, Carol, Kenneth D. Black, Barry T. Hargrave, and James A. Morris Jr. 2015. "Marine cage culture and the environment: effects on water quality and primary production." *Aquaculture Environment Interactions* 6:151-174.

Richards, R., M. Sanó., A. Roiko, R.W. Carter, M. Bussey, J. Matthews, and T.F. Smith. 2013. "Bayesian belief modeling of climate change impacts for informing regional adaptation options." *Environmental Modelling & Software* 44:113-121.

Richardsen, Roger, Heidi Bull-Berg, and Inger Lise T. Grindvoll. 2016. Nasjonal betydning av sjømatnæringen: En verdiskapings- og ringvirkningsanalyse med data fra 2015 og 2016 (National Importance of the Seafood Industry: A Value Creation- and Ripple Effect analysis with data from 2015 and 2016). edited by SINTEF Ocean.

Ridler, N., M. Wowchuk, B. Robinson, K. Barrington, T. Chopin, S. Robinson, F. Page, G. Reid, M. Szemerda, J. Sewuster, and S. Boyne-Travis. 2007. "Integrated multi-trophic aquaculture (IMTA): a potential strategic choice for farmers." *Aquaculture Economics & Management* 11:1,:99–110.

Ross, Lester. 1992. *Environmental policy in China*.

Salgado, Hugo, Jennifer Bailey, Rachel Tiller, and John Ellis. 2015. "Stakeholder perceptions of the impacts from salmon aquaculture in the Chilean Patagonia." *Ocean & Coastal Management* 118 (Part B):189-204.

Smith, Jackie, John D. McCarthy, Clark McPhail, and Boguslaw Augustyn. 2001. "From Protest to Agenda Building: Description Bias in Media Coverage of Protest Events in Washington, D.C." *Social Forces* 79 (4):1397-1423.

Smith, Mark P. 2009. "Finding Common Ground: How Advocacy Coalitions Succeed in Protecting Environmental Flows." *Journal of the American Water Resources Association (JAWRA)* 45 (5):1100-1115.

Soto, Doris. 2009. Integrated mariculture: a global review. edited by Food and Agriculture Organization of the United Nations (FAO).

Statistics Norway. 1995. Historical Statistics 1994. edited by Division for Primary Industry Statistics.

Statistics Norway. 1997. Rearing of Fish 1993-1994. edited by Division for Primary Industry Statistics.

Statistics Norway. 2005. Fish Farming 2002. edited by Division for Primary Industry Statistics.

Statistics Norway. 2008. Aquaculture 2006. edited by Division for Primary Industry Statistics.

Surowiecki, James. 2004. *The wisdom of crowds: Why the many are smarter than the few and how collective wisdom shapes business, economies, societies, and nations.* New York, NY, US: Doubleday & Co.

Tiller, R., R. Richards, H. Salgado, H. Strand, E. Moe, and J Ellis. 2014. "Assessing Stakeholder Adaptive Capacity to Salmon Aquaculture in Norway." *Consilience: The Journal of Sustainable Development* 11 (1):62-96.

Tiller, Rachel, Tove Brekken, and Jennifer Bailey. 2012. "Norwegian aquaculture expansion and Integrated Coastal Zone Management (ICZM): simmering conflicts and competing claims." *Marine Policy* 36 (5):1086-1095.

Tiller, Rachel G., Yngve Svalestuen, Pinar Öztürk, and Axel Tidemann. 2015. "Simulating Stakeholder Behavior in a Marine Setting: Integrated Coastal Zone Planning and the Influential Power of Selected Stakeholders in Frøya, Norway." *Frontiers in Marine Science* 2 (90).

Tiller, Rachel, Rebecca Gentry, and Russell Richards. 2013. "Stakeholder driven future scenarios as an element of interdisciplinary management tools; the case of future offshore aquaculture development and the potential effects on fishermen in Santa Barbara, California." *Ocean & Coastal Management* 73:127-135. doi: https://doi.org/10.1016/j.ocecoaman.2012.12.011.

Tiller, Rachel Gjelsvik , Lillian Hansen, Russell Richards, and Hillevi Strand. 2015. "Work segmentation in the Norwegian salmon industry: The application of segmented labor market theory to work migrants on the island community of Frøya, Norway." *Marine Policy* 51:563-572.

Tiller, Rachel, and Russell Richards. 2015. "Once bitten, twice shy: Aquaculture, stakeholder adaptive capacity, and policy implications of iterative stakeholder workshops; the case of Frøya, Norway." *Ocean & Coastal Management* 118:98-109.

Tiller, Rachel, and Russell Richards. 2018. "Ocean futures: Exploring stakeholders' perceptions of adaptive capacity to changing marine environments in Northern Norway." *Marine Policy*:12.

Troell, M., C. Halling, A. Neori, T. Chopin, A.H. Buschmann, N. Kautsky, and C Yarish. 2003. "Integrated mariculture: asking the right questions." *Aquaculture* 266 (1-4):69-90.

Troell, Max, Alyssa Joyce, Thierry Chopin, Amir Neori, Alejandro H. Buschmann, and Jian-Guang Fang. 2009. "Ecological engineering in aquaculture — Potential for integrated multi-trophic aquaculture (IMTA) in marine offshore systems." *Aquaculture* 297 (1-4):1-9.

Vogel, Brennan, and Daniel Henstra. 2015. "Studying local climate adaptation: A heuristic research framework for comparative policy analysis." *Global Environmental Change* 31:110-120.

Wang, X, Andresen K, Handå A, Jensen B, Reitan KI, and Olsen Y. 2013. "Chemical composition of feed, fish and faeces as input to mass balance estimation of biogenic waste discharge from an Atlantic salmon farm with an evaluation of IMTA feasibility." *Aquaculture Environment Interactions* 4:147-162.

Wang, Xinxin, Lasse Mork Olsen, Kjell Inge Reitan, and Yngvar Olsen. 2012. "Discharge of nutrient wastes from salmon farms: environmental effects, and potential for integrated multi-trophic aquaculture." *Aquaculture Environment Interactions* 2:267-283.

Wang, Xinxin, Ole Jacob Broch, Silje Forbord, Aleksander Handå, Jorunn Skjermo, Kjell Inge Reitan, Olav Vadstein, and Yngvar Olsen. 2014. "Assimilation of inorganic nutrients from salmon (Salmo salar) farming by the macroalgae (Saccharina latissima) in an exposed coastal environment: implications for integrated multi-trophic aquaculture." *Journal of Applied Phycology* 26 (4):1869-1878.

Yetton, Philip W., and Preston C. Bottger. 1982. "Individual Versus Group Problem Solving: An Empirical Test of a Best-Member Strategy." *Organizational Behavior and Human Performance* 29:307-321.