Key players in the Grieg NL Placentia Bay Atlantic Salmon Aquaculture Project: a social network analysis

By

Ryan J. Maxwell

Submitted in partial fulfillment of the requirements for the degree
of
Master of Marine Management

at

Dalhousie University
Halifax, Nova Scotia

December 2018

Table of Contents

Abstract

Maxwell, R. 2018. Key players in the Grieg NL Placentia Bay Atlantic Salmon Aquaculture Project: a social network analysis [graduate project]. Halifax, NS: Dalhousie University.

Global aquaculture is one of the fastest growing food industries, accounting for approximately half of all finfish and invertebrate production as of 2016. In Canada, both the federal and provincial governments are pushing strongly for the development of the industry, which creates a problem in that governments are both regulators and promoters of the industry. In Newfoundland (NL), a recent aquaculture development, the Grieg NL Placentia Bay Atlantic Salmon Aquaculture Project, was controversial due to the waiving of an environmental impact assessment (EIA) by the NL Government, resulting in a court case. Here, the Grieg NL case was studied to understand how stakeholders operate in salmon aquaculture developments, specifically when governments waive critical procedures such as EIAs. A social network analysis was accompanied by open-ended questions to identify key players associated with the Project and their underlying motivations. The results indicated that ENGOs and aquaculture industry were the two key stakeholder groups with opposing views on the Project, the former being opposed to the Project and the latter being supportive of the Project. The four underlying motivations from the open-ended questions included: (1) social and economic benefits associated with the Project, (2) farmed salmon as healthy/unhealthy food, (3) environmental concerns, and (4) government regulation. This study highlights the growing importance of the term social licence to operate (SLO) in aquaculture developments, and stresses the practicality of using social network analysis and open-ended questions to better understand the different stakeholders that are involved in the granting/withholding of SLOs.

List of tables

List of figures

List of abbreviations

ASF	Atlantic Salmon Federation
BK	Bacterial Kidney Disease
BMA	Bay Management Area
BP	Burin Peninsula
CSAS	Canadian Science Advisory Secretariat
DFO	Fisheries and Oceans Canada
EA	Environmental Assessment
EIA	Environmental Impact Assessment
E-I	External-internal
EIS	Environmental Impact Statement
ENGOs	Environmental Non-governmental Organizations
FFAW	Fish, Food and Allied Workers Union
MAPERSC	Marine Affairs Program Ethics Review Standing Committee
MPT	Marine Protection Tasmania
MOU	Memorandum of Understanding
NAIA	Newfoundland Aquaculture Industry Association
NL	Newfoundland
NL-CAR	Newfoundland Coalition for Aquaculture Reform
NLDFLR	Newfoundland Department of Fisheries and Land Resources
NLDMAE	Newfoundland Department of Municipal Affairs and Environment
PB	Placentia Bay
SAEN	Salmonid Association of Eastern Newfoundland
SCNL	Salmonid Council of Newfoundland
SLO	Social Licence to Operate
SNA	Social network analysis
VOCM	Voice of the Common Man

Chapter 1 – Introduction

1.1 – Overview of management problem

Global aquaculture is one of the fastest growing food industries, accounting for approximately 47% of all finfish and invertebrate production and 97% of the total seaweed production as of 2016 (FAO, 2018). In fact, combined global aquaculture production surpassed wild capture fisheries production in 2013 (FAO, 2016). The vast majority of aquaculture products are produced in Asia, representing 92% of global production in 2016 (FAO, 2018). The rest of the production comes from the Americas and Europe, which represented 3% each, and Africa, producing 2% of total global aquaculture in 2016. Although the aquaculture industry continues to grow, expansion has slowed in recent years. For instance, the average annual growth rate of aquaculture production tonnage from 2013-2016 was 4.3%, representing a decrease compared to 2000-2012 where the average annual growth rate was 6.7% (FAO, 2018).

Aquaculture can be divided into three general sectors, based off the species cultivated: finfish, shellfish and seaweeds (Neori et al., 2004). In Canada, the finfish sector is dominant, the shellfish sector is strong, and the seaweed sector is growing (Chopin, 2015). In Atlantic Canada, finfish aquaculture has a brief history, but has much potential due to the natural advantages that Atlantic Canada offers, including a large coastline, abundance of cold and clean water, favorable climate, rich marine and fishery tradition, established trade relationships with the United States, Asia, and Europe, and a commitment to sustainable and responsible practices (Chopin, 2015).

In Atlantic Canada, salmon farming represented 98% of all finfish aquaculture production at 33 011 tonnes in 2016, but production has been volatile since farmed salmon production peaked at 42 121 tonnes in 2002 (Figure 1). In 2010, DFO estimated that Canada's aquaculture production would double by 2020 (Surprenant, 2010), but Canada is not on track to meeting this estimation, which could be driven by competing uses in the marine environment and a need to better understand disease and carrying capacity for aquaculture (Bostock et al., 2010). Nevertheless, both the Canadian federal government and provincial governments in Atlantic Canada are pushing strongly for the development of the industry. For instance, strategic development plans such as "The Way Forward" policy in NL (Government of NL and Labrador, 2016), and the New Brunswick Finfish Aquaculture Development Strategy (Province of New Brunswick, 2010) have been implemented to grow the aquaculture industry.

This provincial governmental push for aquaculture development, especially in NL and New Brunswick, does not coincide with DFO's position on aquaculture development at the national level, as highlighted in a report by the Commissioner of the Environment and Sustainable Development, Julie Gelfand in April 2018 (The Globe and Mail, 2018). The report suggested that the Canadian Government is not adequately addressing the risks to wild stocks associated with salmon farming (Office of the Auditor General of Canada, 2018). Gelfand stated in a press conference that "the department [DFO] is at risk of being seen to be promoting aquaculture over the protection of wild fish". Hence, management of the Canadian salmon aquaculture industry requires acknowledging conflicting views from various stakeholders (e.g., ENGOs, government, communities, academia, industry, etc.; Figure 2).

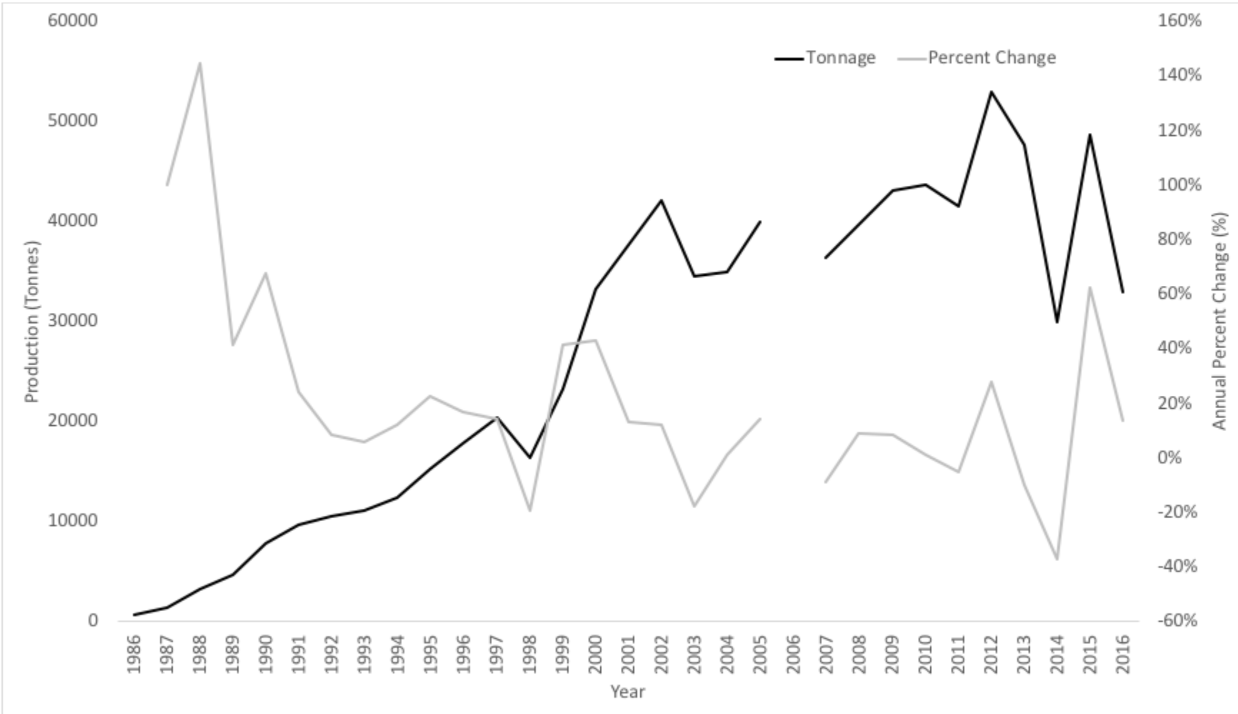

Figure 1. Atlantic Canada Atlantic salmon aquaculture production in tonnage by year and the annual rate of change from 1986-2016. Note that DFO did not report production in 2006 because it was considered "confidential data at Canada level". Newfoundland and Labrador data was only available from 2005-2015. Reproduced from DFO and NLDFLR data (DFO, 2018a; NLDFLR, 2018a).

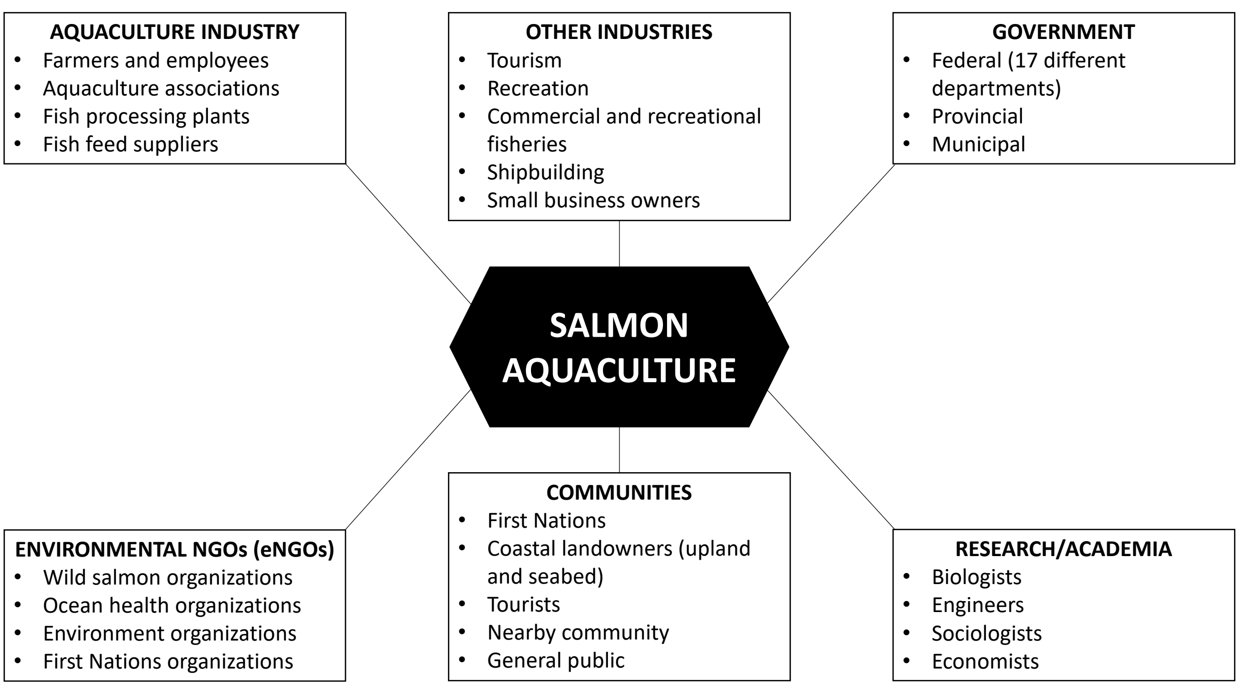

Figure 2. Stakeholders associated with salmon aquaculture. Modified from Hutchinson (2006).

1.2 – Background on study site: Placentia Bay, Newfoundland and Labrador (NL)

Newfoundland and Labrador is a Canadian coastal province located in the Northwest Atlantic Ocean (Figure 3). With a coastline length of 243 797 km, Canada has the longest coastline in the world (Ricketts & Harrison, 2007), and Newfoundland and Labrador has the longest coastline of any Canadian province at nearly 29 000 km (Pariona, 2017). As such, Newfoundland and Labrador presents an opportunity for the development of salmon aquaculture, especially along the south coast where there are several unique long narrow inlets that offer protection from rigorous sea ice travelling with the Labrador Current (Figure 3; Rigby et al., 2017), and preferable temperatures for the rearing of Atlantic salmon (Narayanan et al., 1995).

Figure 3. Map of Newfoundland, Canada, showing the several long narrow inlets along the south coast.

Placentia Bay (PB) is one of these inlets on the south coast of Newfoundland (NL). The western portion of the Bay is bordered by the Burin Peninsula (BP), which has had a population decline of 18% since 2001 (NL Statistics Agency, 2018). In fact, several rural areas in

Newfoundland and Labrador have observed population declines, as the only region in Newfoundland and Labrador with a steady increase in population since 2001 was the capital region of NL, St. John's (NL Statistics Agency, 2018). The growth of the aquaculture industry along the south coast of NL has been proposed as one way to promote rural economic development in coastal NL communities (NLDFLR, 2018b). In 2016, the NL aquaculture industry provided employment for approximately 425 people directly, and set a NL record at $276 million (28 600 tonnes) in production value for all species combined (Government of NL and Labrador, 2017). These values have since declined (DFO, 2018a), and the NL Government is committed to growing the industry once again to support social and economic development in rural communities (Kinsella, 2017). In fact, the NL Government released "The Way Forward" policy in 2016 that aims to support the aquaculture industry in growing its production to 50 000 metric tonnes annually for salmon, and 10 750 metric tonnes annually for mussels (Government of Newfoundland and Labrador, 2016).

The governance structure and regulatory framework for aquaculture in NL includes mainly federal and provincial levels of government (Figure 4). A memorandum of understanding (MOU) between the federal (DFO) and provincial government (once the NL Department of Fisheries and Aquaculture, but currently the NL Department of Fisheries, Forestry and Agrifoods [DFFA]) was signed in 1988 (AMEC Earth and Environmental Ltd., 2002). The MOU established the areas of responsibility of each government and provided co-operative joint participation in the management of the aquaculture industry while respecting the constitutional jurisdictions of the provincial and federal governments. Areas that were outlined in the MOU include regulatory, compliance and inspection, planning, applied research and development, stock registry, education and training, statistics, and coordination (AMEC Earth and Environmental Ltd., 2002). For licencing and regulation of aquaculture in NL, the MOU established that the Government of NL would be the lead agency under the *Aquaculture Act*, with advice and recommendations provided from other federal and provincial departments and agencies.

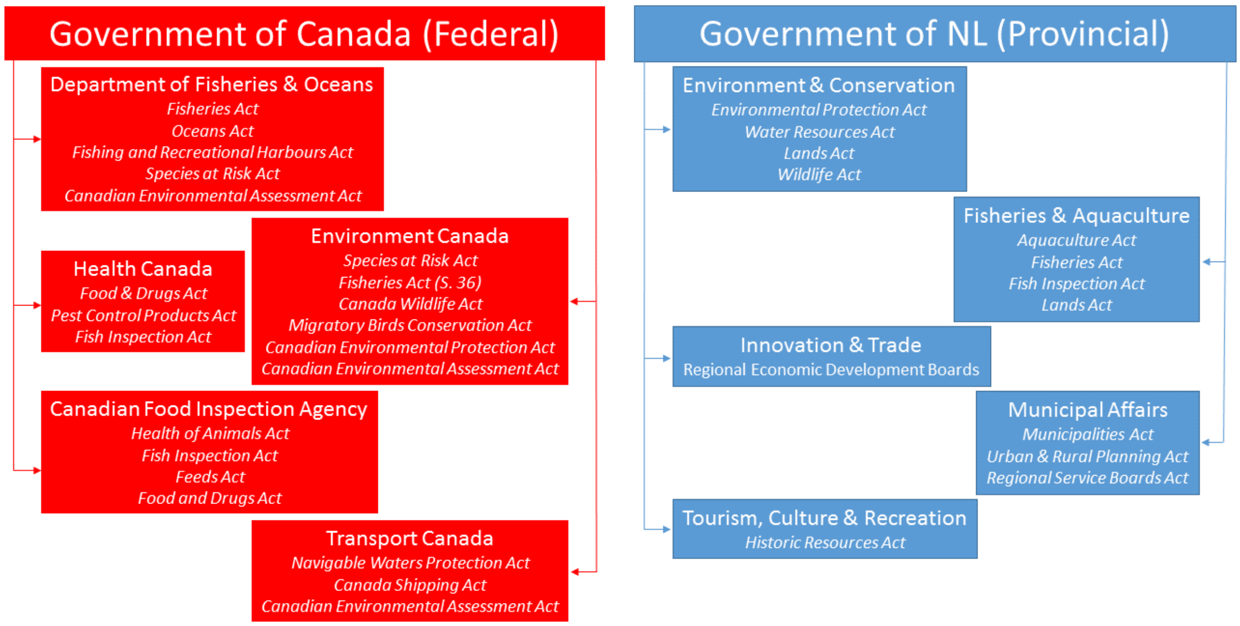

Figure 4. Government regulatory framework for aquaculture management in NL.

1.3 – Overview of case study: PB Atlantic Salmon Aquaculture Project

In early 2018, Grieg Seafood®, a Norwegian Atlantic salmon aquaculture company, partnered with Ocean Choice International, a 100% NL owned fish processing company, to grow salmon in Placentia Bay (PB) (Grieg NL, 2016a). The outcome of this partnership, Grieg NL, is divided into two separate operations: Grieg NL Seafarms Ltd. and Grieg Nurseries NL Ltd. based in PB and Marystown, respectively. Grieg NL proposed to establish themselves into the NL Atlantic salmon aquaculture industry by introducing 11 open net-pen sea farms in PB (Grieg NL, 2016b). In Canada, Norway and Chile, open net-pen aquaculture systems are the salmon farming industry's preferred technology for the grow-out phase of operations (Liu, Rosten, Henriksen, Hognes, Summerfelt, & Vinci, 2016). Grieg's proposed plan, called the PB Atlantic

Salmon Aquaculture Project (herein referred to as the Project), although in line with NL provincial government aspirations, has been highly controversial.

On January 21, 2016, Grieg NL submitted a proposal to the NL Department of Environment and Conservation, including a description of both the sea cage operations in PB and hatchery operations in Marystown, as well as a third stage associated with the processing facility (*ASF (Canada) v. NL (Environment and Conservation)*, 2017). The processing facility stage was controversial, as both Eric Watton, an environmental scientist, and Justin Mellor, with the NL Department of Justice, recommended that the processing facility be included as part of the undertaking under section 29 of the *Environmental Assessment Regulations* (herein referred to as the *Regulations*). Section 29 mandates that aquaculture projects be registered (NLDMAE, 2003), and the processing phase was considered part of the aquaculture operations. However, on February 19, 2016, Registration 1834 was given by the then-NL Minister of the Environment and Conservation, Honourable Perry Trimper, for the hatchery and marine-based farm without description of the processing facility.

Between February 23 and April 26, 2016, the Project proposal was released for public comment where residents and interested groups submitted over 200 negative comments to the NL Minister of Environment and Conservation (*ASF (Canada) v. NL (Environment and Conservation)*, 2017). Between May 19 and July 21, 2016, comments were also received from provincial interdepartmental and federal agencies. These comments were summarized comprehensively in a document by environmental scientist Eric Watton on July 22, 2016, in which he recommended that the Project should undergo an environmental impact statement (EIS) pursuant to Section 25 of the *Regulations*. On the same date, the Assistant Deputy Minister, Martin Goebel, released a separate memorandum, recommending that the Minister release the Project subject to conditions. On July 22, 2016, the Minister announced his decision (herein referred to as Release Decision) to release the project from further environmental assessment subject to five conditions:

1. Only triploid Atlantic salmon are to be used.
2. The NL Department of Environment and Conservation acknowledges and supports the recommendation by the Canadian Science Advisory Secretariat (CSAS) Report, regarding the use of all-female triploid Atlantic salmon (CSAS, 2016). The Department will require an annual progress report regarding the phased approach from using mixed sex triploids to the use of all female triploids.
3. Prior to the commencement of construction, the proponent (i.e., Grieg NL) must submit to the Department of Advanced Education and Skills additional information on workforce and timelines for the Project.
4. Prior to the commencement of construction, the proponent must submit a Women's Employment Plan for the Project to the Women's Policy Office that meets the approval of the Deputy Minister.
5. Prior to the commencement of construction, the proponent must submit to Health Canada an inventory of all regulated substances that are intended to be used for the Project.

After the Release Decision was publicized, the Atlantic Salmon Federation (ASF) appealed the Minister's decision on August 31, 2016 pursuant to Section 107 of the *Environmental Protection Act* (herein referred to as the Act). The Minister upheld his Release Decision on September 30, 2016. On October 13, 2016, the ASF filed an Originating Application 201601G6118 to the courts to quash both the decision to allow the registration of the Project without the processing plant being described, and the Minister's Release Decision (*ASF (Canada) v. NL (Environment and Conservation)*, 2017). A separate Originating Application 201601G4856 was filed by a lawyer, Owen Myers, on behalf of the public on August 16, 2016. On December 8, 2016, it was ordered that both 201601G6118 and 201601G4856 would be heard simultaneously with evidence from one being evidence in the other.

The case was heard in court on March 30 and 31, 2017 and April 17 and 18, 2017. On July 20, 2017, Supreme Court Justice Gillian Butler ruled that the NL Government should not have released the project from additional environmental assessment; she ruled that an EIA must be performed in full. On August 4, 2017, the provincial government announced that they would appeal the Supreme Court decision. In the appeal, the NL Government argued that the Minister's decision was reasonable because any environmental risk would be protected by Fisheries and Oceans Canada (DFO) or existing provincial regulations (CBC, 2017a). The ASF applauded Butler's decision, as they were of the opinion that the Minister lacked jurisdiction to release the Project in the light of public concerns associated with the Project and potential for significant environmental effects. As of November 26, 2018, the Court has not released the decision on the appeal.

On November 9, 2017, then-NL Minister of Municipal Affairs and the Environment (i.e., formerly known as Minister of Environment and Conservation), Honourable Eddie Joyce, announced that Grieg NL would be required to provide an environmental impact statement (EIS) as part of their EIA (NLDMAE, 2018a). The EA Committee was appointed on November 22, 2017 by the Minister and included a representative from various federal and provincial government departments (Box 1).

Box 1. Members of the EA Committee as appointed by the NL Minister of Municipal Affairs and Environment, Honourable Eddie Joyce on November 22, 2017 (NLDMAE, 2017).

NLDMAE • Environmental Assessment Division • Pollution Prevention Division • Water Resources Management Division
NLDFLR • Aquaculture Development Division • Aquatic Animal Health Division • Forestry and Wildlife Branch
Tourism Product Development within the Department of Tourism, Culture, Industry and Innovation
Fisheries and Oceans Canada
Environment and Climate Change Canada
Health Canada

On January 2, 2018, the draft EIS Guidelines were released by the Committee for public review; comments were due on February 11, 2018 (NLDMAE, 2018a). The EIS Guidelines were approved on March 8, 2018, and were given to the proponent. Grieg NL held their main public consultation meeting as part of their EIS on March 13, 2018 in Marystown, NL with footage being displayed in St. John’s, Corner Brook and Gander as well. Various concerns were mentioned by the public at the meeting ranging from sea ice to disease to escapes (CBC, 2018a). On May 22, 2018, the proponent submitted their EIS to the NLDMAE, attempting to address these concerns (NLDMAE, 2018a). Public comments on the EIS were invited until July 25, 2018. On August 28, 2018, the acting NLDMAE, Honourable Andrew Parsons, determined that the EIS was acceptable. On September 6, 2018, the Minister announced for a second time that the Project was released from further EA, subject to 15 conditions (NLDMAE, 2018b).

The process (Figure 5) associated with the PB Atlantic Salmon Aquaculture Project is unprecedented in NL in terms of the court case that was filed against the NL Government. In late September 2018, Grieg NL started the construction phase of the hatchery in Marystown (The Telegram, 2018a). As such, there were nearly three years of key events that stalled the Project from when it was initially submitted to the Province of NL in January 2016.

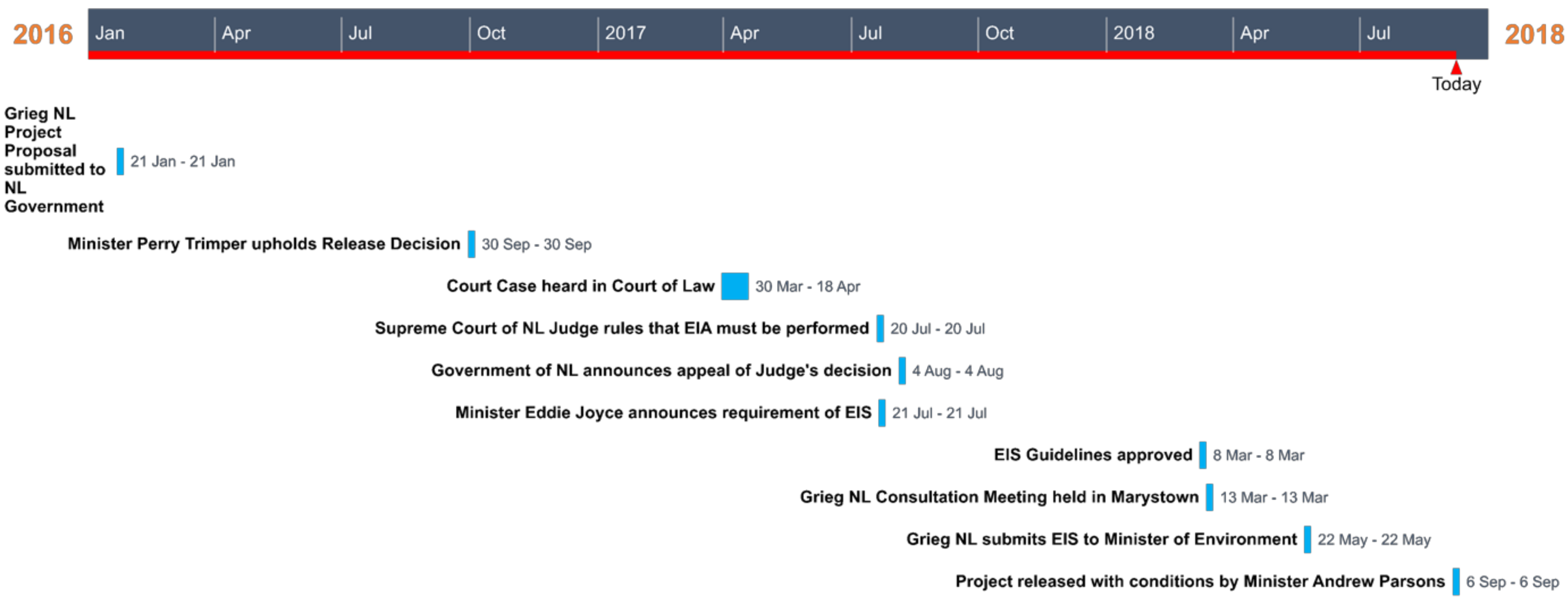

Figure 5. Timeline of key events throughout the Grieg NL EIS and court case process.

1.4 – Research objectives

Newfoundland and Labrador, a province on the coast of Atlantic Canada, is an area that has potential for increased salmon aquaculture production for a variety of reasons such as the presence of several fjord-like systems suitable for salmon aquaculture, and preferable water temperatures (Rigby et al., 2017; Narayanan et al., 1995). In a historic project proposal submitted to the NLDMAE in early 2016, Grieg NL proposed a development of 11 open net-pen salmon farms in PB, which resulted in a controversial decision by the NLDMAE Minister to release the Project from further EA. This decision was controversial because it caused disagreement between different stakeholders about how the Project was regulated due to the potential impact that the Project could have on the socio-ecological system in PB, and as a result there was a historic process that occurred with the court proceedings. Hence, The Grieg NL case study provides an opportunity to understand how stakeholders operate in salmon aquaculture developments, specifically when governments waive critical procedures such as EIAs. As such, this research examined the Greig Project as a case study, and attempted to (1) investigate the roles of different stakeholders throughout the process and (2) explore the underlying motivations of different stakeholders in the Grieg NL Project network. These objectives were accomplished with the following research questions:

1. What key stakeholders played a role in connecting different players associated with the Grieg NL PB Atlantic Salmon Aquaculture Project?
2. What were the underlying motivations of each competing view on the Grieg NL PB Atlantic Salmon Aquaculture Project?

To address these questions, representatives from the aquaculture industry, other industries, ENGOs, communities, academia, government and law were interviewed. During these interviews, both social network analysis (SNA) and open-ended questions were completed. The first research question above was answered using SNA with an emphasis on communication and trust networks. SNA is used to identify the coalitions and to investigate the roles of different players within a network (Scott, 1988). SNA has been used to study communication in governance of natural resource management problems with complex social networks (e.g., Bodin et al., 2006; Bodin and Crona, 2009; Ernoul and Wardell-Johnson, 2013; Hartley, 2010; Parag et al., 2013; Robins et al., 2011; Vance-Borland and Holley, 2011; Weiss et al., 2012; Wilson et al., 2018). As such, SNA is an appropriate method for the Grieg NL case study because it is a clear resource management problem with different stakeholders that have conflicting views on the Project. The second research question was answered using open-ended questions that identified the underlying arguments behind competing views on the Project. In sum, the social network associated with the Grieg NL Project was studied to identify the structure of novel salmon aquaculture stakeholder networks in NL, and to identify the motives of different stakeholders in the network.

1.5 – Graduate project structure

This graduate project has six chapters: (1) Introduction, (2) Literature Review, (3) Methodology, (4) Identification of Key Players in the Social Network, (5) Key Themes Identifying the Motivations of Each Stakeholder Group, (6) Discussion, and (7) Conclusion and Recommendations. In the first chapter, an overview of the management problem, background on the study site, an overview of the case study and the research objectives are described. Chapter two provides a literature review on the effects of salmon aquaculture and social licence. The third chapter describes the methodology used to conduct this research from stakeholder identification and recruitment to data analysis using SNA. Chapter four identifies the key players from the SNA, while chapter five presents themes from the open-ended questions that were used to better understand the motives of different groups. The sixth chapter discusses the SNA and open-ended questions results together, and compares this case study to other resource management case studies. Finally, the seventh chapter provides conclusions and recommendations from the research.

Chapter 2 – Literature Review

2.1 – Environmental and social effects of Atlantic salmon aquaculture

The effects of salmon aquaculture expansion can be divided into two categories: environmental and social. The environmental effects are currently described under three different spatial scales: the near-field, the far-field, and the global scale (Soto et al., 2008). The near-field includes the individual farm or cage, and is the scale at which most aquaculture regulations are currently implemented. The far-field encompasses the ecosystem or watershed level, and the global scale describes effects that occur throughout the world (Soto et al., 2008). The effects mentioned below are traditional effects of salmon aquaculture and attempts have been made to address these effects mainly through technological improvements (e.g., feeding systems, net cleaners, cage technology, etc.).

2.1.1 – Near-field environmental effects

One key environmental impact of salmon aquaculture at the near-field scale is the release of organic material such as fish waste products and excess fish feed. The release of these compounds contributes to organic loading on the benthic floor that increases the biological oxygen demand (BOD) of the system from the elevated metabolism of benthic macrofauna and aerobic bacteria (Hargrave, 2010; Burt et al., 2012). This increase in BOD could create hypoxic conditions that could not only affect nearby benthic species, but also extend to the water column affecting the farmed salmon themselves by increasing stress and thus their susceptibility to diseases (Burt et al., 2013). Eventually, organic loading can reach the point where anoxic levels can be observed in the benthos, and the bacterial community composition changes from aerobic bacteria to anaerobic bacteria (Hamoutene, 2014; Hargrave, 2010; Salvo et al., 2015).

The excess fish feed that settles on the bottom and the presence of antifoulants on nets and other fish farm structures (Fitridge et al., 2012) could be a source of heavy metals and trace elements (i.e., chemical elements present in minute amounts such as Cu, Zn, Fe and Cd; Kalantzi et al., 2013). This is important as some of these metals pose harm to marine ecosystems since Cu and Zn can both be toxic to marine benthic organisms (Nash, 2003). Moreover, antibiotics and therapeutants are deposited to control bacterial and parasitic infections such as bacterial kidney disease (BKD) and sea lice (Bakke & Harris, 1998). These depositions can have effects on surrounding marine life. For instance, Waddy et al. (2002) concluded that emamectin benzoate, if ingested, can induce premature molting in American lobsters (*Homarus americanus*).

Further issues with water quality arise from the release of protein rich wastes and other chemicals into the water column that increase the total ammonia nitrogen (TAN), total organic carbon (TOC) and the BOD. Indeed, TAN (i.e., nutrient) levels can increase directly through the release of fish waste (Gray, Wu, & Or, 2002) or indirectly through the decomposition of organic material below Atlantic salmon pens that releases ammonia and phosphates into the water column (Holmer, Marba, Terrados, Duarte, & Fortes, 2002). TOC levels increase when any organic matter is released into the water column that can be decomposed by aerobic bacteria, thus promoting their growth and increasing the total BOD of the system; increasing BOD could create hypoxic conditions (Burt et al., 2013).

Finally, habitat modification from the physical presence of floating and submerged objects required for fish farming can create or change habitat for several marine organisms. This is especially critical for those organisms that depend on sensitive benthic habitats such as seagrass beds (Primavera, 2006). Seagrasses are photosynthetic organisms and thus depend on light penetration to perform their metabolic functions; the presence of a large net pen could reduce seagrass densities from shading (see Perez, Garcia, Invers, & Ruiz, 2008). These net structures create habitat that can also promote the attachment of unwanted fouling organisms that could have unintended ecological consequences (e.g., introducing novel diseases; Braithwaite & McEvoy, 2005). Moreover, large finfish farms have the potential to reduce current flows by 30-60% (San Diego-McGlone, Azanza, Villanoy, & Jacinto, 2008), which can decrease flushing rates and increase water residence time. This change in local hydrodynamics can exacerbate these potential water quality issues associated with salmon aquaculture.

2.1.2 – Far-field environmental effects

Diseases and parasites at the watershed level pose potential threats to both wild and farmed fish (Madhun et al., 2015; Madhun et al., 2017). Diseases that originate in salmon pens are likely to proliferate due to the high stocking densities of suitable hosts in net-pens and that the diseases are likely highly antibiotic resistant (AR) due to the vaccinations and antibiotics used in aquaculture operations (Shah et al., 2014). Diseases can either be transmitted to passing-by wild populations of Atlantic salmon or other wild fishes from farmed salmon (i.e., introduced "foreign" pathogen on native fish stocks; Sindermann 1990), or through wild populations infecting farmed salmon (i.e., enzootic pathogens affecting introduced farmed salmon stocks; Sindermann 1990).

Salmon escapees can result from major storms, vandalism, predators and net-biting that damage the net-pen (Jensen et al., 2010). However, the effects of salmon escapees on wild populations are highly contested and complex (Glover et al., 2017). Studies have suggested that escapees compete with wild salmon for niche space (Jonsson & Jonsson, 2006; Thorstad et al., 2008), and could cause genetic introgression in wild populations (Keyser et al., 2018), decreasing their fitness (Gross, 1998; Karlsson et al., 2016; Verspoor et al., 2016). Others argue that farmed fish have significantly less competitive ability than their wild counterparts since they are reared in environments that have no predation and abundant food (Bentsen & Thodesen, 2005).

Marine litter from aquaculture sites could drift afloat (Hinojosa & Thiel, 2009), sink to the bottom and become derelict fishing gear (Macfadyen et al., 2009; Jung et al., 2010; Strafella et al., 2015), or accumulate on shore (Ribic et al., 2012). Consequences of this gear include entanglement, smothering, physical harm or even ingestion by marine life if the gear breaks down enough, yielding ingestible microplastics (Gregory, 2009; Andrady, 2011); the gear can also present a navigational hazard for mariners (Wiber et al., 2012).

Atlantic salmon aquaculture can also alter food web dynamics through wild species aggregations of pelagic, benthic and aerial (e.g., seabirds) organisms that occur due to the presence of large quantities of prey, food and nutrients (Nash et al., 2000; Kemper et al., 2003; Dempster et al., 2011; Price et al., 2017). These aggregations could alter food web dynamics in other areas of the ocean if certain organisms are moving out of their habitat into a space with more food (Stabel, 2011). Further, these aggregations result in further organic deposition on the benthic floor, as there are many species besides the farmed salmon that are concentrated around the farm that produce organic waste (White, Bannister, Dworjanyn, Husa, Nichols, & Dempster, 2018). Near-field organic deposition can lead to algal blooms and eventual eutrophication at the ecosystem level (i.e., far-field scale; Robinson et al., 2005; Price et al., 2015).

2.1.3 – Global environmental effects

The culture of carnivorous fish relies on regional or global forage fish stocks (Naylor et al., 2000). As such, making feed for salmon can result in altered fishing pressure on non-farm associated fish (Weitzman, Steeves, Bradford, & Filgueira, 2019). In 2014, the FAO (2016) reported that over 75% of wild capture fisheries for non-human consumption were used in fish meal and fish oil production or for other aquaculture uses. Thus, this effect could also be viewed through a global lens as fish feed production relying too heavily on high trophic level animals, making food conversion ratios (FCRs) higher and creating a sustainability debate (Ottolenghi, 2008; Naylor et al., 2009; Natale et al., 2013).

2.1.4 – Social effects

The social effects of salmon aquaculture include both negative and positive consequences. The negative effects include the problems derived from environmental effects such as effects on wild fisheries (Dalton & Jin, 2018), and conflict for space with other marine stakeholders (Weitzman et al., 2019; CBC, 2017b). The positive effects include jobs and livelihoods that derive from the aquaculture sector (CBC, 2015).

The environmental effects of salmon aquaculture described above can indirectly result in social effects as well. For instance, Milewski et al. (2018) showed that the presence of an aquaculture farm negatively affected market and berried American lobster (*Homarus americanus*) catches in Port Mouton Bay, NS; concomitantly affecting lobster fishers. Further, any effects from salmon aquaculture that result in declines of wild salmon populations could negatively affect salmon recreational fisheries that contribute to the overall $1.4 billion recreational fishery in Atlantic Canada (DFO, 2018b). More importantly, according to DFO

(2018c), salmon are considered a valued angling fish, an indicator of environmental quality, an animal of respect and an attraction for eco-tourism, thus salmon have an importance beyond economic returns.

Conflict for marine space with other marine users (e.g., tourism, residential, fisheries, etc.) is another result of salmon aquaculture that could have social consequences. For instance, in the European Union, one study showed that marine aquaculture is not limited by a lack of space, but rather that it has a strong negative spatial interaction with other industries such as tourism (Hofherr, Natale, & Trujillo, 2015). Another example showed that residential property values decreased significantly in Penobscot Bay, Maine, United States of America as aquaculture leases became larger, denser and closer to residential areas near the coast (Evans, Chen, & Robichaud, 2017). Finally, in some instances aquaculture companies are viewed as outsiders to local communities and giving licences to establish sea farms is perceived as a form of expropriation of marine space that is used for traditional fishing activities by local groups (Marshall, 2001; Suryanata & Umemoto, 2003; Pinkerton & Silver, 2013). These examples show that salmon aquaculture can have important social conflicts with other marine stakeholders; however, salmon aquaculture can also have positive interactions with other marine space users.

Salmon aquaculture can have positive social effects on surrounding communities. For instance, there are job opportunities that are presented to rural communities by the aquaculture industry directly and by other industries indirectly that benefit from the aquaculture industry (e.g., shipbuilding; NLDFLR, 2018b). Having stable job opportunities in rural communities can result in families staying together in close spatial proximity for future generations rather than newer generations having to move afar for employment (i.e., rural community development; Burbidge, Hendrick, Roth, & Rosenthal, 2001).

2.2 – Social license to operate (SLO) in aquaculture

The term SLO first arose in the mining industry during the 1990s when companies acknowledged the importance of addressing the growing social concerns with their operations (Mercer-Mapstone et al., 2017; Thomson & Boutilier, 2011). SLO was a way for the industry to build strong relations with the communities that they were working in, but SLO was also used as a tool by the industry to obtain a level of social acceptance with their activities (Thomson & Boutilier, 2011). Nearly thirty years after being adopted, SLO is now well-established in the mining industry; however, in other resource intensive industries such as aquaculture, SLO is in its infancy (Mather & Fanning, 2019).

In the aquaculture industry, there is a growing body of work on social acceptance of aquaculture, particularly in countries such as Australia (Mazur & Curtis, 2006), New Zealand (Baines & Edwards, 2018) and Scotland (Billing, 2018). However, recently ENGOs have capitalized on the term SLO in the aquaculture sector, and are deploying it as a means to contest corporate activities, particularly activities that are viewed as environmentally unsustainable (Murphy-Gregory, 2018). ENGOs are also using SLO to mobilize citizens, shape corporate decision-making on production processes, bust most importantly as a campaign to participate in regulatory reviews of corporate activity to have a stronger role in the process of governance (Murphy-Gregory, 2018). Thus, in the brief history of SLO in the aquaculture industry, ENGOs have used the term strategically to oppose the development of the industry.

SLO generally involves working with communities that are directly affected by a project; however, problems arise when thinking about the spatial scale of SLO. Dare et al. (2014) proposed the terms "communities of place" and "communities of interest" to distinguish between those stakeholders that are geographically closer to a resource development site. The use of these two terms identifies the diverse interests and interactions between communities at different spatial scales (Mather & Fanning, 2019). Moreover, one complexity with the aquaculture industry compared to mining and other resource intensive sectors is the more extensive stakeholder network, which results from the oceans being a "public commons" (Mather & Fanning, 2019; Costello & Ballantine, 2015). In resource management scenarios where there are complex social networks, such as the network associated with the Grieg NL case, it is crucial for regulators to assess the relative importance of different stakeholder motives. When assessing the importance of different stakeholder motives, a key step is to consider whether stakeholders are linked to the community of place or community of interest groups, especially when discussing SLO. As such, SNA is a tool that can help analyze stakeholders and facilitate industry obtaining access to their SLO.

Chapter 3 – Methodology

3.1 – Stakeholder identification and recruitment

Interview participants were identified by consulting a variety of secondary literature sources associated with the Project. A key source was a video showing two hour footage of the Environmental Impact Statement (EIS) hearing held in Marystown in March 2018 where public questions were raised and considered by the proponent (i.e., Grieg). Other secondary sources that were valuable for recruitment purposes included letters to the editor of news sources such as the Telegram or Voice of the Common Man (VOCM), two prominent local news sources in NL, and radio talk shows (e.g., CBC The Broadcast), which are popular in NL. Further, government representatives were identified by searching on the DFO and DFFA websites, and considering those individuals on the Environmental Assessment Committee (EAC) appointed by the NL Minister of Municipal Affairs and Environment (NLDMAE, 2017). Finally, a large number of participants were identified using snowball recruitment at the end of each interview (Wasserman, Pattison & Steinley, 2005; see sample survey in Appendix 1, question 28).

Emails were used as the primary means to recruit interview participants. A total of 102 potential participants were contacted first by email. If a reply was not obtained after 48 hours, a second email was distributed to follow up with potential participants, asking if they had questions or concerns about the study. If email communication was unsuccessful a second time, potential participants were phoned. A total of 23 individuals agreed to be interviewed, resulting in a response percentage of 22.5%. The 23 participants were distributed across seven general stakeholder groups: aquaculture industry (n=2), ENGOs (n=9), communities (n=5), research (n=2), government (n=3), other industries (n=1), law (n=1).

3.2 – Data collection: SNA and open-ended questions

Throughout the month of May 2018, a series of 23 open-ended questions were conducted under Dalhousie University Marine Affairs Program Ethics Review Standing Committee (MAPERSC) file # MAP2018-03. Interviews consisted of two parts, the first part involving open-ended questions to understand the motivations behind each organization or individual's interests in the Project. The second part of the interview involved asking participants a series of questions to understand the social network of the most relevant stakeholders involved in the Grieg NL Project (Appendix 1). To aid participants with the visualization of the social network, a stakeholder map was used so participants could draw connections to other stakeholders in the network (Figure 6).

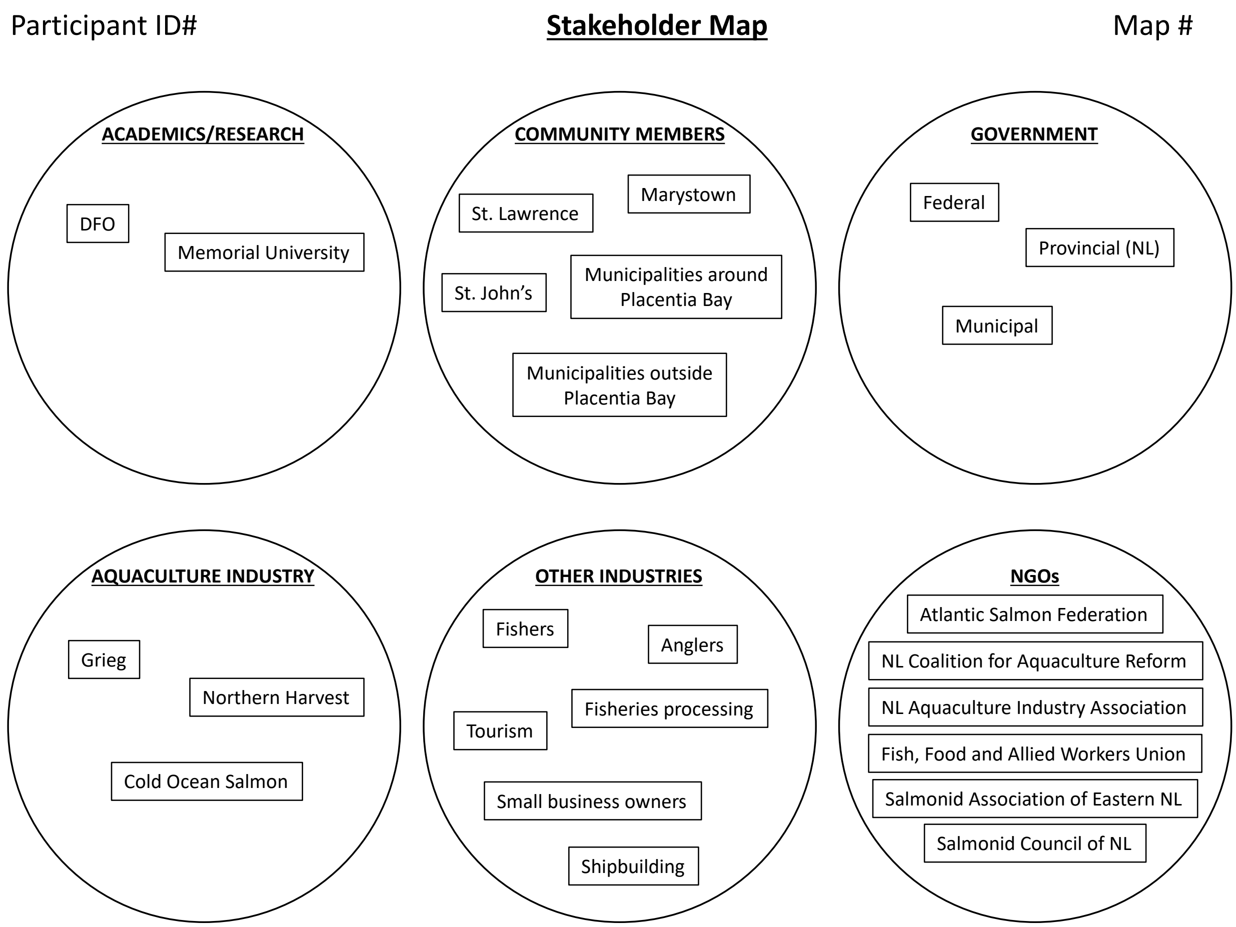

Figure 6. Sample of the initial stakeholder map used for the SNA portion of the interviews. Note that the map presented a selection of key stakeholders; however, participants were encouraged to add relevant stakeholders to the map where appropriate.

3.3 – Data analysis: Social network analysis (SNA)

The social network of the stakeholders interviewed that were associated with the Grieg Aquaculture Project in Placentia Bay was analyzed using SNA. SNA is used to investigate social structure within a network (Scott, 1988), and has been used to study communication in governance of natural resource management problems (e.g., Bodin et al., 2006; Bodin and Crona, 2009; Ernoul and Wardell-Johnson, 2013; Hartley, 2010; Parag et al., 2013; Robins et al., 2011; Vance-Borland and Holley, 2011; Weiss et al., 2012). Specifically, the social network associated with the Project was analyzed using a communication network in which the strength of communication links between stakeholders was evaluated, and a trust network in which levels of trust in other stakeholders were assessed. The communication network was analyzed at two scales: (1) organization/individual level and (2) stakeholder group level, whereas the trust network was only analyzed at the stakeholder group level for ethical reasons.

Communication links were scaled using frequency and formality of communication to quantify these relationships. High communication frequency results in strong communication ties, as more frequent communication yields more opportunities to form relationships and more opportunities to exchange information within the network (Keck & Sakdapolrak, 2013; Van de Ven, Walker & Liston, 1979). Regarding formality of communication, informal communication included dialogue such as text message, face-to-face communication over coffee, unstructured emails, etc., whereas formal communication included methods such as formal meetings, structured emails, public information sessions, etc. Informal communication ties yield stronger relationships that can drive collective action within a community or network (Pelling & High, 2005). As such, more frequent communication in a less formal manner received the highest communication score. The frequency of communication was viewed as more important in assessing the communication strength than the level of formality (Van de Ven et al., 1979; Renaud-Byrne, 2017), as displayed in the communication scoring table (Table 1). Once each communication link was scored, the data was compiled into a communication matrix (e.g., Table 2) that summarized each connection between different stakeholders. When there were multiple individuals interviewed from the same stakeholder group, the mean score was calculated for each connection to other stakeholders. Note that there were several stakeholders that were not interviewed in the network, and thus only connections towards these stakeholders could be displayed.

Table 1. Values used to quantify the strength of the communication networks between stakeholders, modified from Renaud-Byrne (2017).

	Very Formal (1 point)	Formal (2 points)	Neutral (3 points)	Informal (4 points)	Very Informal (5 points)
Daily (30 points)	31	32	33	34	35
Weekly (25 points)	26	27	28	29	30
Bi-weekly (20 points)	21	22	23	24	25
Monthly (15 points)	16	17	18	19	20
Quarterly (10 points)	11	12	13	14	15
Yearly (5 points)	6	7	8	9	10

Table 2. Example of communication matrix used to store each communication score between stakeholders.

		Participant's Perception of Communication with Others			
		NGO_1	NGO_2	Government_1	Industry_1
Stakeholder Interviewed	NGO_1		12	33	6
	NGO_2	23		26	17
	Government_1	10	29		18
	Industry_1	27	35	30	

A series of metrics was used to quantitatively describe the communication network. First, the network density was considered, as it represents the number of ties in a network divided by the number of possible ties in a network (Table 3), and consequently reveals the level of communication in a network compared to the maximum amount of communication that can happen in the network (Hanneman & Riddle, 2005). Second, to identify powerful groups in the communication network, three different centrality measures were used at the organization/individual scale: total degree centrality, betweenness centrality and eigenvector centrality (Figure 7). Total degree centrality identifies those groups that have a high number of direct connections to other groups, suggesting that these individuals or organizations are “in the know” because they are linked to several others, and thus have access to a variety of ideas, thoughts and beliefs (Table 3; Wasserman & Faust, 1994). Betweenness centrality identifies groups that act as a gatekeeper between groups, meaning that the group with high betweenness centrality brokers connections between groups and can pass on the influence of one group and their network onto another group and their network (Table 3; Freeman, 1979). Eigenvector centrality refers to those individuals or organizations that are in a clique, and the group or individual that is most connected to others in the clique and other cliques is the leader of the clique and has high eigenvector centrality (Table 3; Bonacich, 1987). Individuals or groups that are connected to several otherwise isolated individuals or organizations will have a much lower eigenvector centrality than those that are connected to groups that have many connections in the clique. In other words, individuals or organizations that share connections with well-connected groups are more central than those that share connections with less-connected groups. The three centrality measures were calculated in ORA 2.3.2, which is a network visualization and analysis software. Nodes were scaled accordingly to each centrality measure with larger nodes being more central than smaller nodes.

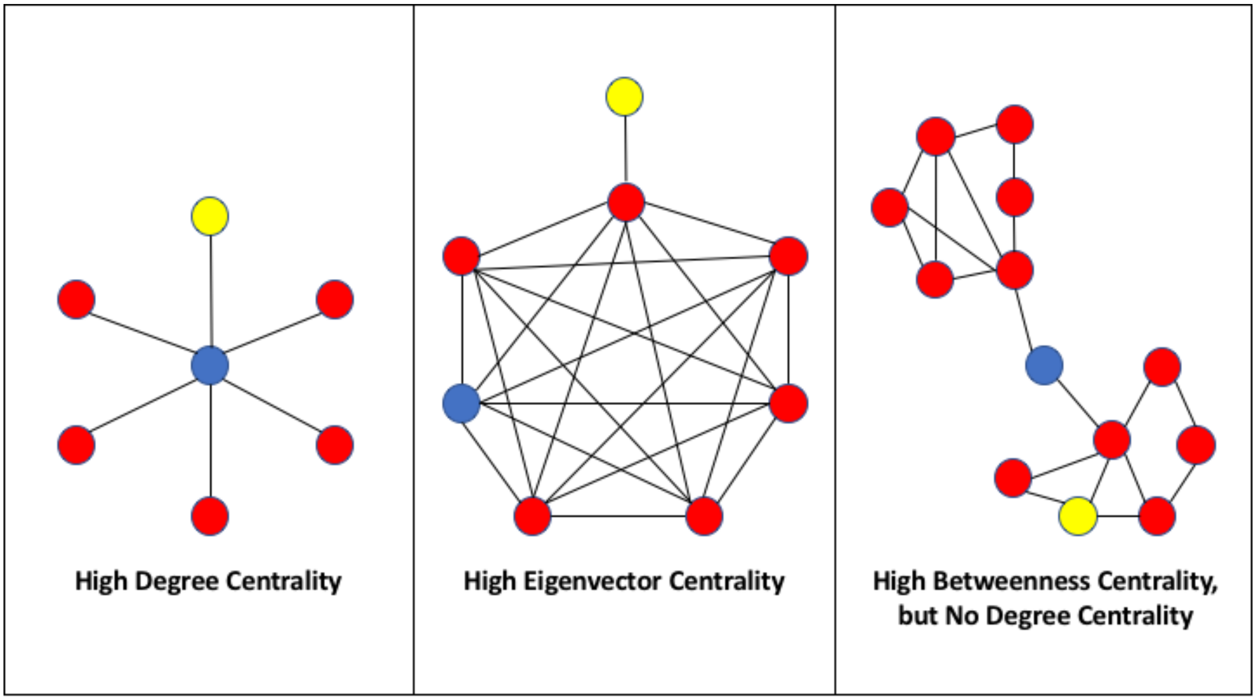

Figure 7. Visualizations of high/low degree centrality, high/low eigenvector centrality, and high/low betweenness centrality but no degree centrality. Note that the blue and yellow nodes are representative of the highest and lowest centrality mentioned in each diagram, respectively. The red nodes are displayed to show the relative centrality of the blue and yellow nodes, and are not meant to show high or low centralities.

A Pearson correlation analysis was completed on each pair of centrality measures using SPSS Premium at the 0.01 significance level. This analysis was completed to justify combining three SNA communication maps (i.e., total degree, betweenness and eigenvector) into one map at the organization/individual level. The resulting communication map (i.e., consolidated map) at the organization/individual level was obtained using the average centrality calculated from the three centrality measures. These average centralities for each organization/individual were then used to calculate an average centrality and coefficient of variation (Table 3) for each stakeholder group to determine whether stakeholder groups were homogeneous (i.e., everyone in the group playing similar roles in the network) or heterogeneous (i.e., some group members playing larger roles in the network than others).

At the stakeholder group scale, the external-internal (E-I) index was used to measure the proportion of external ties for a stakeholder group (Hanneman & Riddle, 2005); the equation is displayed below.

$$EI\ Index = \frac{Number\ of\ External\ Links}{Number\ of\ Internal\ Links + Number\ of\ External\ Links}$$

E-I ranges from zero to one, where zero indicates no external ties outside of the stakeholder group, and one indicates that this stakeholder group only has connections with other stakeholder groups (Table 3). The resulting E-I index reveals which stakeholder groups communicate more often internally (i.e., within their stakeholder group) or externally (i.e., outside of their stakeholder group) (Carcamo et al., 2014; Vance-Borland & Holley, 2011).

Interview participants were also asked about their trust perceptions of different stakeholders associated with the Grieg NL Aquaculture Project. Participants were asked to score their trust perceptions using a scale from zero to five where zero indicated “no trust”, one was “little trust”, two was “somewhat trust”, three was “trust”, four was “strong trust”, and five was “very strong trust". The resulting data was compiled into a second matrix (i.e., similar to Table 2) that scored the trust relationships between each stakeholder regarding information about the Project. The mean score was calculated when there were multiple individuals interviewed for one stakeholder.

The trust network was analyzed using two measures to compute maps, (1) in-degree centrality and (2) out-degree centrality measures in ORA (Table 3). The in-degree centrality determines how much a stakeholder is trusted by other stakeholders in the network. The out-degree centrality determines how much trust a stakeholder gives to other stakeholders in the network. After compiling the trust scores into a matrix at the organization/individual level, the average trust link scores for each combination of stakeholder groups were calculated. In-degree and out-degree trust values were calculated in ORA 2.3.2, and were used to scale nodes accordingly to each trust measure with larger nodes receiving or giving more trust for in-degree and out-degree centrality, respectively. Note that the media and law stakeholder groups were not asked about trust relationships, and thus only connections towards these stakeholders (i.e., in-degree centrality) could be displayed.

Both matrices (i.e., communication network and trust network) were analyzed by producing reports and visualizations in the form of maps using ORA 2.3.2. Line width on the maps was proportional to the strength of the network tie, where thicker lines indicate a stronger communication or trust between two stakeholders. The strength of each connection in the communication network was categorized as strong, moderate or weak using the scores 26-35, 16-25 and 6-15, respectively. To simplify the communication network maps at the organization/individual scale, weak communication links (i.e., strength $\leq$ 15) were eliminated to show connections more clearly. Trust network maps did not need to be simplified, as trust was only presented at the stakeholder group scale for ethical reasons.

Table 3. Summary of measures used to analyze both communication and trust networks associated with the Project.

Measure	Minimum Value	Maximum Value	Description
Network Density	0	1	The number of ties in a network divided by the number of possible ties in a network; a measure of how much communication happens in a network
Total Degree Centrality	0	1	Groups that have a high number of direct connections to other groups; "in the know" because they are linked to several others, and thus have access to a variety of ideas, thoughts and beliefs
Betweenness Centrality	0	1	Groups that act as a gatekeeper between groups, meaning that the group with high betweenness centrality brokers connections between groups and can pass on the influence of one group and their network onto another group and their network
Eigenvector Centrality	0	1	Groups that are in a clique, and the group or individual that is most connected to others in the clique and other cliques is the leader of the clique and has high eigenvector centrality
In-degree Trust	0	1	Trusted groups
Out-degree Trust	0	1	Trusting groups
E-I Index	0	1	Measures the proportion of external ties for a stakeholder group
Coefficient of Variation	0	>1	Measure of variation used to determine homogeneity within a group

3.4 – Data analysis: Open-ended questions

During the interview, a series of questions were asked to understand the underlying thoughts and motivations of the participant about the Project (Appendix 1, questions 1-4). Interviews were recorded whenever permitted by the participant and detailed notes were taken throughout the interview to facilitate the identification of key quotes during analysis. Select quotes were included in the results to identify the underlying motivations or common interests associated with the Project for key groups of stakeholders that were identified in the SNA.

Chapter 4 – Identification of Key Players in the Social Network

4.1 – Communication network structure and content at organization/individual scale

After interviewing 23 individuals, a total of 48 organizations in the network were identified as part of 8 stakeholder groups (Table 4). The network included 242 links out of 2256 possible links (i.e., $48^2 - 48 = 2256$), indicating a density of 0.11 (11%).

Table 4. Network distribution by stakeholder group, indicating the number and percentage of organizations in the network by each stakeholder group.

Stakeholder Group	Number of Organizations in the Network
Government	10 (21%)
ENGOs	8 (17%)
Aquaculture Industry	8 (17%)
Communities	7 (15%)
Other Industries	6 (13%)
Research	5 (10%)
Law	3 (6%)
Media	1 (2%)
Total	48

Regarding the degree centrality, NGO_2, one of the 48 organizations, was an ENGO stakeholder that had the highest number of connections in the network, and thus had the highest total degree centrality score of one (Table 5). Both AQ_IND_2 and AQ_IND_1, two of the 48 organizations, were part of the aquaculture industry stakeholder group and also had high total degree centrality at 0.71 and 0.65, respectively. Regarding the betweenness centrality, AQ_IND_1 received the highest score of 0.08, indicating that the organization connects groups of people that would otherwise be unconnected (Table 5). NGO_2 also plays a bridger role, as their betweenness centrality score was 0.06, the second highest in the network (Table 4). Regarding eigenvector centrality, NGO_2 had the highest score at one, and thus was well-connected to actors that are also well-connected (Table 5). AQ_IND_2 and AQ_IND_1 also had high eigenvector centrality scores of 0.89 and 0.72, respectively.

Table 5. Metrics for each organization or individual mentioned in the Grieg NL PB Atlantic Salmon Aquaculture Project.

ORA Code	Total Degree Centrality	Betweenness Centrality	Eigenvector Centrality	Average Centrality
AQ_IND_1	0.65	0.09	0.72	0.48
AQ_IND_2	0.71	0.02	0.90	0.54
AQ_IND_3	0.07	< 0.01	0.13	0.07
AQ_IND_4	0.09	< 0.01	0.23	0.11
AQ_IND_5	0.05	< 0.01	0.15	0.07
AQ_IND_6	0.09	< 0.01	0.23	0.11
AQ_IND_7	0.09	< 0.01	0.23	0.11
AQ_IND_8	0.02	< 0.01	0.05	0.02
COMM_1	0.21	0.01	0.31	0.18
COMM_2	0.13	< 0.01	0.29	0.14
COMM_3	0.13	< 0.01	0.30	0.14
COMM_4	0.21	< 0.01	0.39	0.20
COMM_5	0.36	0.02	0.46	0.28
COMM_6	0.13	< 0.01	0.32	0.15
COMM_7	0.04	< 0.01	0.12	0.05
GOV_1	0.25	0.01	0.33	0.20
GOV_10	0.05	< 0.01	0.07	0.04
GOV_2	0.13	< 0.01	0.29	0.14
GOV_3	0.31	0.02	0.48	0.27
GOV_4	0.23	0.02	0.33	0.19
GOV_5	0.12	< 0.01	0.28	0.14
GOV_6	0.02	< 0.01	0.06	0.03
GOV_7	< 0.01	< 0.01	< 0.01	< 0.01
GOV_8	0.08	< 0.01	0.17	0.08
GOV_9	0.02	< 0.01	0.02	0.01
LAW_1	0.03	< 0.01	0.06	0.03
LAW_2	0.03	< 0.01	0.11	0.05
LAW_3	0.02	< 0.01	< 0.01	0.01
MEDIA	0.05	< 0.01	0.13	0.06
NGO_1	0.17	< 0.01	0.31	0.16
NGO_2	1.00	0.07	1.00	0.69
NGO_3	0.37	0.03	0.55	0.32

NGO_4	0.37	0.03	0.55	0.32
NGO_5	0.22	< 0.01	0.45	0.22
NGO_6	< 0.01	< 0.01	< 0.01	< 0.01
NGO_7	0.16	< 0.01	0.34	0.17
NGO_8	< 0.01	< 0.01	< 0.01	< 0.01
OTHER_1	0.34	0.01	0.48	0.27
OTHER_2	0.20	< 0.01	0.35	0.18
OTHER_3	0.12	< 0.01	0.27	0.13
OTHER_4	0.28	< 0.01	0.54	0.27
OTHER_5	0.18	< 0.01	0.39	0.19
OTHER_6	0.03	< 0.01	0.06	0.03
RES_1	0.07	< 0.01	0.22	0.10
RES_2	< 0.01	< 0.01	< 0.01	< 0.01
RES_3	< 0.01	< 0.01	< 0.01	< 0.01
RES_4	0.06	< 0.01	0.16	0.07
RES_5	0.02	< 0.01	0.02	0.01

The Pearson correlation analysis revealed that all three centralities (i.e., total degree, betweenness and eigenvector) were correlated at the 0.01 level (Table 6). As such, the mean centrality was calculated to combine the three centralities into one centrality score for each organization or individual. NGO_2 had the highest average centrality at 0.69, followed by AQ_IND_2 at 0.54 and AQ_IND_1 at 0.48 (Table 5, Figure 8).

Table 6. Summary of results of the Pearson correlation test completed for total degree, betweenness and eigenvector centralities. Note that * denotes significance at the 0.01 level.

Centralities	Pearson Correlation Coefficient
Total Degree, Betweenness	0.844*
Total Degree, Eigenvector	0.953*
Betweenness, Eigenvector	0.720*

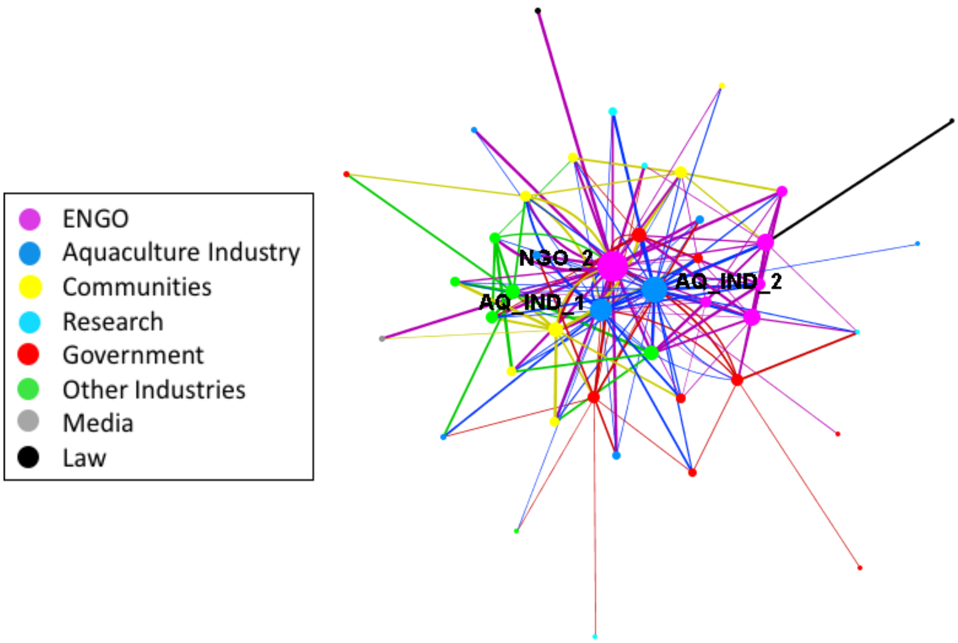

Figure 8. A visual representation of the communication network associated with the Grieg Aquaculture Project by organization/individual. Node size is indicative of average centrality of total degree, betweenness and eigenvector. Note that link colours are indicative of the source (i.e., interviewed) organization or individual.

4.2 - Communication and trust network structure and content at stakeholder group scale

The external-internal (E-I) index is useful to determine the ratio of internal to external ties that a stakeholder group has in a social network. The ENGO and other industries stakeholder groups had E-I indices of 0.78 and 0.75, respectively (Table 7), which are lower when compared to other stakeholder groups in the network except the law stakeholder group. This is also reflected in the network map (Figure 8), as the two distinct coloured clusters of ENGOs on the right and other industries on the left is indicative that these stakeholder groups had relatively more internal ties than external ties compared to other stakeholder groups. When looking at other stakeholder groups such as government, communities and aquaculture industry, all of these stakeholder groups had E-I values that were greater than 0.8, thus indicating that these stakeholder groups collaborate with other stakeholder groups more frequently than the ENGO, other industry and law groups. The research stakeholder group only communicated with other stakeholder groups and thus had the highest E-I index of one.

Table 7. External-internal (E-I) index results for the Grieg Aquaculture Project communication network by stakeholder group. Note that nobody was interviewed from the media stakeholder group, and thus an E-I index could not be calculated.

Stakeholder Group	Number of Organizations in Group	Number of External Links	Number of Internal Links	Total Number of Links	E-I Index
Government	10	30	7	37	0.81
ENGOs	8	69	19	88	0.78
Aquaculture Industry	8	48	12	60	0.80
Communities	7	21	4	25	0.84
Other Industries	6	15	5	20	0.75
Research	5	6	0	6	1
Law	3	4	2	6	0.67
Media	-	-	-	-	-

At the stakeholder group scale, the ENGOs had the highest mean centrality at 0.23 followed by the aquaculture industry at 0.19; the law stakeholder group had the lowest centrality at 0.03 (Figure 9; Table 8). The coefficient of variation (COV) revealed that the research stakeholder group had the highest COV at 1.25 (Table 8), suggesting high heterogeneity within the group. Two research representatives were interviewed and they played very different roles in the communication network. Communities had the lowest coefficient of variation at 0.42, suggesting that each community interviewed played similar roles in the network and talked to similar stakeholders (Table 8). Finally, the ENGO and aquaculture industry stakeholder groups also had high COVs at 0.95 and 1.08, respectively, showing the importance of NGO_2, AQ_IND_1 and AQ_IND_2 in the network, as they played an important role in the heterogeneous centrality measures within their stakeholder group (Table 8).

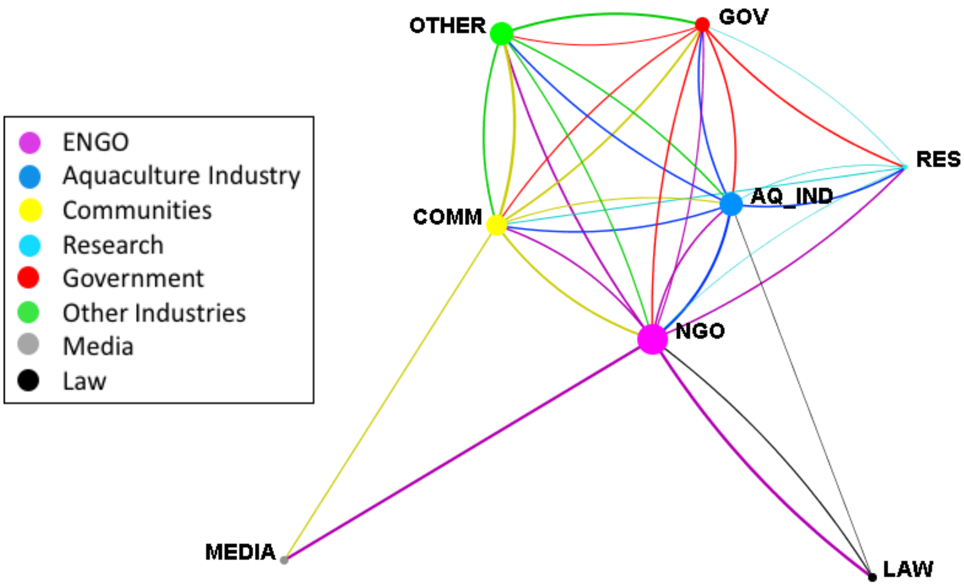

Figure 9. A visual representation of the communication network associated with the Grieg Aquaculture Project by stakeholder group. Node size is indicative of average centrality. Note that link colours are indicative of the source (i.e., interviewed) stakeholder group.

Table 8. Mean, standard deviation and coefficient of variation for centrality, and in-degree and out-degree trust values for each stakeholder group in the communication network. Note that nobody was interviewed from the media stakeholder group, and thus centrality and related metrics could not be calculated.

Stakeholder Group	Mean Centrality	Standard Deviation	Coefficient of Variation	In-Degree Trust	Out-Degree Trust
Government	0.11	0.09	0.84	0.79	0.86
ENGOs	0.23	0.22	0.95	0.42	0.51
Aquaculture Industry	0.19	0.20	1.08	0.61	1.00
Communities	0.16	0.07	0.42	0.69	0.50
Other Industries	0.18	0.09	0.51	0.53	0.60
Research	0.04	0.05	1.25	1.00	0.45
Law	0.03	0.02	0.76	-	-
Media	-	-	-	0.94	-

In-degree centrality was used to demonstrate the extent that an actor in the network is trusted by other actors. Conversely, out-degree centrality was used to identify the actors that put a lot of trust in other actors within the network. Research obtained the highest mean in-degree centrality score of one, indicating that they were the recipients of the most trust from other actors in the network (Figure 10; Table 8). The media was also a recipient of high trust from other actors in the network with an in-degree centrality score of 0.94. Conversely, stakeholder groups that were less trusted included ENGOs, aquaculture industry and other industries with in-degree centrality scores of 0.42, 0.61 and 0.53, respectively (Figure 10). Regarding out-degree centrality, aquaculture industry puts the most trust into others in the network compared to any other stakeholder group, as the out-degree centrality score was one for aquaculture industry (Figure 11; Table 8). Further, research had the lowest out-degree trust of 0.45, indicating that this stakeholder group does not trust others in the network when comparing to the out-degree trust scores of other stakeholder groups (Figure 11; Table 8).

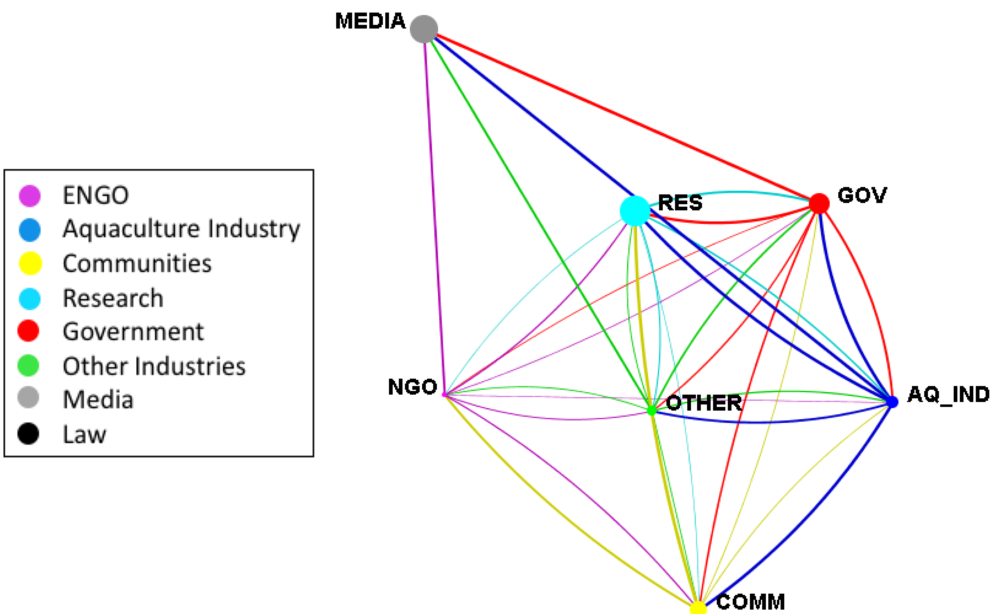

Figure 10. A visual representation of the trust network associated with the Grieg Aquaculture Project by stakeholder group. Node size is indicative of in-degree centrality, which identifies the stakeholder groups that receive the most trust in the network. Note that link colours are indicative of the source (i.e., interviewed) stakeholder group.

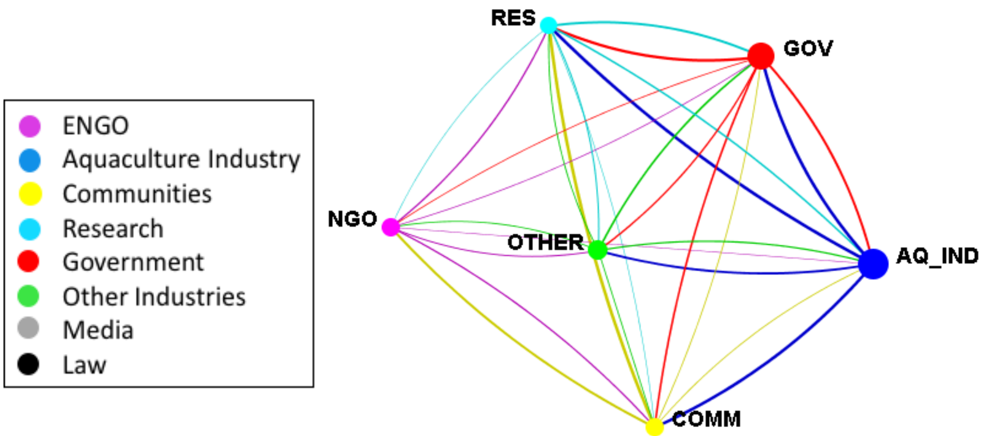

Figure 11. A visual representation of the trust network associated with the Grieg Aquaculture Project by stakeholder group. Node size is indicative of out-degree centrality, which identifies the stakeholder groups that are the most trusting of other groups in the network. Note that link colours are indicative of the source (i.e., interviewed) stakeholder group.

4.3 – Summary of key players in the Grieg NL Project network

The SNA identifies that the main player in the Grieg NL Project network is an ENGO, but there are also two aquaculture industry representatives that play strong roles; however, the level of trust that these stakeholder groups are given by other stakeholder groups in the network is low. SNA is unable to capture information such as group dynamics and underlying motivations of each stakeholder group that ultimately define the social structure. Accordingly, the open-ended questions were used to gather information on the nature of the connections and coalitions that contribute to the competing views.

Chapter 5 – Key Themes Identifying the Motivations of Each Stakeholder Group

From the SNA results, there were three key players leading two distinct coalitions with different common interests, the first coalition being opposed to the Project, led by NGO_2, and the second coalition being supportive of the Project, led by AQ_IND_1 and AQ_IND_2. The underlying themes describing the motivations of each player in the network were captured using open-ended questions (Appendix 1, questions 1-4). The major themes identified include (1) social and economic benefits associated with the Project, (2) a debate about farmed salmon as healthy/unhealthy food, (3) environmental concerns, and (4) government regulation.

5.1 – Social and economic benefits associated with the Project

The coalition that supported the Project focused on the social and economic opportunities that the Project would bring to rural communities in NL, as stated by AQ_IND_2:

> Marystown is job hungry with the closure of the dockyard and the Kiewit facility, and now the reduction in megaprojects. They are looking for employment opportunities. Outside of food sustainability, they are looking at jobs. Most of the communities are calling me for information on the current status of the Project (Participant ID # 062YDQOQ).

Before proposing the Project and throughout the EIS stage, Greig NL held a series of meetings with citizens of the BP, presenting the potential job opportunities that the Project could bring to an area that is "job hungry". Most citizens of the BP were attracted to the job opportunities that were expressed by Grieg NL in the community meetings and during the EIS hearing in Marystown. For instance, one small business owner and resident of the BP outlined the economic effects that something as big as the Grieg Project could bring to the area:

> What will happen though is a sense of security with the introduction of a new industry to the area that will create employment and restore faith in the region (Participant ID # Q99YH0A9).

This point merges into the social benefits that the Project could bring to the BP:

> For me, here is an opportunity that my kids may spend a lifetime growing up in the same lifestyle here in rural NL that I did and enjoy the same laid back way of life. My son, he could work in his own industry, he could work in that industry [aquaculture], he could work in an industry feeding that industry. I don't care if my kids work within NL, but if they can be within an hour of me in Marystown, bonus, so I can get my car after supper and go drive and see them. And that means I'll see grandkids, and that means that everybody will enjoy a better

> family life. So, you can look at the economics, but more importantly you have to look at the social aspects of this (Participant ID # Q99YH0A9).

Here, this BP resident highlights his/her narrow justification behind supporting the Project in that it would bring jobs to the region. However, the participant then explains the broader social context in that jobs from the Project would "restore faith in the region" and establish a basis for intergenerational continuity for BP residents.

Conversely, a representative from NGO_2 questioned the Project's promise of job creation, arguing that the number of jobs generated from the Grieg Project would be high at first during the construction phase of the Project, but the number of jobs would eventually reach a threshold and then decrease as the construction phase transitions into the operations phase. It was also argued that the jobs created would be low paying and volatile, especially when farms experience disease outbreaks and parasites (e.g., BKD, sea lice).

> When you talk about this Project creating a lot of employment, I don't see this as necessarily true, but I believe that there's going to be a high employment rate at the beginning, the construction phase. But then I think that after everything gets set up there's not going to be that many people employed by it [the Project]. And I also believe that the people that are employed by Grieg Aquaculture will probably be the lowest paying jobs in all of Canada. I think that if it does go ahead, it is going to be doom and gloom and it is going to crash the environment. It's not only going to be those few people that are out of jobs, it is also going to affect the fishermen, the truckers, the plant workers and everybody else that is affiliated not only down in PB, but in the rest of the geographic region as well (Participant ID # 16CEGR8C).

This theme on the social and economic opportunities that the Project could bring to the BP was a debate about job stability, pay and the number of jobs created. Local residents and small business owners on the BP that would be directly affected with new jobs were supportive of the Project, while the ENGO representatives and anglers focused on critically analyzing the number of jobs that would be available over time, and the quality of the work and pay.

5.2 – Farmed salmon as healthy/unhealthy food

Another representative with NGO_2 stated what their overall motivations were in being opposed to the Project, making reference to his/her personal values about the unhealthiness of farmed salmon due to the pesticides used to control sea lice infestations.

> I haven't eaten farmed salmon in four years anyway and I won't eat it. I can tolerate the steroids in the food. I don't like the antibiotics they use to control the disease, that's iffy. But I refuse to eat fish because of the pesticides, the thousands and thousands of pesticides they use to kill those sea lice. That is nothing but pure toxic chemical, horrible for you and I would encourage nobody to eat it when it's done like that. That was the killer for me, the pesticides (Participant ID # IM4ENJFY).

In contrast, one resident of the BP that was overall in favour of the Project stated the opposite when discussing farmed salmon as food, "I would love to have the first piece of salmon that comes out of it [the Project]" (Participant ID # Q99YH0A9). Thus, there were differences in perceptions on farmed salmon based off personal values relating to the healthiness/unhealthiness of farmed salmon due to the husbandry practices used to control sea lice. Specifically, local residents, small business owners and the aquaculture industry promoted farmed salmon as being healthy food, while the ENGOs raised awareness about the pesticides used that should not be permitted in food products.

5.3 – Environmental concerns

Another motivation for the coalition opposed to the Project was the potential environmental effects of salmon aquaculture on wild salmon (see Chapter 2.1 for a review). This concern was expressed by a representative of NGO_2, "Now, the fact that they kill off the wild salmon is just as bad. I am an avid angler and that's how I got involved in this. And I mean the poor south coast salmon need all the help they can get and they are certainly not getting it" (Participant ID # IM4ENJFY). Indeed, the main concern from the perspective of the anglers and ENGOs was the potential consequences that farmed salmon can have on dwindling Atlantic salmon stocks. This was apparent with the several angling organizations that coalesced to have a stronger voice throughout the Grieg NL Project, including the ASF, NL-CAR, SAEN and SCNL to name a few.

The Project proposal from Grieg NL included several new mitigation measures to address environmental concerns that have either not been used in Atlantic Canada or are above the standards required by provincial and federal governments (New Brunswick Department of Agriculture, Aquaculture and Fisheries, 2011; DFO, 2018d; NLDFLR, 2018c; Nova Scotia Department of Fisheries and Aquaculture, 2018). One regulator mentioned the following when asked about his/her thoughts on the Project, “Larger smolt size, I thought was great, the use of triploids, reduced sea cage production cycle, separated Bay Management Areas (BMAs), I thought were all very responsible activities by that company [Grieg NL]” (Participant ID # 0RAQ4HWQ). The mitigation measures mentioned by this regulator focus on minimizing the negative effects of aquaculture on wild salmon. First, the use of larger smolt size was important because the fish would spend less time in the net-pen, minimizing the time for interactions with other marine life and reducing the chance of successfully reproducing with wild salmon if a farmed fish escaped. The likelihood of reproduction would decrease because as fish spend more time in the hatchery, they become less adapted to surviving in the ocean. Second, the use of triploids would further decrease the likelihood of genetic introgression with wild salmon, as triploid fish are unable to produce viable offspring. Third, the use of BMAs is a tactic that is becoming more popular to reduce environmental effects and the chance of disease spread by managing farms using an ecosystem approach to aquaculture (EAA; Kripa, 2015; Soto et al., 2008). Although there are other negative environmental effects of aquaculture such as benthic habitat degradation from waste products (see Chapter 2.1 for a review), the main concern expressed by those opposed to the Project was the effects on wild salmon.

5.4 – Government regulation

The NL Government plays a lead role in approving and regulating aquaculture leases in NL, and is also a major supporter of aquaculture development (see "The Way Forward" policy; Government of Newfoundland and Labrador, 2016). One government representative offered a unique perspective when talking about the NL Government's motivations with the Project, stating that the Government may not have had an objective viewpoint in approving this development.

> From a totally different perspective, that's become a very political issue. You have the BP represented by the current Liberal government with two members. There is so much open optimism in the area about this Project with the new jobs, new industry that I think, puts them [the Liberals] in a situation of 'listen we want to get this project done at all costs, this is very important for the area, this is very important politically for us and the members down there.' There was so much 'we got to get this done' that they bypassed the process that they should have went through from the beginning and that created the tailspin that we are into now. If it wasn't politically driven, we wouldn't be here today, I think we would be looking at an industry that's [up and running], or it [the Project] would be done (Participant ID # W3AM0O5F).

This perspective was unique because there were no other stakeholders that mentioned these political dynamics in the interviews. However, there were ENGO members that highlighted the controversial decision of the NL Government to waive the Project from further EA. Specifically, a member of NGO_5 noted,

> The provincial government of NL, despite being the key regulator, they have also put out a recent plan to expand the industry over the next five years, to double production. To them, it is all about the jobs. Understandable that they want jobs, but they are also taking a $45 million interest equity stake in the Grieg Project. And we have seen them three times now try to avoid their own EA process. So again, I see them almost being the proponent of the Project (Participant ID # RZGXQF23).

After the court decision of Justice Butler in 2017, Grieg NL was required by law to complete an EIA with an EIS that involved hearing and addressing public concerns with the Project. After completing the EIS, the current NL Minister of Municipal Affairs and

Environment, Honourable Andrew Parsons, released the Project from further environmental assessment with 16 conditions that promote the sustainable and responsible growth of aquaculture that Newfoundlanders value (NLDMAE, 2018b). Some of the more stringent conditions that the NL Government has imposed on Grieg NL include the following:

1. Grieg NL shall be required to mark all imported and grown in province Atlantic Salmon smolt for ease of identification in recapture, using a methodology approved by the Ministers of Municipal Affairs and Environment and Fisheries and Land Resources;
2. Grieg NL shall be required to conduct testing for triploidy when smolt are in the hatchery, at a sample size and frequency to be determined in consultation with Fisheries and Oceans Canada and the NLDFLR; and
3. Prior to operation of the sea cages, an onsite environmental monitor, funded by Grieg NL, shall be established to monitor the entire project, and provide reports to the NLDMAE. The monitor must be hired for the first 10 years of the Project operations to confirm outcomes at peak production (NLDMAE, 2018b).

The EIA process that Grieg NL completed resulted in more stringent conditions from the NLDMAE Minister, as noted above. These conditions may not have been imposed if the ASF had not taken the NL Government to court. As such, the mitigation measures were a positive movement for the ENGOs and other stakeholder groups, including conservation researchers, local residents and other industries on the BP that may be affected by the Project.

5.5 – Summary of key themes

The open-ended questions revealed four key themes describing the motivations behind different groups in the network: (1) social and economic benefits associated with the Project, (2) a debate about farmed salmon as healthy/unhealthy food, (3) environmental concerns, and (4) government regulation. The coalition that was promoting the Project focused on the job opportunities that the Project could bring to the BP, which would improve the social conditions for local residents. Conversely, the coalition that was opposed to the Project argued that there would be fewer jobs than expected, and that the jobs would be low-paying and volatile. Those opposed to the Project also expressed environmental concerns of salmon aquaculture and health concerns associated with eating farmed salmon. A further concern was the different levels of government, and especially the NL Government, which acted as both a promoter and regulator of the Project due to the political advantages they would gain on the BP with the Project. According to one research participant, these political advantages led the NL Government to bypass the proponent from performing an EIA, which was a key trigger for the court proceedings. Finally, despite the EIA being waived by the NL Government initially, stringent conditions were imposed on Grieg NL before the Project was finally approved.

Chapter 6 – Discussion

The Grieg NL Placentia Bay Atlantic Salmon Aquaculture Project was a historic case that started with a proposal in 2016 to develop 11 new salmon sites in Placentia Bay. Later in 2016, the NL Government waived the EIS for the Project, a controversial decision that resulted in a court case between the Government and the ASF. In court, the judge rule that an EIS was required. This was the first time that a proposed aquaculture project in Newfoundland received such strong opposition.

This research had two objectives: (1) to investigate the roles of different stakeholders throughout the Grieg NL process, and (2) to explore the underlying motivations of different stakeholders in the Grieg NL Project network. First, from the SNA, there were three key organizations identified that were leading two main coalitions: (1) the coalition promoting the Project due to the social and economic benefits it could bring the rural NL, led by two industry organizations (AQ_IND_1 and AQ_IND_2), and (2) the coalition opposed to the Project, led by an ENGO (NGO_2). Second, the four main underlying themes identified from the open-ended questions were: (1) social and economic benefits associated with the Project, (2) farmed salmon as healthy/unhealthy food, (3) environmental concerns, and (4) government regulation. These two methodologies aimed to improve understanding of the social network dynamics and motivations associated with the Grieg NL Placentia Bay Atlantic Salmon Aquaculture Project.

6.1 – Key players in the Grieg NL Project network

The communication network associated with the Grieg NL Project identified key stakeholders that had pivotal roles in the network. One measure that assesses communication in a network is network density, which is a way to standardize the amount of communication in a network, allowing for comparisons across networks regardless of the number of stakeholders involved (Hanneman & Riddle, 2005). From the SNA, the density for the Grieg NL Project network was 11%, which is higher than other coastal resource management networks. For instance, a study by Wilson & MacDonald (2018) reported a network density of 3.33% for a Bay of Fundy tidal power communication network. Other coastal resource management studies reported densities ranging from 0.5 to 6% (Carcamo et al., 2014; Vance-Borland & Holley, 2011). Accordingly, and comparing to other coastal zone resource projects, the Grieg NL Project network had greater communication between stakeholders, which could be due to the large scope of the Project (i.e., 7 million fish at peak production; Grieg NL, 2016b), and the extensive media coverage that engaged the public.

Total degree, betweenness and eigenvector centralities are three common measures used in SNA when analyzing the role of different stakeholders in communication networks (Carley, Reminga, Storrick, & Columbus, 2010). After determining that all three centralities were highly correlated across organizations/individuals, the average centrality was calculated and NGO_2 had the highest average centrality, indicating that it was the largest player in the network, followed by AQ_IND_2 and AQ_IND_1. In other words, NGO_2, AQ_IND_1 and AQ_IND_2 were the most active organizations in the Grieg NL case, which reveals the key roles that

ENGOs and the aquaculture industry play in opposing and supporting resource development projects, respectively. Indeed, similar findings have been noted in other resource development case studies (e.g., Gritten & Saastamoinen, 2010; McGee, Cullen, & Gunton, 2009), and even other aquaculture development case studies (e.g., Tassal and Okehampton Bay expansion in Tasmania; O'Connor, 2016). In the specific case of betweenness centrality, the theoretical maximum value is 1, and thus the maximum value in this study, 0.09, may seem small. A study by Weiss, Hamann, Kinney & Marsh (2012) on a marine wildlife co-management network in Northern Australia identified "rather low" betweenness centralities in the network. Moreover, a study by Leydesdorff (2007) used betweenness centrality as a measure of the interdisciplinarity of scientific journals, and identified a maximum betweenness centrality of 0.15. Therefore, the low betweenness centralities in the Grieg NL network, and other resource development project networks, suggest that key stakeholders talk among each other, and thus there are no true gatekeepers in the network that relay information between groups (Figure 8).

At the stakeholder group scale, the ENGOs had the highest mean centrality followed by the aquaculture industry, and their relatively high coefficient of variation for centrality indicated that both groups were highly heterogeneous in their communication. In other words, there were members of the ENGO and aquaculture industry stakeholder groups that played a more active role in the communication network compared to other members in their stakeholder group. This imbalance in the communication roles of actors in the ENGO and aquaculture industry stakeholder groups suggests that NGO_2, AQ_IND_1 and AQ_IND_2 are key players in their stakeholder groups.

Regarding the trust network at the stakeholder group scale, the ENGO and aquaculture industry groups were not trusted highly in the network, as indicated by their low in-degree trust scores. Interviews revealed that these stakeholder groups were not trusted due to their highly polarized views on the Project. Interestingly, Chambers (1993) noted that ENGO motivations are typically value-driven, and values often create polarized viewpoints. Hence, often the stakeholders that have less vested interests or less polarized views in management problems are the ones that are recipients of more trust in negotiations (Roberts, McNulty, & Stiles, 2005). This suggests that the stakeholder groups at polar extremes of a spectrum, such as ENGOs and aquaculture industry in this case, are subject to lower levels of trust.

Considering the communication and trust networks together brings to question the influence of the ENGO and aquaculture industry stakeholder groups on the public because, although they may be active in the communication network, their overall trust reputation is poor. As such, this may create public confusion about the effects of salmon aquaculture if two vocal, but relatively untrusted stakeholder groups are spreading contradicting information across the network. This problem has been recognized in recent studies (see Flaherty et al., 2018; Hynes, Skoland, Ravagnan, Gjerstad, & Krovel, 2018; Froehlich et al., 2017a; Osmundsen & Olsen, 2017). Further, Flaherty et al. (2018) noted the effectiveness of ENGOs in simplifying complex issues associated with aquaculture that can attract public attention and render opposition to the industry. One proposed solution to the public obtaining contradicting information from ENGOs and industry is the development of education programs designed by policy makers and industry (Flaherty et al., 2018), where SLO could be used as a tool to develop dialogue and educate different stakeholders on the effects of salmon aquaculture (Kelly et al., 2017).

6.2 – Social and economic benefits of the Project

The main reason that the coalition supportive of the Project had the backing of local citizens on the BP is due to the social and economic benefits that the Project could bring to the region. The Grieg NL Project was predicted to produce more than 800 jobs on the BP, most during the construction phase; however, approximately 128 of these jobs are considered part-time and full-time positions for salmon aquaculture operations (CBC, 2018b). The importance of jobs on the BP was emphasized by Marystown mayor, Sam Synard in a media interview, “we haven’t really had any meaningful employment [in Marystown] since the Kiewit job finished in 2015” (The Southern Gazette, 2017).

In September 2018, after getting approval to proceed with the Project from NLDMAE Minister Honourable Andrew Parsons, Grieg NL confirmed initial estimates that the Project would create more than 800 jobs at full production capacity (NLDFLR, 2018b). These 800 jobs would be broken down into 440 jobs associated with Grieg NL directly, and another 380 jobs in other affiliated sectors. Moreover, the NL Department of Finance performed a financial and economic impact analysis and concluded that at full capacity the Project will generate $33M in labour income and $82.5M in Gross Domestic Product annually (NLDFLR, 2018b). However, jobs can be unstable in the aquaculture industry, especially when there are disease outbreaks that can result in culling of the entire farm in severe instances (Assefa & Abunna, 2018). This point was mentioned by interview participants opposed to the Project who specifically referred to an ISA outbreak that occurred in St. Alban’s, NL where many jobs were lost.

It cannot be argued that there will be some jobs created with the Project; however, there has been recent speculation as to whether the BP has the workforce to fill all jobs that may arise as part of the Project. As reported in a recent CBC (2018c) report, Paul Antle, a businessman owning some of Marbase Marystown Inc., stated that Grieg NL and other companies part of the aquaculture industry would need to resort to immigrant labour to fill positions on the BP, as there were not enough human resources available in the area. Another report explained this further, suggesting that the Marystown Shipyard would be turned into an aquaculture hub by Marbase Marystown Inc. and jobs would need to be filled (The Telegram, 2018b). These statements by industry investors raise questions about whether local people on the BP will benefit from the Project. Not surprisingly, Paul Antle, has since retracted the statement that the Project will require immigrant labor.

One of the main topics in the Grieg NL case study was the anticipation of job opportunities, which is often one of the main drivers used by proponents to gain public support in aquaculture projects (Knapp & Rubino, 2016). For instance, on the east coast of the United States, traditional fishing communities have lost commercial fishing jobs, and aquaculture has filled some of these job vacancies, giving former fishing families a new livelihood (Lapointe, 2013). Specifically, several fishers are starting their own businesses growing mussels, oysters, seaweed and fish (Ruth et al., 2005). Instances like these point to the possibility that former fish harvesters may be hired into the aquaculture sector; however it remains to be seen whether this is the case in PB. As such, in places where aquaculture is restoring lost fishing livelihoods, people generally are supportive of the industry.

6.3 – Healthiness of farmed salmon and socio-ecological effects

The two main reasons why people opposed the Project were due to the pesticides used to control sea lice that raise concern about eating salmon as food, and the environmental effects of aquaculture on wild fish. The perception of farmed salmon being unhealthy due to pesticide treatments may have been triggered by the coalition opposed to the Project as a mechanism to increase opposition by attracting people that were passionate about healthy eating. The public backlash against pesticides and the negative effects of pesticides on the environment have triggered research efforts on alternative sea lice treatment methods, causing a reduction in the use of pesticides in Atlantic Canada (Hammel, 2018).

Regarding the socio-ecological effects of salmon aquaculture on wild fish and other coastal zone users, the main concern was expressed by anglers who were worried about the environmental effects of farmed salmon on dwindling Atlantic salmon stocks (see Chapter 2.1 for a review). Indeed, the environmental effects of salmon aquaculture remain the top concern of the public, and this statement can be generalized globally (Carr, 2019; Flaherty et al., 2018; Hynes et al., 2018; Froehlich et al., 2017b; Kelly et al., 2017; Olsen & Osmundsen, 2017; Osmundsen & Olsen, 2017). In Norway, there are constant debates about escapees and sea lice, whereas in Ireland, the main concern is the effects of sea lice on wild salmon, which is an important recreational fishery (Hynes et al., 2018). In Canada, on both the Atlantic and Pacific coasts, people recognize the importance of aquaculture in creating jobs; however, there is concern about the environmental effects (Flaherty et al., 2018). Canadians on the Pacific coast express more environmental concern than those on the Atlantic coast primarily because of the risks that farmed salmon pose on other species of wild salmon; the main concern on the Atlantic coast is the use of chemicals and antibiotics (Flaherty et al., 2018). Therefore, many of the issues expressed by concerned stakeholders associated with the Grieg NL Project are consistent with what is observed in Canada and other places around the world.

The potential environmental effects of salmon aquaculture have been recognized by the NL Government through the strict mitigation measures imposed on Grieg NL. First, all farmed salmon smolt had to be marked to facilitate recapture in the event of an escapement. Second, the use of triploid salmon was one condition of release; triploidy has been successfully applied to prevent introgression between escapees and wild fish in farm strain rainbow trout (Koenig, Kozfkay, Meyer, & Schill, 2011) and grass carp (Dick, Smith, Schad, & Owens, 2016). Although a more novel concept with Atlantic salmon, a recent study suggested that escaped triploid farmed Atlantic salmon cannot reproduce in the wild (Murray, Kainz, Hebberecht, Sales, Hindar, &

Gage, 2018). However, those opposed to the Project focused on the fact that there is only a 96 to 99% success rate of triploid induction in Atlantic salmon eggs (ASF, 2016). Finally, an onsite environmental monitor for sea cage operations that would report to the NLDMAE was required for the first 10 years of the Project to confirm the predicted environmental effects at peak production.

The negative environmental effects of salmon aquaculture are the main concern expressed by the public globally; however, the specific environmental concerns vary depending on the region (Carr, 2019; Flaherty et al., 2018; Hynes et al., 2018; Froehlich et al., 2017b; Kelly et al., 2017; Olsen & Osmundsen, 2017; Osmundsen & Olsen, 2017). In NL, salmon have high social and cultural relevance as an iconic species (DFO, 2018c), and as such, the majority of the concerns with the Grieg NL Project were oriented towards the effects of farmed salmon on wild salmon populations. Accordingly, the mitigation measures imposed on Grieg NL were oriented towards minimizing the risks to wild salmon. Although the imposed mitigation measures reduced some of the risks of farmed salmon on wild salmon populations, the risks were not eliminated, which is an issue that was recognized by Kapuscinski (2007) with triploid salmon. As such, the risks to wild salmon that are associated with salmon aquaculture are still an issue that must be considered by regulators and industry.

6.4 – Government regulation

The theme that the NL Government may have had deeper political motivations in releasing the Project from further environmental assessment in 2016 emphasizes a key problem in aquaculture regulation that government are regulators of the industry but also promoters. For instance, Rigby et al. (2017) recognized the NL Government as a regulator, investor and development advocate for the aquaculture private sector, particularly because aquaculture was seen as an opportunity after the cod collapse in 1992. Specifically with the Grieg NL case, government authorities were promoters for two main reasons. First, the NL Government authorities released Grieg NL from an EIA because of the government's desire to expedite investments, which was a clear motivation in this case study from the beginning. Second, authorities in the Grieg NL case had specific political motivations due to the advantages that politicians would gain with the social and economic regional benefits that would be given to the BP from the Project. The latter concept can be applied at a broader scale because resource development projects often offer social and economic benefits to communities that in turn present opportunities for politicians (Knapp & Rubino, 2016; Wappel, 2003; Phyne, 1996).

6.5 – A discussion/reflection on the relevance of spatial scale on SLO

The term SLO has its roots in the mining industry and is a relatively new term in the aquaculture industry (Mercer-Mapstone et al., 2017; Thomson & Boutilier, 2011). When considering the spatial scale of SLO, there has been much speculation in the mining industry over whether local communities are the lone entity responsible for granting or withholding SLO (Mather & Fanning, 2019). On one side, some argue that the communities will be the ones that experience firsthand both the positive and negative effects of resource developments, and thus should make decisions on SLO (Parsons, Lacey, & Moffat, 2014; Prno & Slocombe, 2012). On the other hand, Moffat, Lacey, Zhang, & Leipold (2015) argue that granting or withholding SLO should not be the sole responsibility of local communities since the world is becoming increasingly globalized and organization-driven. Furthermore, Dare et al. (2014) proposed that in an increasingly globalized world, companies will need to secure multiple SLOs at local, regional and global scales. These multiple scales can be simplified into two groups: (1) communities of place and (2) communities of interest, that distinguish stakeholders based on their proximity to a resource development site (Mather & Fanning, 2019; Dare et al., 2014).

When considering SLO with the Grieg NL case study, the spatial scale is highly relevant. If the boundaries for SLO included only residents of the BP (i.e., community of place; Mather & Fanning, 2019; Dare et al., 2014), Grieg NL may have claimed its SLO because the general public on the BP was on the whole in support of the Project from the beginning. However, if the boundaries for SLO included stakeholders outside of the local community at a larger spatial scale (i.e., community of interest; Mather & Fanning, 2019; Dare et al., 2014) such as anglers, conservationists, etc., Grieg NL did not have its SLO. For instance, the ASF is an organization that "is dedicated to the conservation, protection and restoration of wild Atlantic salmon and the ecosystems on which their well-being and survival depend" (ASF, 2017a). The ASF also promotes the recreational angling of Atlantic salmon, and receives most of its funding from its membership, which is broad spatially and includes Canadian, American and international members (ASF, 2017b). The large geographic extent of the ASF suggests that they are part of the community of interest group (Mather & Fanning, 2019). If the ASF had a relevant voice in the granting of Grieg NL's SLO, the proponent did not have access to their SLO. This problem of the aquaculture industry failing to address opposition at larger spatial scales such as nationally and internationally (i.e., communities of interest) has been recognized in the literature (Young & Liston, 2010). Yet, this concept of support by communities of place and opposition by communities of interest in the aquaculture industry cannot be generalized, as perceptions are often case-specific (Mather & Fanning, 2019). For instance, opposition to the aquaculture industry in British Columbia largely comes from coastal communities, including Indigenous groups that are worried about ecological effects and land rights (MacDonald, Murray, & Patterson, 2015; Shafer, Inglis, & Martin, 2010).

In summary, a conceptualization of SLO for aquaculture industry with clear spatial scales should be defined to help weight the voices of different stakeholders associated with aquaculture. However, often there will need to be multiple SLOs granted from stakeholders at the local, regional and global scales. Using SNA can help define the relevant stakeholders in resource development projects and at what spatial scales they operate at; as such, SNA is a tool that industry can use to obtain access to their SLOs.

Chapter 7 – Conclusion and Recommendations

7.1 – Conclusion

The Grieg NL Placentia Bay Atlantic Salmon Aquaculture Project involves the introduction of 11 new salmon sites in Placentia Bay, NL. Controversially, the project proposal was waived from the EIA process by the NL Government. The Government's decision to waive the EIA was challenged in court where the judge ruled that an EIA must be performed. Due to the historic nature of this case study, this research analyzed the stakeholder network, and identified two key coalitions using SNA: (1) the coalition supportive of the Project and the social and economic benefits generated from it, and (2) the coalition opposed to the Project due to the negative health and environmental effects. The former coalition was led by the aquaculture industry stakeholder group, whereas the latter coalition was led by the ENGO stakeholder group; both coalitions had clear vested interests in the Project. SNA is able to identify the key actors in a social network, but it should always be accompanied by open-ended questions to understand the underlying motivations of the key actors and other players in the network. From the open-ended questions in this study, there were four underlying themes identified: (1) social and economic benefits associated with the Project, (2) farmed salmon as healthy/unhealthy food, (3) environmental concerns, and (4) government regulation. The Grieg NL case study presented an opportunity to understand how stakeholders operate in salmon aquaculture developments, specifically when governments waive critical procedures such as EIAs in favour of aquaculture development. These stakeholder dynamics and motivations are important to understand because they can inform industry and regulators about the importance of EIAs, and established regulation in general, and the key issues recognized with salmon aquaculture developments, which can help in decision-making processes. Moreover, understanding and addressing the key concerns raised from EIAs can help industry claim its SLO. It still remains to be answered whether Grieg NL claimed its SLO for the Project, as this question largely depends on the geographic scale to be considered (i.e., community of place versus community of interest). If considering only the community of place, Grieg NL may have claimed its SLO, as the proponent appeared to have the backing of the majority of residents on the BP. This point stresses the need to clearly define the spatial scale of SLO to help weight the voices of different stakeholders associated with aquaculture.

7.2 – Recommendations

From this research, there are three key recommendations. First, when discussing SLO with aquaculture projects, due to the complex stakeholder networks in the coastal zone, it is crucial that spatial scale(s) for SLO are clearly defined. In some cases, aquaculture industry has been successful at obtaining SLO from stakeholders part of the community of place group, but are failing to obtain access to their SLO from stakeholders that are more geographically broad and part of the community of interest. The Grieg NL case study was an example of this concept; however, there are still anglers on the BP who are opposed to the Project, thus it is problematic to generalize the community of place being supportive of aquaculture developments and the community of interest being opposed to aquaculture developments (Mather & Fanning, 2019).

More research is needed to clearly indicate whether aquaculture industry should be obtaining multiple SLOs at different spatial scales or one SLO at a local scale. Second, this research stresses the importance of undergoing procedures such as EIAs, which can inform industry and regulators about the key salmon aquaculture concerns recognized by the public (Kelly, Pecl, & Flemming, 2017). Therefore, EIAs should not be waived by governments for political incentives, especially for projects that may cause significant social and environmental harm. Finally, an aquaculture regulatory framework is needed that provides solutions to the issue of government being both a regulator and promoter of aquaculture. Perhaps an independent regulatory body is needed that would eliminate the political motivations that are often associated with resource development projects.

Acknowledgements

Thank you to my biggest supporters throughout my education, my father and mother, Jim and Claudette Maxwell. To my co-supervisors, Ramon Filgueira and Charles Mather, for their endless dedication and positivity in advising me through the process. I would like to also acknowledge all of my interview participants that spent their valuable time speaking with me and helping me learn about the Project. To my internship host, Erin Laking, at Fisheries and Oceans Canada, thank you for the opportunity to develop my knowledge in aquaculture management. Scholarships and funding for this research were generously provided by the Douglas M. Johnston – MASC Scholarship in Marine Affairs, the Faculty of Graduate Studies at Dalhousie University, and the Ocean Frontier Institute. Last but certainly not least, thank you to all the friends I have met in the Marine Affairs Program (i.e, “Marine Mafia”, “MAP family”) for the inspiration and amazing times we had together.

References

AMEC Earth and Environmental Ltd. (2002). Aquaculture information review – an evaluation of known effects and mitigations on fish and fish habitat in Newfoundland and Labrador. Retrieved November 26, 2018, from http://waves-vagues.dfo-mpo.gc.ca/Library/268481.pdf

Andrady, A. L. (2011). Microplastics in the marine environment. *Marine Pollution Bulletin*, *62*(8), 1596–1605.

ASF. (2016). Letter to the Minister of Environment and Climate Change. Retrieved October 29, 2018, from https://0104.nccdn.net/1_5/0de/178/1ea/ASF-Appeal-to-Minister-Regarding-Placentia-Bay-Aquaculture-Approval.pdf

ASF. (2017a). About. Retrieved November 9, 2018, from http://asf.ca/about.html

ASF. (2017b). Special Membership Offer. Retrieved October 29, 2018, from http://asf.ca/special-offer-for-new-members.html

Assefa, A., & Abunna, F. (2018). Maintenance of Fish Health in Aquaculture: Review of Epidemiological Approaches for Prevention and Control of Infectious Disease of Fish. Retrieved October 29, 2018, from https://www.hindawi.com/journals/vmi/2018/5432497/

Atlantic Salmon Federation (Canada) v. Newfoundland (Environment and Climate Change), 2017 NLTD(G) 137

Baines, J., & Edwards, P. (2018). The role of relationships in achieving and maintaining a social licence in the New Zealand aquaculture sector. *Aquaculture*, *485*, 140–146. https://doi.org/10.1016/j.aquaculture.2017.11.047

Bakke, T. A., & Harris, P. D. (1998). Diseases and parasites in wild Atlantic salmon (Salmo salar) populations. *Canadian Journal of Fisheries and Aquatic Sciences*, *55*(S1), 247–266. https://doi.org/10.1139/d98-021

Bentsen, H. B., & Thodesen, J. (2005). Genetic interactions between farmed and wild fish, with examples from the Atlantic salmon case in Norway. In *Selection and breeding programs in aquaculture* (pp. 319–334). Springer.

Billing, S.-L. (2018). Using public comments to gauge social licence to operate for finfish aquaculture: Lessons from Scotland. *Ocean & Coastal Management*, *165*, 401–415. https://doi.org/10.1016/j.ocecoaman.2018.09.011

Bodin, Ö., Crona, B., & Ernstson, H. (2006). Social Networks in Natural Resource Management: What Is There to Learn from a Structural Perspective? *Ecology and Society*, *11*(2). Retrieved from https://www.jstor.org/stable/26266035

Bodin, Ö., & Crona, B. I. (2009). The role of social networks in natural resource governance: What relational patterns make a difference? *Global Environmental Change*, *19*(3), 366–374. https://doi.org/10.1016/j.gloenvcha.2009.05.002

Bonacich, P. (1987). Power and Centrality: A Family of Measures. *American Journal of Sociology*, *92*(5), 1170–1182. https://doi.org/10.1086/228631

Bostock, J., McAndrew, B., Richards, R., Jauncey, K., Telfer, T., Lorenzen, K., … Corner, R. (2010). Aquaculture: global status and trends. *Philosophical Transactions of the Royal Society B: Biological Sciences*, *365*(1554), 2897–2912. https://doi.org/10.1098/rstb.2010.0170

Boutilier, R. G. (2014). Frequently asked questions about the social licence to operate. *Impact Assessment and Project Appraisal*, *32*(4), 263–272. https://doi.org/10.1080/14615517.2014.941141

Braithwaite, R. A., & McEvoy, L. A. (2005). Marine biofouling on fish farms and its remediation. *Advances in Marine Biology*, *47*, 215–252. https://doi.org/10.1016/S0065-2881(04)47003-5

Burbridge, Hendrick, Roth, & Rosenthal. (2001). Social and economic policy issues relevant to marine aquaculture. *Journal of Applied Ichthyology*, *17*(4), 194–206. https://doi.org/10.1046/j.1439-0426.2001.00316.x

Burt, K., Hamoutene, D., Mabrouk, G., Lang, C., Puestow, T., Drover, D., … Page, F. (2012). Environmental conditions and occurrence of hypoxia within production cages of Atlantic salmon on the south coast of Newfoundland. *Aquaculture Research*, *43*(4), 607–620.

Burt, K., Hamoutene, D., Perez-Casanova, J., Kurt Gamperl, A., & Volkoff, H. (2013). The effect of intermittent hypoxia on growth, appetite and some aspects of the immune response of Atlantic salmon (Salmo salar). *Aquaculture Research*, *45*(1), 124–137.

Cárcamo, P. F., Garay-Flühmann, R., & Gaymer, C. F. (2014). Collaboration and knowledge networks in coastal resources management: How critical stakeholders interact for multiple-use marine protected area implementation. *Ocean & Coastal Management*, *91*, 5–16. https://doi.org/10.1016/j.ocecoaman.2014.01.007

Carley, K. M., Reminga, J., Storrick, J., & Columbus, D. (2010). ORA User's Guide 2010. Center for the Computational Analysis of Social and Organization Systems.

Carr, L. M. (2019). Seeking stakeholder consensus within Ireland's conflicted salmon aquaculture space. Marine Policy, 99, 201–212. https://doi.org/10.1016/j.marpol.2018.10.022

CBC. (2015). "Feels like we"re getting pushed out': Opinions divided on Marystown salmon hatchery | CBC News. Retrieved November 2, 2018, from https://www.cbc.ca/news/canada/newfoundland-labrador/aquaculture-expansion-1.3307672

CBC. (2017a). Judge's errors led to environmental assessment order of Grieg fish farm proposal, says N.L. government. Retrieved February 27, 2018, from http://www.cbc.ca/news/canada/newfoundland-labrador/grieg-salmon-farm-eis-appeal-1.4403367

CBC. (2017b). Do you support salmon farming in the province? Retrieved November 2, 2018, from https://www.cbc.ca/listen/shows/cross-talk/segment/13489389

CBC. (2018a). Jobs, environment clash at Marystown meeting about $250M salmon farm. Retrieved November 26, 2018, from https://www.cbc.ca/news/canada/newfoundland-labrador/grieg-marystown-meeting-1.4573778

CBC. (2018b). Here & Now Friday September 14 2018. Retrieved November 26, 2018, from https://www.youtube.com/watch?v=c4l8Cf7ANgU

CBC. (2018c). Immigrants needed to fill jobs at Marystown aquaculture hub, says Paul Antle. Retrieved October 28, 2018, from https://www.cbc.ca/news/canada/newfoundland-labrador/marbase-jobs-immigration-1.4848577

Chambers, E. (1993). *Challenging the professions: frontiers for rural development*. London: ITDG Publishing.

Chopin, T. (2015). Marine aquaculture in Canada: well-established monocultures of finfish and shellfish and an emerging Integrated Multi-Trophic Aquaculture (IMTA) approach including seaweeds, other invertebrates, and microbial communities. *Fisheries*, *40*(1), 28–31.

Costello, M. J., & Ballantine, B. (2015). Biodiversity conservation should focus on no-take Marine Reserves: 94% of Marine Protected Areas allow fishing. *Trends in Ecology & Evolution*, *30*(9), 507–509. https://doi.org/10.1016/j.tree.2015.06.011

CSAS. (2016). Proposed use of European-strain triploid Atlantic salmon in marine cage aquaculture in Placentia Bay, NL. Retrieved November 26, 2018, from http://waves-vagues.dfo-mpo.gc.ca/Library/40621248.pdf

Dalton, T. M., & Jin, D. (2018). Attitudinal Factors and Personal Characteristics Influence Support for Shellfish Aquaculture in Rhode Island (US) Coastal Waters. *Environmental Management*, *61*(5), 848–859. https://doi.org/10.1007/s00267-018-1011-z

Dare, M., Schirmer, J., & Vanclay, F. (2014). Community engagement and social licence to operate. Impact Assessment and Project Appraisal, 32(3), 188–197. https://doi.org/10.1080/14615517.2014.927108

Dempster, T., Sanchez-Jerez, P., Fernandez-Jover, D., Bayle-Sempere, J., Nilsen, R., Bjørn, P.-A., & Uglem, I. (2011). Proxy Measures of Fitness Suggest Coastal Fish Farms Can Act as Population Sources and Not Ecological Traps for Wild Gadoid Fish. *PLOS ONE*, *6*(1), e15646. https://doi.org/10.1371/journal.pone.0015646

DFO. (2015). National Aquaculture Strategic Action Plan Initiative – Overarching Document. Retrieved October 20, 2018, from http://www.dfo-mpo.gc.ca/aquaculture/lib-bib/nasapi-inpasa/Report-eng.htm

DFO. (2018a). Aquaculture Production Quantities and Values. Retrieved November 26, 2018, from http://www.dfo-mpo.gc.ca/stats/aqua/aqua16-eng.htm

DFO. (2018b). Canada's Fisheries Fast Facts 2017. Retrieved November 7, 2018, from http://waves-vagues.dfo-mpo.gc.ca/Library/40706990.pdf

DFO. (2018c). Canada's Wild Atlantic Salmon Conservation Policy. Retrieved November 26, 2018, from http://www.dfo-mpo.gc.ca/reports-rapports/regs/wildsalmon-atl-saumonsauvage-eng.htm

DFO. (2018d). Aquaculture Activities Regulations. Retrieved November 26, 2018, from http://www.dfo-mpo.gc.ca/aquaculture/management-gestion/aar-raa-eng.htm

Dick, G. O., Smith, D. H., Schad, A. N., & Owens, C. S. (2016). Native aquatic vegetation establishment in the presence of triploid grass carp. *Lake and Reservoir Management*, *32*(3), 225–233. https://doi.org/10.1080/10402381.2016.1167147

Ernoul, L., & Wardell-Johnson, A. (2013). Governance in integrated coastal zone management: a social networks analysis of cross-scale collaboration. *Environmental Conservation*, *40*(3), 231–240. https://doi.org/10.1017/S0376892913000106

Evans, K. S., Chen, X., & Robichaud, C. A. (2017). A Hedonic Analysis of the Impact of Marine Aquaculture on Coastal Housing Prices in Maine. *Agricultural and Resource Economics Review*, *46*(2), 242–267. https://doi.org/10.1017/age.2017.19

FAO. (2016). The State of World Fisheries and Aquaculture (SOFIA) | FAO | Food and Agriculture Organization of the United Nations. Retrieved November 26, 2018, from http://www.fao.org/publications/sofia/2016/en/

FAO. (2018). The State of World Fisheries and Aquaculture 2018 | FAO. Retrieved November 26, 2018, from http://www.fao.org/family-farming/detail/en/c/1145050/

Fitridge, I., Dempster, T., Guenther, J., & Nys, R. de. (2012). The impact and control of biofouling in marine aquaculture: a review. *Biofouling*, *28*(7), 649–669. https://doi.org/10.1080/08927014.2012.700478

Flaherty, M., Reid, G., Chopin, T., & Latham, E. (2018). Public attitudes towards marine aquaculture in Canada: insights from the Pacific and Atlantic coasts. Aquaculture International. https://doi.org/10.1007/s10499-018-0312-9

Freeman, L. C. (1979). Centrality in social networks conceptual clarification. *Social Networks*, *1*(3), 215–239.

Froehlich, H. E., Gentry, R. R., & Halpern, B. S. (2017a). Conservation aquaculture: Shifting the narrative and paradigm of aquaculture's role in resource management. Biological Conservation, 215, 162–168. https://doi.org/10.1016/j.biocon.2017.09.012

Froehlich, H. E., Gentry, R. R., Rust, M. B., Grimm, D., & Halpern, B. S. (2017b). Public Perceptions of Aquaculture: Evaluating Spatiotemporal Patterns of Sentiment around the World. PLOS ONE, 12(1), e0169281. https://doi.org/10.1371/journal.pone.0169281

Glover, K. A., Solberg, M. F., McGinnity, P., Hindar, K., Verspoor, E., Coulson, M. W., … Svåsand, T. (2017). Half a century of genetic interaction between farmed and wild Atlantic salmon: Status of knowledge and unanswered questions. *Fish and Fisheries*, *18*(5), 890–927. https://doi.org/10.1111/faf.12214

Government of NL and Labrador. (2016). The Way Forward: a vision for sustainability and growth in Newfoundland and Labrador. Retrieved November 26, 2018, from https://www.gov.nl.ca/pdf/the_way_forward.pdf

Government of NL and Labrador. (2017). The Economy 2017. Retrieved November 13, 2018, from https://www.economics.gov.nl.ca/E2017/TheEconomy2017.pdf

Gray, J. S., Wu, R. S., & Or, Y. Y. (2002). Effects of hypoxia and organic enrichment on the coastal marine environment. *Marine Ecology Progress Series*, *238*, 249–279.

Gregory, M. R. (2009). Environmental implications of plastic debris in marine settings—entanglement, ingestion, smothering, hangers-on, hitch-hiking and alien invasions. *Philosophical Transactions of the Royal Society B: Biological Sciences*, *364*(1526), 2013–2025. https://doi.org/10.1098/rstb.2008.0265

Grieg NL. (2016a). The following is a statement from Grieg NL. Retrieved November 26, 2018, from https://www.griegnl.com/the-following-is-a-statement-from-grieg-nl/

Grieg NL. (2016b). Registration of an undertaking under the Environmental Assessment Regulations, 2003, Section 29 "Placentia Bay Atlantic Salmon Aquaculture Project". Retrieved November 26, 2018, from https://www.mae.gov.nl.ca/env_assessment/projects/Y2016/1834/1834_reg_doc_hatchery_copy.pdf

Gritten, D., & Saastamoinen, O. (2010). The Roles of Legitimacy in Environmental Conflict: An Indonesian Case Study. *Society & Natural Resources*, *24*(1), 49–64. https://doi.org/10.1080/08941920802713580

Gross, M. R. (1998). One species with two biologies: Atlantic salmon (Salmo salar) in the wild and in aquaculture. *Canadian Journal of Fisheries and Aquatic Sciences*, *55*(S1), 131–144. https://doi.org/10.1139/d98-024

Hammel, L. (2018). Presentation at the Atlantic Canada Fish Farmers' Association Conference, Saint Andrews, NB. 24 to 25 October 2018.

Hamoutene, D. (2014). Sediment sulphides and redox potential associated with spatial coverage of Beggiatoa spp. at finfish aquaculture sites in Newfoundland, Canada. *ICES Journal of Marine Science*, *71*(5), 1153–1157. https://doi.org/10.1093/icesjms/fst223

Hanneman, R. A., & Riddle, M. (2005). *Introduction to social network methods*. University of California Riverside.

Hargrave, B. T. (2010). Empirical relationships describing benthic impacts of salmon aquaculture. *Aquaculture Environment Interactions*, *1*(1), 33–46.

Hartley, T. W. (2010). Fishery management as a governance network: Examples from the Gulf of Maine and the potential for communication network analysis research in fisheries. *Marine Policy*, *34*(5), 1060–1067. https://doi.org/10.1016/j.marpol.2010.03.005

Hinojosa, I. A., & Thiel, M. (2009). Floating marine debris in fjords, gulfs and channels of southern Chile. *Marine Pollution Bulletin*, *58*(3), 341–350.

Hofherr, J., Natale, F., & Trujillo, P. (2015). Is lack of space a limiting factor for the development of aquaculture in EU coastal areas? *Ocean & Coastal Management*, *116*, 27–36. https://doi.org/10.1016/j.ocecoaman.2015.06.010

Holmer, M., Marbá, N., Terrados, J., Duarte, C. M., & Fortes, M. D. (2002). Impacts of milkfish (Chanos chanos) aquaculture on carbon and nutrient fluxes in the Bolinao area, Philippines. *Marine Pollution Bulletin*, *44*(7), 685–696.

Hutchison, M. (2006). *Towards consensus building within Canada's aquaculture industry: Design of a framework for addressing conflict, information management and public consultation* (M.Sc.E.). University of New Brunswick (Canada), Canada. Retrieved from https://search.proquest.com/docview/304935617/abstract/284D5C754CF54C58PQ/1

Hynes, S., Skoland, K., Ravagnan, E., Gjerstad, B., & Krøvel, A. V. (2018). Public attitudes toward aquaculture: An Irish and Norwegian comparative study. Marine Policy, 96, 1–8. https://doi.org/10.1016/j.marpol.2018.07.011

Jensen, Ø., Dempster, T., Thorstad, E. B., Uglem, I., & Fredheim, A. (2010). Escapes of fishes from Norwegian sea-cage aquaculture:: causes, consequences and prevention. *Aquaculture Environment Interactions*, *1*(1), 71–83.

Jonsson, B., & Jonsson, N. (2006). Cultured Atlantic salmon in nature: a review of their ecology and interaction with wild fish. *ICES Journal of Marine Science*, *63*(7), 1162–1181.

Jung, R.-T., Sung, H. G., Chun, T.-B., & Keel, S.-I. (2010). Practical engineering approaches and infrastructure to address the problem of marine debris in Korea. *Marine Pollution Bulletin*, *60*(9), 1523–1532.

Kalantzi, I., Shimmield, T. M., Pergantis, S. A., Papageorgiou, N., Black, K. D., & Karakassis, I. (2013). Heavy metals, trace elements and sediment geochemistry at four Mediterranean fish farms. *Science of the Total Environment*, *444*, 128–137.

Kapuscinski, A. R. (2007). Environmental Risk Assessment of Genetically Modified Organisms. CABI.

Karlsson, S., Diserud, O. H., Fiske, P., & Hindar, K. (2016). Widespread genetic introgression of escaped farmed Atlantic salmon in wild salmon populations. *ICES Journal of Marine Science*, *73*(10), 2488–2498. https://doi.org/10.1093/icesjms/fsw121

Keck, M., & Sakdapolrak, P. (2013). What is social resilience? Lessons learned and ways forward. JSTOR. Retrieved September 3, 2018, from https://www-jstor-org.ezproxy.library.dal.ca/stable/23595352

Kelly, R., Pecl, G. T., & Fleming, A. (2017). Social licence in the marine sector: A review of understanding and application. Marine Policy, 81, 21–28. https://doi.org/10.1016/j.marpol.2017.03.005

Kemper, C. M., Pemberton, D., Cawthorn, M., Heinrich, S., Mann, J., Wursig, B., … Gales, R. (2003). Aquaculture and marine mammals: co-existence or conflict. *Marine Mammals: Fisheries, Tourism and Management Issues*, 208–225.

Keyser, F., Wringe, B. F., Jeffery, N. W., Dempson, J. B., Duffy, S., & Bradbury, I. R. (2018). Predicting the impacts of escaped farmed Atlantic salmon on wild salmon populations. *Canadian Journal of Fisheries and Aquatic Sciences*, *75*(4), 506–512. https://doi.org/10.1139/cjfas-2017-0386

Kinsella, S. (2017, September 26). Ball unveils aquaculture plan to double year-round jobs | CBC News. Retrieved June 17, 2018, from http://www.cbc.ca/news/canada/newfoundland-labrador/premier-dwight-ball-aquaculture-plan-jobs-1.4307840

Knapp, G., & Rubino, M. C. (2016). The Political Economics of Marine Aquaculture in the United States. *Reviews in Fisheries Science & Aquaculture*, *24*(3), 213–229. https://doi.org/10.1080/23308249.2015.1121202

Koenig, M. K., Kozfkay, J. R., Meyer, K. A., & Schill, D. J. (2011). Performance of Diploid and Triploid Rainbow Trout Stocked in Idaho Alpine Lakes. *North American Journal of Fisheries Management*, *31*(1), 124–133. https://doi.org/10.1080/02755947.2011.561163

Kripa, V. (2015). Ecosystem Approach to Aquaculture [Teaching Resource]. Retrieved November 11, 2018, from http://eprints.cmfri.org.in/10663/

Krause, G., Brugere, C., Diedrich, A., Ebeling, M. W., Ferse, S. C. A., Mikkelsen, E., … Troell, M. (2015). A revolution without people? Closing the people–policy gap in aquaculture development. *Aquaculture*, *447*, 44–55. https://doi.org/10.1016/j.aquaculture.2015.02.009

Lapointe, G. (2013). NROC White Paper: Overview of the Aquaculture Sector in New England. Retrieved November 22, 2018, from https://northeastoceancouncil.org/wp-content/uploads/2013/03/Aquaculture-White-Paper.pdf

Leydesdorff, L. (2007). Betweenness centrality as an indicator of the interdisciplinarity of scientific journals. *Journal of the American Society for Information Science and Technology*, *58*(9), 1303–1319. https://doi.org/10.1002/asi.20614

Liu, Y., Rosten, T. W., Henriksen, K., Hognes, E. S., Summerfelt, S., & Vinci, B. (2016). Comparative economic performance and carbon footprint of two farming models for producing Atlantic salmon (Salmo salar): Land-based closed containment system in freshwater and open net pen in seawater. *Aquacultural Engineering*, *71*, 1–12. https://doi.org/10.1016/j.aquaeng.2016.01.001

MacDonald, P. A., Murray, G., & Patterson, M. (2015). Considering social values in the seafood sector using the Q-method. *Marine Policy*, *52*, 68–76. https://doi.org/10.1016/j.marpol.2014.10.029

Macfadyen, G., Huntington, T., & Cappell, R. (2009). Abandoned, lost or otherwise discarded fishing gear. *FAO Fisheries and Aquaculture Technical Paper*, (No.523). Retrieved from https://www.cabdirect.org/cabdirect/abstract/20093147840

Madhun, A. S., Karlsbakk, E., Isachsen, C. H., Omdal, L. M., Eide Sørvik, A. G., Skaala, Ø., … Glover, K. A. (2015). Potential disease interaction reinforced: double-virus-infected escaped farmed Atlantic salmon, Salmo salar L., recaptured in a nearby river. *Journal of Fish Diseases*, *38*(2), 209–219.

Madhun, A. S., Wennevik, V., Skilbrei, O. T., Karlsbakk, E., Skaala, Ø., Fiksdal, I. U., … Glover, K. A. (2017). The ecological profile of Atlantic salmon escapees entering a river throughout an entire season: diverse in escape history and genetic background, but frequently virus-infected. *ICES Journal of Marine Science*, *74*(5), 1371–1381. https://doi.org/10.1093/icesjms/fsw243

Marshall, J. (2001). Landlords, leaseholders & sweat equity: changing property regimes in aquaculture. *Marine Policy*, *25*(5), 335–352. https://doi.org/10.1016/S0308-597X(01)00020-3

Mather, C., & Fanning, L. (2019). Social licence and aquaculture: Towards a research agenda. *Marine Policy*, *99*, 275–282. https://doi.org/10.1016/j.marpol.2018.10.049

Mazur, N. A., & Curtis, A. L. (2006). Risk Perceptions, Aquaculture, and Issues of Trust: Lessons From Australia. *Society & Natural Resources*, *19*(9), 791–808. https://doi.org/10.1080/08941920600835551

McGee, G., Cullen, A., & Gunton, T. (2010). A new model for sustainable development: a case study of The Great Bear Rainforest regional plan. *Environment, Development and Sustainability*, *12*(5), 745–762. https://doi.org/10.1007/s10668-009-9222-3

Mercer-Mapstone, L., Rifkin, W., Louis, W., & Moffat, K. (2017). Meaningful dialogue outcomes contribute to laying a foundation for social licence to operate. *Resources Policy*, *53*, 347–355. https://doi.org/10.1016/j.resourpol.2017.07.004

Milewski, I., Loucks, R. H., Fisher, B., Smith, R. E., McCain, J. S. P., & Lotze, H. K. (2018). Sea-cage aquaculture impacts market and berried lobster (Homarus americanus) catches. *Marine Ecology Progress Series*, *598*, 85–97. https://doi.org/10.3354/meps12623

Moffat, K., Lacey, J., Zhang, A., & Leipold, S. (2015). The social licence to operate: A critical review. Forestry, 1–12.

Murphy-Gregory, H. (2018). Governance via persuasion: environmental NGOs and the social licence to operate. *Environmental Politics*, *27*(2), 320–340. https://doi.org/10.1080/09644016.2017.1373429

Murray, D. S., Kainz, M. J., Hebberecht, L., Sales, K. R., Hindar, K., & Gage, M. J. G. (2018). Comparisons of reproductive function and fatty acid fillet quality between triploid and diploid farm Atlantic salmon (Salmo salar). *Royal Society Open Science*, *5*(8), 180493.

Narayanan, S. (1995). Marine climate off Newfoundland and its influence on salmon (Salmo salar) and capelin (Mallotus villosus). *Climate Change and Northern Fish Populations*. Retrieved from https://ci.nii.ac.jp/naid/10022014044/

Nash, C. E. (2003). Interactions of Atlantic salmon in the Pacific Northwest: VI. A synopsis of the risk and uncertainty. *Fisheries Research*, *62*(3), 339–347.

Nash, C. E., Iwamoto, R. N., & Mahnken, C. V. (2000). Aquaculture risk management and marine mammal interactions in the Pacific Northwest. *Aquaculture*, *183*(3-4), 307–323.

Natale, F., Hofherr, J., Fiore, G., & Virtanen, J. (2013). Interactions between aquaculture and fisheries. *Marine Policy*, *38*(Supplement C), 205–213. https://doi.org/10.1016/j.marpol.2012.05.037

Naylor, R. L., Goldburg, R. J., Primavera, J. H., Kautsky, N., Beveridge, M. C. M., Clay, J., … Troell, M. (2000). Effect of aquaculture on world fish supplies. *Nature*, *405*(6790), 1017. https://doi.org/10.1038/35016500

Naylor, R. L., Hardy, R. W., Bureau, D. P., Chiu, A., Elliott, M., Farrell, A. P., … Nichols, P. D. (2009). Feeding aquaculture in an era of finite resources. *Proceedings of the National Academy of Sciences*, *106*(36), 15103–15110. https://doi.org/10.1073/pnas.0905235106

Neori, A., Chopin, T., Troell, M., Buschmann, A. H., Kraemer, G. P., Halling, C., … Yarish, C. (2004). Integrated aquaculture: rationale, evolution and state of the art emphasizing seaweed biofiltration in modern mariculture. *Aquaculture*, *231*(1), 361–391. https://doi.org/10.1016/j.aquaculture.2003.11.015

New Brunswick Department of Agriculture, Aquaculture and Fisheries. (2011). Aquaculture Act. Retrieved October 29, 2018, from http://laws.gnb.ca/en/showdoc/cs/2011-c.112/se:1;se:2

NLDFLR. (2018a). Statistics. Retrieved November 26, 2018, from https://www.fishaq.gov.nl.ca/stats/

NLDFLR. (2018b). New Aquaculture Project to Create Hundreds of Jobs on the Burin Peninsula. Retrieved October 28, 2018, from https://www.releases.gov.nl.ca/releases/2018/exec/0914n04.aspx

NLDFLR. (2018c). Legislation | Fisheries and Aquaculture. Retrieved October 29, 2018, from https://www.fishaq.gov.nl.ca/department/legislation.html

NLDMAE. (2003). Legislation | Municipal Affairs. Retrieved November 13, 2018, from https://www.mae.gov.nl.ca/department/legislation.html#envAss

NLDMAE. (2017). Environmental Assessment Bulletin. Retrieved November 26, 2018, from https://www.mae.gov.nl.ca/env_assessment/bulletins/Y2017/20171122.pdf

NLDMAE. (2018a). Placentia Bay Atlantic Salmon Aquaculture Project. Retrieved January 15, 2018, from http://www.mae.gov.nl.ca/env_assessment/projects/Y2016/1834/

NLDMAE. (2018b). Environmental Assessment Bulletin. Retrieved November 26, 2018, from https://www.mae.gov.nl.ca/env_assessment/bulletins/Y2018/20180906.pdf

NL Statistics Agency (2018). Population Estimates, July 1, 2001 to 2017, Census Divisions and St. John's Census Metropolitan Area (CMA), Newfoundland and Labrador. Retrieved November 26, 2018, from http://www.stats.gov.nl.ca/statistics/population/pdf/population_estimates_cdcma.pdf

Nova Scotia Department of Fisheries and Aquaculture. (2014, October 20). Government of Nova Scotia. Retrieved October 29, 2018, from https://novascotia.ca/fish/aquaculture/laws-regs/

O'Connor, T. (2016). Tassal's east coast expansion plans halted pending review. Retrieved October 20, 2018, from https://www.abc.net.au/news/2016-08-12/tassal-okehampton-bay-expansion-plans-halted/7722940

Office of the Auditor General of Canada. (2018). Report 1 – Salmon Farming. Retrieved November 26, 2018, from http://www.oag-bvg.gc.ca/internet/English/parl_cesd_201804_01_e_42992.html

Olsen, M. S., & Osmundsen, T. C. (2017). Media framing of aquaculture. Marine Policy, 76, 19–27. https://doi.org/10.1016/j.marpol.2016.11.013

Osmundsen, T. C., & Olsen, M. S. (2017). The imperishable controversy over aquaculture. Marine Policy, 76, 136–142. https://doi.org/10.1016/j.marpol.2016.11.022

Ottolenghi, F. (2008). Capture-based aquaculture of bluefin tuna. *Capture-Based Aquaculture. Global Overview. FAO Fisheries Technical Paper*, *508*, 169–182.

Parag, Y., Hamilton, J., White, V., & Hogan, B. (2013). Network approach for local and community governance of energy: The case of Oxfordshire. *Energy Policy*, *62*, 1064–1077. https://doi.org/10.1016/j.enpol.2013.06.027

Pariona, A. (2017). The Coastline Of Canada, The Longest In The World. Retrieved June 17, 2018, from https://www.worldatlas.com/articles/the-coastline-of-canada-the-longest-in-the-world.html

Parsons, R., Lacey, J., & Moffat, K. (2014). Maintaining legitimacy of a contested practice: How the minerals industry understands its "social licence to operate." Resources Policy, 41, 83–90. https://doi.org/10.1016/j.resourpol.2014.04.002

Pelling, M., & High, C. (2005). Understanding adaptation: what can social capital offer assessments of adaptive capacity? *Global Environmental Change*, *15*(4), 308–319.

Pérez, M., García, T., Invers, O., & Ruiz, J. M. (2008). Physiological responses of the seagrass Posidonia oceanica as indicators of fish farm impact. *Marine Pollution Bulletin*, *56*(5), 869–879. https://doi.org/10.1016/j.marpolbul.2008.02.001

Phyne, J. (1996). Along the coast and in the state: Aquaculture and politics in Nova Scotia and New Brunswick. *Aquaculture Development: Social Dimensions in an Emerging Industry, Edited by Conner Bailey, Svein Jentofl and Peter Sinclair, Westview Press Inc*.

Pinkerton, E., & Silver, J. (2011). Cadastralizing or coordinating the clam commons: Can competing community and government visions of wild and farmed fisheries be reconciled? *Marine Policy*, *35*(1), 63–72. https://doi.org/10.1016/j.marpol.2010.08.002

Price, C., Black, K. D., Hargrave, B. T., & Jr, J. A. M. (2015). Marine cage culture and the environment: effects on water quality and primary production. *Aquaculture Environment Interactions*, *6*(2), 151–174. https://doi.org/10.3354/aei00122

Price, C. S., Morris, J. A., Keane, E. P., Morin, D. M., Vaccaro, C., & Bean, D. W. W. (2017). Protected species and marine aquaculture interactions.

Primavera, J. (2006). Overcoming the impacts of aquaculture on the coastal zone. *Ocean & Coastal Management*, *49*(9-10), 531–545.
Prno, J., & Slocombe, S. D. (2012). Exploring the origins of “social license to operate” in the mining sector: Perspectives from governance and sustainability theories. Resources Policy, 37(3), 346–357. https://doi.org/10.1016/j.resourpol.2012.04.002
Province of New Brunswick. (2010). New Brunswick Finfish Aquaculture Development Strategy 2010-2014. Retrieved November 26, 2018, from https://www2.gnb.ca/content/dam/gnb/Departments/10/pdf/Publications/Aqu/FinfishStrategy2010-2014.pdf
Renaud-Byrne, G, 2017. Social-Ecological Resilience to Climate Change: A case Study of the Sandy Island Oyster Bed Marine Protected Area [graduate project]. Halifax, NS: Dalhousie University.
Ribic, C. A., Sheavly, S. B., & Klavitter, J. (2012). Baseline for beached marine debris on Sand Island, Midway Atoll. *Marine Pollution Bulletin*, *64*(8), 1726–1729.
Ricketts, P., & Harrison, P. (2007). Coastal and ocean management in Canada: moving into the 21st century. *Coastal Management*, *35*(1), 5–22.
Rigby, B., Davis, R., Bavington, D., & Baird, C. (2017). Industrial aquaculture and the politics of resignation. *Marine Policy*, *80*, 19–27. https://doi.org/10.1016/j.marpol.2016.10.016
Roberts, J., McNulty, T., & Stiles, P. (2005). Beyond Agency Conceptions of the Work of the Non-Executive Director: Creating Accountability in the Boardroom. *British Journal of Management*, *16*(s1), S5–S26. https://doi.org/10.1111/j.1467-8551.2005.00444.x
Robins, G., Bates, L., & Pattison, P. (2011). Network Governance and Environmental Management: Conflict and Cooperation. *Public Administration*, *89*(4), 1293–1313. https://doi.org/10.1111/j.1467-9299.2010.01884.x
Robinson, S. M. C., Auffrey, L. M., & Barbeau, M. A. (n.d.). Far-Field Impacts of Eutrophication on the Intertidal Zone in the Bay of Fundy, Canada with Emphasis on the Soft-Shell Clam, <Emphasis Type=“Italic”>Mya arenaria</Emphasis>. In *Environmental Effects of Marine Finfish Aquaculture* (pp. 253–274). Springer, Berlin, Heidelberg. Retrieved from https://link.springer.com/chapter/10.1007/b136014
Ruth, A. M., Sturmer, L., & Adams, C. M. (2005). Organizational Structures and Strategies For the Hard Clam Aquaculture Industry in Florida [Monograph or Serial Issue]. Retrieved November 22, 2018, from http://nsgl.gso.uri.edu/flsgp/flsgps05001.pdf
Salvo, F., Hamoutene, D., & Dufour, S. C. (2015). Trophic analyses of opportunistic polychaetes (Ophryotrocha cyclops) at salmonid aquaculture sites. *Journal of the Marine Biological Association of the United Kingdom*, *95*(4), 713–722. https://doi.org/10.1017/S0025315414002070
San Diego-McGlone, M. L., Azanza, R. V., Villanoy, C. L., & Jacinto, G. S. (2008). Eutrophic waters, algal bloom and fish kill in fish farming areas in Bolinao, Pangasinan, Philippines. *Marine Pollution Bulletin*, *57*(6-12), 295–301. https://doi.org/10.1016/j.marpolbul.2008.03.028
Scott, J. (1988). Social Network Analysis. *Sociology*, *22*(1), 109–127. https://doi.org/10.1177/0038038588022001007
Shah, I. A. (2004). Environmental impact assessment: an effective management tool. *Journal of Engineering and Applied Sciences (Peshawar)*, *23*(2), 85–95.
Shah, S. Q. A., Cabello, F. C., L’Abée-Lund, T. M., Tomova, A., Godfrey, H. P., Buschmann, A. H., & Sørum, H. (2014). Antimicrobial resistance and antimicrobial resistance genes in marine bacteria from salmon aquaculture and non-aquaculture sites. *Environmental Microbiology*, *16*(5), 1310–1320. https://doi.org/10.1111/1462-2920.12421

Shafer, C. S., Inglis, G. J., & Martin, V. (2010). Examining Residents' Proximity, Recreational Use, and Perceptions Regarding Proposed Aquaculture Development. Coastal Management, 38(5), 559–574. https://doi.org/10.1080/08920753.2010.511700

Sindermann, C. J. (1990). *Principal Diseases of Marine Fish and Shellfish: Diseases of marine fish*. Gulf Professional Publishing.

Soto, D., Aguilar-Manjarrez, J., Brugère, C., Angel, D., Bailey, C., Black, K., … Deudero, S. (2008). Applying an ecosystem-based approach to aquaculture: principles, scales and some management measures. *Building an Ecosystem Approach to Aquaculture*, *14*.

Stabel, D. (2011). *Do salmon aquaculture sites alter wild fish communities in the Broughton Archipelago?* (Thesis). Retrieved from https://dspace.library.uvic.ca//handle/1828/3742

Strafella, P., Fabi, G., Spagnolo, A., Grati, F., Polidori, P., Punzo, E., … Cvitkovic, I. (2015). Spatial pattern and weight of seabed marine litter in the northern and central Adriatic Sea. *Marine Pollution Bulletin*, *91*(1), 120–127.

Surprenant, D. (2010). *Aquaculture in Eastern Canada*. Parliamentary Information and Research Service.

Suryanata, K., & Umemoto, K. N. (2003). Tension at the Nexus of the Global and Local: Culture, Property, and Marine Aquaculture in Hawai'i. *Environment and Planning A: Economy and Space*, *35*(2), 199–213. https://doi.org/10.1068/a35116

The Globe and Mail. (2018). Canada not properly managing fish farms: environment commissioner. Retrieved from https://www.theglobeandmail.com/politics/article-canada-not-properly-managing-fish-farms-environment-commissioner/

The Southern Gazette. (2017). Marystown mayor disheartened by Placentia Bay aquaculture project ruling | The Southern Gazette. Retrieved October 2, 2018, from http://www.southerngazette.ca/news/local/marystown-mayor-disheartened-by-placentia-bay-aquaculture-project-ruling-89957/

The Telegram. (2018a). Grieg NL preparing site for construction phase. Retrieved October 2, 2018, from http://www.thetelegram.com/news/local/grieg-nl-preparing-site-for-construction-phase-239227/

The Telegram. (2018b). Plan in works to turn Marystown Shipyard into aquaculture service hub. Retrieved October 28, 2018, from http://www.thetelegram.com/business/plan-in-works-to-turn-marystown-shipyard-into-aquaculture-service-hub-232596/

Thomson, I., & Boutilier, R. G. (2011). Social license to operate. *SME Mining Engineering Handbook*, *1*, 1779–1796.

Thorstad, E. B., Fleming, I. A., McGinnity, P., Soto, D., Wennevik, V., & Whoriskey, F. (2008). Incidence and impacts of escaped farmed Atlantic salmon Salmo salar in nature. *NINA Special Report*, *36*(6).

Vance-Borland, K., & Holley, J. (2011). Conservation stakeholder network mapping, analysis, and weaving. *Conservation Letters*, *4*(4), 278–288. https://doi.org/10.1111/j.1755-263X.2011.00176.x

Van de Ven, A. H., Walker, G., & Liston, J. (1979). Coordination Patterns Within an Interorganizational Network. *Human Relations*, *32*(1), 19–36. https://doi.org/10.1177/001872677903200102

Verspoor, E., Knox, D., & Marshall, S. (2016). Assessment of interbreeding and introgression of farm genes into a small Scottish Atlantic salmon Salmo salar stock: ad hoc samples–ad hoc results? *Journal of Fish Biology*, *89*(6), 2680–2696.

Waddy, S. L., Burridge, L. E., Hamilton, M. N., Mercer, S. M., Aiken, D. E., & Haya, K. (2002). Rapid Communication / Communication RapideEmamectin benzoate induces molting in

American lobster, Homarus americanus. *Canadian Journal of Fisheries and Aquatic Sciences*, *59*(7), 1096–1099. https://doi.org/10.1139/f02-106

Wappel, T. (2003). The federal role in aquaculture in Canada. Retrieved October 29, 2018, from http://www.ourcommons.ca/Content/Committee/372/FOPO/Reports/RP1032312/foporp03/foporp03-e.pdf

Wasserman, S., & Faust, K. (1994). *Social Network Analysis: Methods and Applications*. Cambridge University Press.

Wasserman, S., Pattison, P., & Steinley, D. (2005). Encyclopedia of Statistics in Behavioral Science. Retrieved November 26, 2018, from https://www.wiley.com/en-us/Encyclopedia+of+Statistics+in+Behavioral+Science-p-9780470860809

Weiss, K., Hamann, M., Kinney, M., & Marsh, H. (2012). Knowledge exchange and policy influence in a marine resource governance network. *Global Environmental Change*, *22*(1), 178–188. https://doi.org/10.1016/j.gloenvcha.2011.09.007

Weitzman, J., Steeves, L., Bradford, J., & Filgueira, R. (2019). Chapter 11 - Far-Field and Near-Field Effects of Marine Aquaculture. In C. Sheppard (Ed.), *World Seas: an Environmental Evaluation (Second Edition)* (pp. 197–220). Academic Press. Retrieved from http://www.sciencedirect.com/science/article/pii/B9780128050521000115

White, C. A., Bannister, R. J., Dworjanyn, S. A., Husa, V., Nichols, P. D., & Dempster, T. (2018). Aquaculture-derived trophic subsidy boosts populations of an ecosystem engineer. *Aquaculture Environment Interactions*, *10*, 279–289. https://doi.org/10.3354/aei00270

Wiber, M. G., Young, S., & Wilson, L. (2012). Impact of Aquaculture on Commercial Fisheries: Fishermen's Local Ecological Knowledge. *Human Ecology*, *40*(1), 29–40. https://doi.org/10.1007/s10745-011-9450-7

Wilson, L., & MacDonald, B. H. (2018). Characterizing bridger organizations and their roles in a coastal resource management network. *Ocean & Coastal Management*, *153*, 59–69. https://doi.org/10.1016/j.ocecoaman.2017.11.012

Young, N., & Liston, M. (2010). (Mis)managing a risk controversy: the Canadian salmon aquaculture industry's responses to organized and local opposition. Journal of Risk Research, 13(8), 1043–1065. https://doi.org/10.1080/13669877.2010.514429

Appendix 1 – Open-ended questions

<u>Part 1</u> – Grieg Informal Discussion

1. What do you know about the proposed Grieg project?

2. Where did you first hear about the Grieg project? Did you see it on Facebook or other social media or in the news?

3. What do you think about the Grieg project? How do you feel about it?

4. How did all the public interest in the project come about?

<u>Part 2</u> – Social Network Analysis

Mapping the social network of salmon aquaculture stakeholders:

5. Who do you represent with regard to salmon aquaculture and the Grieg project? (Participants may identify more than one stakeholder group, and if so, we must go through Q2-15 for each one – tell them to think of only one stakeholder group they represent at a time. (HIGHLIGHT THE GROUPS THEY REPRESENT IN YELLOW)

Bonding social capital: links between individuals within a group:

6. Approximately how many members belong to this group?

7. How often do you speak to others within your group about the Grieg project? (daily, weekly, monthly, 1-2X yearly, never)

8. On a scale of 1-5, how formal are the relationships between members of this group? This can be measured by how much you speak outside of work, and how formal your language and method of communication is (i.e. email, phone, text, in-person). We will rank this on a scale from 1-5 where 1 means "Very informal", 2 means "Informal", 3 means "Neutral", 4 means "Formal", and 5 means "Very formal" (RECORD NOTES ON THIS ON MAP – GET PARTICIPANTS TO ELABORATE)

9. Why do you communicate with people within your group about the Grieg project?

10. What types of information are exchanged? Is the exchange of information one-way or two-way?

11. Is there a key member of this group that acts as the group representative or coordinator? Who is this person?

Bridging social capital: links between distinct groups

12. Who else have you talked to about the Grieg Aquaculture project in Placentia Bay? (Draw lines on map to all connections – both within a stakeholder group (i.e., NGOs) and external ties to other stakeholder groups – DRAW IN RED)

For each connection drawn to another group, ask:

13. How often do you speak with this group about the Grieg project? (daily, weekly, monthly, 1-2X yearly)

14. On a scale of 1-5, how formal are the relationships with this group? This can be measured by how much you speak outside of work, and how formal your language and method of communication is (i.e. email, phone, text, in-person). We will rank this on a scale from 1-5 where 1 means "Very informal", 2 means "Informal", 3 means "Neutral", 4 means "Formal", and 5 means "Very formal" (RECORD NOTES ON THIS ON MAP – GET PARTICIPANTS TO ELABORATE)

15. Why do you communicate with people in this group about the Grieg project?

16. What types of information are exchanged? Is the exchange of information one-way or two-way?

17. Is there a key member of this group that acts as the group representative or coordinator? Who is this person?

Linking social capital: Networks of trust between stakeholder groups

USE THE SECOND MAP

The final portion of the interview will ask about trust relationships. Groups that you do not know about or are impartial to, DO NOT draw a line representing a trust relationship. For the groups that you have a trust relationship with (relationship can range from absolutely no trust to very strong trust), we are going to rank them on a scale from 0-5 where 0 means "No trust", 1 means "Little trust", 2 means "Somewhat trust", 3 means "Trust", 4 means "Strong trust" and 5 means "Very strong trust". This is out-degree centrality.

18. Who do you trust the least regarding salmon aquaculture expansion by Grieg Aquaculture in Placentia Bay? (DRAW IN BLACK)

19. What would you rank this level of trust?

20. Why did you give this ranking?

21. Who do you trust the most regarding salmon aquaculture expansion by Grieg Aquaculture in Placentia Bay? (DRAW IN BLUE)

22. What would you rank this level of trust?

23. Why did you give this ranking?

24. Are there any other groups in between these two extremes that you have a trust perception of? (DRAW IN RED)

25. What would you rank this level of trust?

26. Why did you give this ranking?

Part 3 – Concluding remarks

27. Is there anything else that you want to talk about regarding the Grieg Aquaculture case in Placentia Bay?

28. I have one final question. Do you have any recommendations on people I should try to talk to?