Defining Lobster Fishermen Concern for Finfish Aquaculture on Lobsters and Lobster Fishing Communities in Nova Scotia: A Pilot Study

Laboratory of Innovation in Science and Industry

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Executive summary

This report provides a scientific assessment of lobster fishermen's concerns about marine finfish aquaculture[1]. The findings herein are intended to serve as a governing tool for the systematic and scientific study of the impact of finfish aquaculture on lobsters and lobster fishing in Nova Scotia.

After individual, face-to-face interviews and focus groups with thirty-three lobster fishermen and community stakeholders, we were able to document five environmental concerns and five social, political, and economic concerns:

Environmental concerns	Social, political and economic concerns
Feed, feces and dead water	Big Industry
Pest, pesticides and antifouling agents	Government monitoring
Benthic impact and recovery	Job creation (myth)
Equipment as pollution	Ignored lobster industry
Compatibility	Research

These concerns were shared by all five southern counties of Nova Scotia: Queens (LFA 33), Shelburne (LFA 33), Yarmouth (LFA 34), Digby (LFA 34), and Annapolis (LFA 35). The interviews and focus groups were conducted until we attained a satisfactory saturation point or until we attained "a point of diminishing return, where increasing the sample size no longer contributes to the evidence"[2], as recommended by the experts in the field of qualitative studies[3].

In response to these concerns, three research programs were generated:

- Impact of farm discharges, including organic waste (uneaten feed and faeces), inorganic waste (dissolved nutrients), pesticides and heavy metals on the benthic habitat, lobster populations, and other organisms. Specific areas of concern included:
  - Impact of heavy metals and antifouling agents (i.e. copper, zinc, cadmium) contained in feed on benthic invertebrates.

1 Please note that other reports and scientific articles may use "open-net pens" as an equivalent to "marine finfish aquaculture". Fishermen may also use the term "open pens". Our decision to use "marine finfish aquaculture" as a universal qualifier throughout this text is simply an editing decision.

2 M. Mason (2010), "Sample Size and Saturation in PhD Studies Using Qualitative Interviews," *Forum Qualitative Sozialforschung [Forum: Qualitative Social Research]*, 11(3), Art. 8, accessed at http://nbn-resolving.de/urn:nbn:de:0114-fqs100387.

3 *Ibid*. Also see Greg Guest, Arwen Bunce & Laura Johnson (2006), "How many interviews are enough? An experiment with data saturation and variability", Field Methods, 18(1), 59-82.

- » Impact of pesticides used for treatment of sea lice on benthic invertebrate;

- » reproductive ability and health of adult and larval lobster near salmon farms;
  - » pesticide accumulation in lobsters and other non-target organisms;
  - » wild salmon reproduction and mortality in rivers adjacent to salmon net-pen farms;
  - » proliferation of fish and shellfish as well as human pathogens in the aquatic environment.
- » Impact of organic waste (uneaten feed and faeces) on the benthic environment beneath and surrounding the farm site.
- » The impact of nutrient enrichment (i.e. eutrophication) due to heavy loading of organic and inorganic farm waste (i.e. ammonia, nitrate, phosphate, dissolved organic carbon) on the marine environment, specifically with respect to the occurrence of algal blooms and low oxygen levels.

» An evaluation of standard operating procedures for site management with respect to fishermens concerns (e.g. tagging of pens, noise reduction).

» An evaluation of the socio-economic effects of aquaculture in Nova Scotia.

While some studies on these subjects have already been conducted, research gaps still exist. As Doelle and Lahey state, "[t]he ultimate effectiveness of the regulation of aquaculture in Nova Scotia will depend on research being done to address such gaps"[4]. Studies to come out of this report are to be designed with long-term measurements in mind; multiple studies, conducted in multiple locations, over long periods, are the best way to ensure that regulation is working, that new and existing sites are being properly monitored, and that Nova Scotia becomes a leader in the creation of a sustainable finfish aquaculture industry. These outcomes are essential if the lobster industry, a historic, vital sector of Nova Scotia's economy, is to remain recognized and protected, as the province aims to achieve its *One Nova Scotia Commission* goal of doubling the value of exports from fisheries (including aquaculture)[5].

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4 M. Doelle and W. Lahey (2014), "A New Regulatory Framework for Low-Impact/High-Value Aquaculture in Nova Scotia," *The Final Report of the Independent Aquaculture Regulatory Review for Nova Scotia [The Doelle-Lahey Panel]*, p. X. [Accessed September 18, 2015 at: http://novascotia.ca/fish/documents/Aquaculture_Regulatory_Framework_Final_04Dec14.pdf.]

5 Ray Ivany et al. (2014). *Now or Never: An Urgent Call to Action for Nova Scotians – Final Report*, One Nova Scotia Commission, p. 49. [Accessed September 18, 2015 at: http://onens.ca/wp-content/uploads/Now_or_never_short.pdf.]

Introduction

In 2014, the Nova Scotia government received the final report from the Nova Scotia Commission on Building Our New Economy. In this report titled *Now or Never: An Urgent Call to Action for Nova Scotians* is a suggestion to sustainably double the "value of exports from the fisheries (including aquaculture) and the agriculture sectors"[6]. But the aquaculture industry in Nova Scotia faces a number of economic, environmental, and socio-economic challenges. One of the most significant challenges is public concern about the potential impact of finfish aquaculture operations on the marine environment and on the traditional fisheries in coastal Nova Scotia.

These concerns have led to much media and public attention in several Nova Scotia communities. In their recent review of the aquaculture industry, Doelle and Lahey state that the salmon-farming industry in Nova Scotia has a significant social licence problem which needs to be addressed for the industry to be able to continue to grow[7]. Marine finfish farms are perceived as "significant polluters of the marine environment and [as] using practices that are not sustainable for ecosystems or the health of the fish that are farmed, or the wild fish or other aquatic life that comes into proximity with open-net pens"[8].

The lobster industry, vital to the NS economy, has been adamant in voicing its concerns about net-pen farming of salmon, especially with regard to the impact of such finfish aquaculture on lobster. As stated in the Doelle and Lahey report, "concerns range from displacement of individual fishers from their traditional lobster fishing grounds to contamination of lobster through feed, medication, pest-control products and chemicals used in aquaculture operations, and to the effect of benthic contamination on the abundance of lobster in a given area"[9]. This same report also highlights the lack of scientific information on the subject and stresses the need for further research: "Participants in the February 10, 2014,[*sic*] Knowledge Roster generally agreed that little research has been conducted about the interaction of finfish aquaculture and lobster"[10].

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6 *Ibid.*, p. 49.

7 M. Doelle and W. Lahey (2014). *op. cit.*, p. 22. A 2010 report, "Socio-Economic Impact of Aquaculture in Canada," published by Fisheries and Aquaculture Management of Fisheries and Ocean Canada, addresses the same issue (see http://www.dfo-mpo.gc.ca/aquaculture/ref/aqua-es2009-eng.pdf, p. 39). Finally, this situation is also echoed in the *Final Report*, One Nova Scotia Commission, p. 7.

8 *Ibid.*, p. 22.

9 *Ibid.*, p. 27.

10 *Ibid.*, p. 27.

The pilot study proposed herein has, as its primary objectives, two responses to this lack of research:

- » developing a clear and concise articulation of the NS lobster industry's most pressing concerns about finfish aquaculture;
- » addressing these concerns in research programs that will involve further studies.

These research programs are to form the backbone of systematic, scientific answers to lobster fishermen's concerns about the impact of finfish aquaculture on lobster.

Method and participant description

Throughout this project, we have worked directly with individual communities where salmon farming is being done. As noted earlier, the objective of this work was to identify individuals' issues with and concerns about the potential impact of finfish aquaculture on lobster fishing and lobsters' health. This information can now be used to develop targeted, customized research programs to investigate the impact of finfish aquaculture on communities (socio-economically), on the marine environment, and on traditional fisheries in NS, most notably with regard to lobster fishing.

Table 1: List of southern Nova Scotia communities included in the public consultation/outreach process

Target Area	County	Location of farm sites
1	Queens	Liverpool bay
2	Queens	Port Mouton
3	Shelburne	Jordan bay
4	Shelburne	Shelburne Hbr
5	Shelburne	Barrington Passage
6	Shelburne	Upper Woods Hbr
7	Yarmouth	Pubnico Harbour
8	Yarmouth	Lobster bay
9	Digby	St. Mary's bay
10	Annapolis	Annapolis Basin

At present, finfish aquaculture is being practiced in ten communities in five southern Nova Scotia counties: Queens, Shelburne, Yarmouth, Digby, and Annapolis (see Table 1 for the list of communities). Table 2 provides a further profile of each county (the community information was gathered from Statistics Canada's 2011 Census Profile and from Fisheries and Ocean Canada[11]).

These small population centres cover three Lobster Fishing Areas (LFAs): 33, 34, and 35, as shown in Figure 1. These Fishing Areas are, for the most part, considered healthy, as there is an abundance of landings, a good catch rate, and a good trawl- survey catch rate[12].

11 Statistics Canada (2012) and DFO (2014). Full citation in the References section.

12 DFO (2014). Full citation in the References section.

Table 2: Summary of community profiles

Queens

Total population: 10,960
Language
- English: 10,570
- French: 80
- Non-Official: 150

Population 20-59 years: 5,455
LFA 33 - information
- Total No. of licenses: 707
- Annual lobster landings: 3,377 (2009-10)
- Healthy zone: Yes

Shelburne

Total population: 14,496
Language
- English: 14,050
- French: 155
- Non-Official: 110

Population 20-59 years: 6,430
LFA 33 - information
- Total No. of licenses: 707
- Annual lobster landings: 3,377 (2009-10)
- Healthy zone: Yes

Yarmouth

Total population: 25,725
Language
- English: 19,325
- French: 5,065
- Non-Official: 260

Population 20-59 years: 13,045
LFA 34 - information
- Total No. of licenses: 985
- Annual lobster landings: 19,749 (2009-10)
- Healthy zone: Yes

Digby

Total population: 18,036
Language
- English: 11,850
- French: 5,430
- Non-official: 190

Population 20-59 years: 9,115
LFA 34 - information
- Total No. of licenses: 985
- Annual lobster landings: 19,749 (2009-10)
- Healthy zone: Yes

Annapolis

Total population: 20,756
Language
- English: 19,555
- French: 450
- Non-official: 385

Population 20-59 years: 10,080
LFA 35 - information
- Total No. of licenses: 97
- Annual lobster landings: 1,898 (2009-10)
- Healthy zone: Yes

Healthy zone are based on three abundance indicators (landings, commercial catch rate and trawl survey catch rate)

According to the Aquaculture Site Mapping Tool[13], there are twenty-four Marine Finfish Aquaculture sites in these areas (Figure 2 shows the different site locations). Shelburne County has the greatest number of sites (9), while Queens County has the least (2). The interactions between finfish sites and lobster fishing for each county are rather diverse. For example, the marine finfish farms in the Annapolis County are found within the Annapolis Basin, an area that is greatly affected by tide changes. Digby County has sites at the tip of Long Island, a body of land that, in part, divides Sainte-Mary's Bay from the Bay of Fundy. Yarmouth County has its concentration of finfish farms around such islands as Pumpkin Island or Big Gooseberry Island. Shelburne County has some sites on the southernmost tip of Nova Scotia but also has sites deep within its bay, as far northeast as near Paddy's Cove. Queens County has one site near Port Mouton and another near Coffin Island. We were concerned that these differences might impact our results and therefore included all of them in our sample.

This project involved extensive community outreach in these areas and solicited input from a broad and diverse group of participants. Perceptions were to be drawn from both proponents and opponents of finfish aquaculture operations, particularly with regard to the impact on lobsters' health, population, and habitat, and on the lobster fishery. But of the more than 80 respondents approached, most of those willing to participate were, in the main, opposed to finfish aquaculture operations. It is important to note that community stakeholders who helped with the recruitment of participants confirmed that the situation would be as such, for our study focused specifically on lobster fishermen, a group that has had a tense relationship with marine finfish aquaculture. Furthermore, our observation of opposition confirms Doelle and Lahey's statement, as well as other reports, about the significant social licence problem that the salmon farming industry has had in Nova Scotia[14].

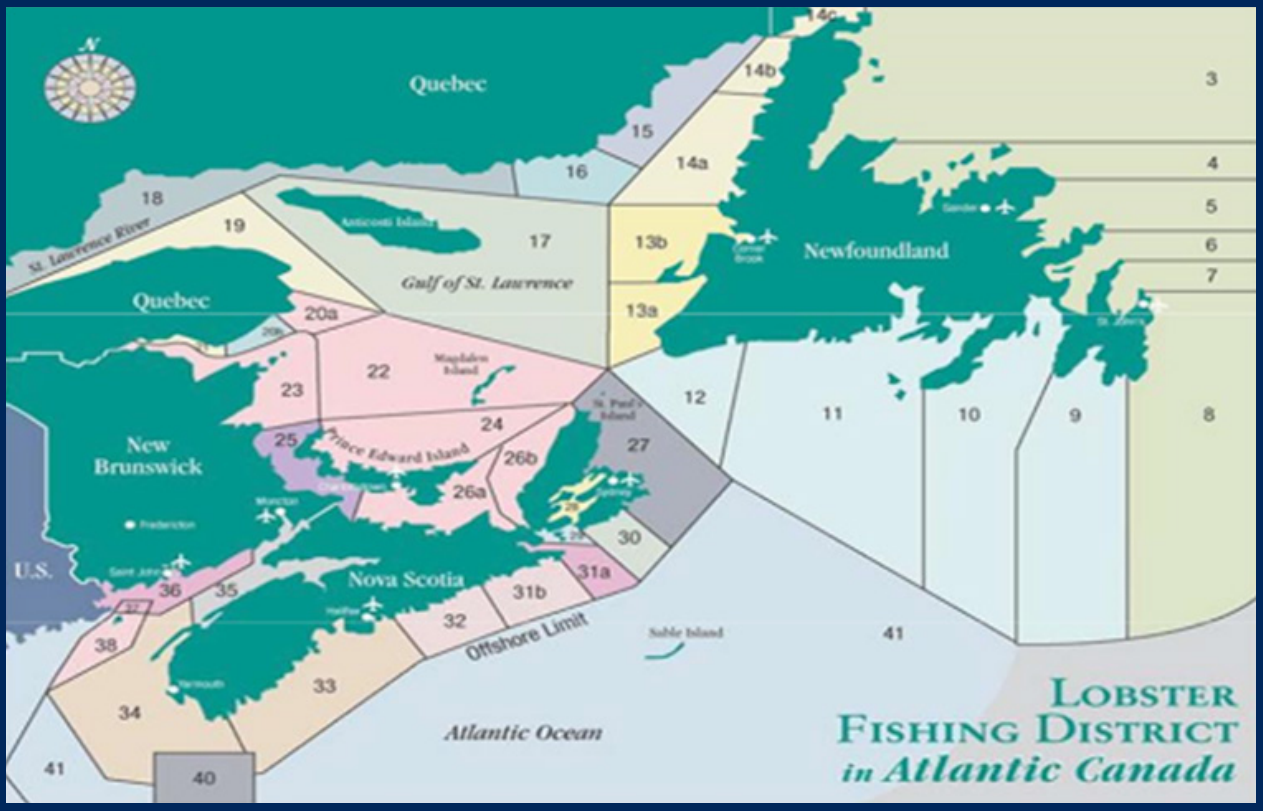
Responses were obtained in face-to-face interviews and focus groups targeting stakeholders in each of the ten communities. These two methods of data collection were preferred to large sample quantitative surveys for three reasons. First, large sample quantitative surveys are better for the verification of a hypothesis and often ill-suited to exploratory research interested in measuring experience and meaning[15] (as required here). Second, responses tend to be more

13 http://novascotia.ca/fish/aquaculture/site-mapping-tool/

14 See Introduction (p. 7).

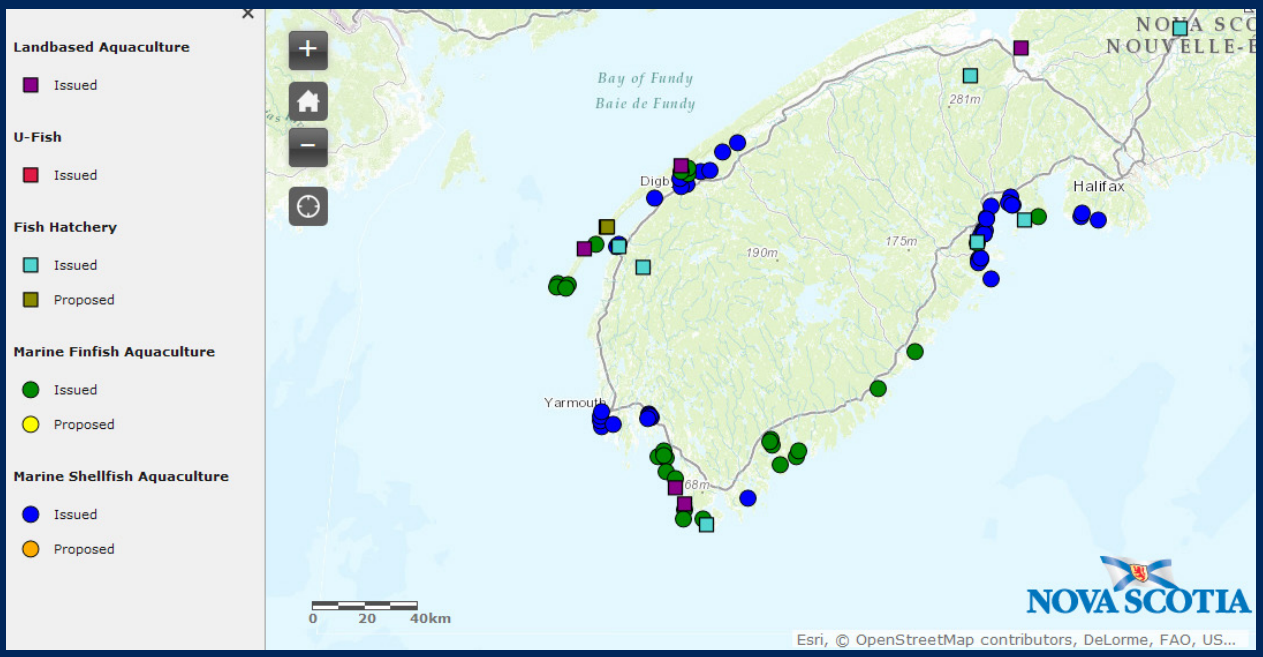
15 J. M. Corbin and A. Strauss (2015), *Basics of Qualitative Research: Techniques and Procedures for Developing Grounded Theory*, SAGE Publications, Thousand Oaks, p. 5; Marc Charron and Simon Laflamme (2008), "Chapitre 2: Les méthodes en sociologie," *Initiation thématique à la sociologie*, ed. Jean Lafontant et Simon Laflamme, Prise de Parole, Sudbury, p. 46; Lorraine Savoie-Zajc (2003), "L'entrevue semi-dirigée," *Recherche sociale: De la problématique à la collecte des données*, dir. Benoît Gauthier, Presse de l'Université du Québec, Saint-Nicolas, p. 294.

Figure 1: Lobster Fishing Areas (LFA)



http://www.dfo-mpo.gc.ca/fm-gp/peches-fisheries/ifmp-gmp/maritimes/insholob-2011-eng.htm

Figure 2: Aquaculture operation in Southern Nova Scotia



http://novascotia.ca/fish/aquaculture/site-mapping-tool/

elaborate and complex when using qualitative data-collecting tools[16]. Finally, qualitative research facilitates information sharing when a subject is politically and emotionally charged[17], as was the case here.

We were also able to draw on some important advantages of combining individual interviews with focus groups. For example, the individual, face-to-face interviews served as a pre-test for our survey tools. We were able to evaluate the effectiveness of our questions with single participants before gathering larger groups of people together. Had we noticed any problem with our survey tools during these face-to-face interviews, we could have corrected the problem with little loss of time, money, and data. Individual, face-to-face interviews also reduce any outside influence during the data collection process. Social psychology has confirmed that group meetings tend to polarize responses instead of enticing diversity. (If, for example, a group leader is quickly acknowledged by the other participating members, it is possible that they toe the line, as they do not want to incite any controversy[18]). It was, therefore, important to allow some participants to share information without fear of being judged by fellow lobster fishermen. These individual interviews would also serve as "respondents" to our focus groups — in other words, if the one-on-one meetings produced different results from our group sessions, we could have concluded that group leaders influenced the other participants and further data collection was necessary. What we observed instead was that those concerns expressed during the focus groups were in line with those presented during individual, face-to-face interviews with key community stakeholders. This, in turn, may mean one of two things: if diverse opinions on the subject do exist within our selected communities, proponents 1) either do not wish to say so, even in confidence, or 2) are not among lobster fishermen and community stakeholders. Regardless, our data collection did not, from the onset, intend to prove whether finfish aquaculture is good or bad. Our mission was to document concerns about marine finfish aquaculture on lobsters. And, as we observed, these concerns were the same for all participants. Finally, individual interviews are one of the most expensive ways of collecting data, as they require a highly specialized interviewer (or interviewers) conduct a large number of interviews, incurring hefty travel costs[19]. By combining both methods, we were able to reduce some of the research cost. For a reasonable price, participants — some alone, some in groups — were given the

16 J. M. Corbin et A. Strauss (2015), *op. cit.*, p. 5.

17 A. Tremblay (1991), *Sondages, histoire, pratique et analyse*, Gaëtan Morin, Montréal, p. 112.

18 M. J. Brauer and V. Jacquelin (2001). "The communication of social stereotypes: The effects of group discussion and information distribution on stereotypic appraisals," *Journal of Personality and Social Psychology*, 68, pp. 1014-1029; M. J. Brauer and M. D. Gliner (1995), "The effects of repeated expressions on attitude polarization during group discussion," *Journal of Personality and Social Psychology*, 8, pp. 463-475; D. M. Mackie (1986), "Social identification effects in group polarization," *Journal of Personality and Social Psychology*, 50, pp. 720-728.

19 A. Tremblay (1991), *op. cit.*, p. 113.

opportunity to present their concerns in an informal environment to university researchers, who acted as an independent third party.

To further reduce outside influence, we used a "recursive style" question at the beginning of our survey. While little literature can be found on this type of open ended question, we have used it in the past with great results[20]. The participants were asked to write on a piece of paper what words come to mind when we say "Salmon farming" or "Finfish aquaculture". The interviewer would then go over each of these words, allowing the participant to fully elaborate their thoughts and responses. The first question only ended once everyone's words had been shared and commented on. By structuring our first question as such, we were certain to not entice the participants beforehand, encouraging neither a positive nor negative perception of the subject. Participants were as free as possible to direct their responses according to their initial perception of salmon farming or finfish aquaculture. During the individual interviews, it was most apparent that no cues from the researcher or from another participant could have encouraged a specific response. And, as noted above, since the individual interviews aligned squarely with what was observed during the focus groups, we are confident that the concerns collected at the beginning of each meeting were not those of the research team or of a dominant group leader. The rest of the survey followed a more semi-directed style of interview, prompting responses based on literature and on our desire to compare positive and negative perceptions of finfish aquaculture. These secondary questions also allowed us to cross-reference responses if an individual or group did not touch on a specific subject. The survey tools are presented in Appendix 1.

Interviews and focus groups were conducted until we attained a satisfactory saturation point, or until we attained "a point of diminishing return, where increasing the sample size no longer contributes to the evidence"[21]. In 2010, Mark Mason examined five hundred and sixty qualitative studies and observed that 31 participants was the mean sample[22]. While this number is not considered a requirement in qualitative research, as some researchers have attained saturation within the first five interviews[23], we felt that it was a suitable number if our categories were to be properly verified. Even after we achieved a point of relative saturation early on, a point where we were able to create 85% of the categories that are found in the results, we continued until 33 participants had voiced their concerns.

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20 S. Laflamme et S. Mainville (2003), *L'Amateur de théâtre en Ontario français: différenciation et indifférenciation (Étude de marché réalisée auprès des abonnés, des acheteurs à billet simple et des non-abonnés des régions de Sudbury)*, Ottawa et Toronto, Ottawa/Sudbury, Théâtre action/ Institut Franco-Ontarien.

21 M. Mason (2010), "Sample Size and Saturation in PhD Studies Using Qualitative Interviews," *Forum Qualitative Sozialforschung [Forum: Qualitative Social Research]*, 11(3), Art. 8, accessed at http://nbn-resolving.de/urn:nbn:de:0114-fqs100387.

22 M. Mason (2010), *op. cit.*

23 M. Mason (2010), *op. cit.*

Results

After the five individual, face-to-face interviews were conducted with community stakeholders, more than eighty lobster fishermen were approached for the focus groups. Of these eighty, thirty-three accepted and met with our Senior Research Associate.

From the transcripts, ten categories were created: five pertaining to the environment and five pertaining to political, social and economic concerns. It is critical to note that these categories arose from interviewees' perceptions and experience; it was quite common for participants to state that they were only expressing their views on the subject matter, gained through hearsay and mostly through experience, and that they were not scientists. They also made it clear that they were aware that much research on the subject already existed. In certain areas, participants submitted some of these articles and they have been listed in Appendix 2.

1. Environmental concerns

Almost every interview or focus group started with expressed concerns about the environment. Pollution, caused by feed, feces or pesticide, was at the forefront of cited fears. Unsurprisingly, though, as we interviewed lobster fishermen, the effect of these pollutants on the ocean bottom was the most recurrent concern. If further research in this area is to be conducted in Nova Scotia, the benthic impact of marine finfish aquaculture must be given priority. Table 3 summarizes these results.

Table 3: Recurrent categories pertaining to environmental concerns

	Port Mouton	Shelburne	Yarmouth	Digby	Annapolis	Stakeholder 1	Stakeholder 2	Stakeholder 3	Stakeholder 4	Stakeholder 5
Feed, feces and dead water	•	•	•	•	•	•	•	•	•	•
Pest, pesticides and antifouling agents	•	•	•	•	•			•	•	•
Benthic impact and recovery*	•	•	•	•	•	•	•	•	•	•
Equipment as pollution		•	•	•	•		•	•	•	•
Compatibility	•	•	•	•		•	•	•	•	•

N.B. Bullets represent concerns identified by participants.

**While benthic is the scientific termed used for the ocean bottom, lobster fishermen preferred the terms "fishing bottom", "ocean bottom", "lobster bottoms" or "bottom".*

1.1 Feed and feces

The practice of grouping a dense population of finfish in such small enclosed often sheltered bays is considered the primary cause of the pollution problem. Every interviewee or focus group mentioned, without prompting, that they believe that the floor bottoms were in very poor condition, and not just immediately around the marine finfish farms, but for kilometres around them. It is widely believed that this is a direct result of the high concentration of feed and feces that fall to the bottom of the ocean and yet are not being carried away by the strong tides. The nutrient-rich feed and feces increase algae build-up, which in turn prevents plant life from properly developing on the ocean bottom. It is for this reason that a substantial number of participants suggested a transfer from marine finfish farms to land-based sites. How are lobsters supposed to feed, reproduce, or even breathe in these environments that become inhospitable habitats? asked many participants. The term "dead water" was also used when referring to oxygen-poor waters surrounding marine finfish farms. Concerns about sulfur and sulfite levels, as well as zinc levels, were also touched upon.

1.2 Pests, pesticide, and antifouling agents

Another problem related to the dense population of finfish aquaculture is sea lice. Participants reported that these small parasitic crustaceans are very troublesome for farmed salmon in marine finfish farms, as they can easily propagate, feeding on the large number of fish skins. While sea lice do not naturally pose any kind of threat to lobsters, the pesticide used to control these parasites is considered, by the participants, to be a problem: both creatures are in the shellfish family and so the products used to kill one almost certainly affects the other. It was also noted that, as sea lice become more resistant to previously used pesticides, the aquaculture industry is forced to use larger doses of more lethal kinds of pesticides. Reports of lobster shells becoming fragile, some even turning into a jelly like substance, were documented during our interviews and focus-group sessions.

Concerns about antifouling agents were also raised by some of the individuals and groups. In order to control the natural accumulation of organisms (e.g., algae or bacteria) on underwater equipment, such as marine finfish aquaculture equipment and wooden lobster traps, antifouling agents are used. These agents are designed to remove or prevent bio-fouling and the participants wondered how increases in their use, because of salmon farming equipment, might further impact the current ecosystem? Copper residues, as a by-product of the marine finfish aquaculture equipment and antifouling agents, were mentioned.

Questions about the detrimental impact of pesticides and antifouling agents on the lobster larvae were also raised, especially as lobster larvae are very vulnerable and float on the surface.

Although not directly related to the question presented by our researcher, a few participants asked if the increase in sea lice, caused by salmon farming, might affect wild salmon.

1.3 Benthic impact and recovery

The benthic effect of marine finfish aquaculture does not seem to simply be a short-term concern. According to testimonies gathered during our meetings, researchers and divers state that the "fallowing" or the temporary cessation of aquaculture operations does not seem to lead to a rapid recovery of the ocean bottom. Some respondents cited testimonies and different scientific articles reporting that it is taking longer than anticipated for the seabed beneath and around marine finfish farms to recover; some mentioned more than 3 to 5 years, while others mentioned more than 6 to 7. This unexpected and unpredictable recovery time is especially worrisome to respondents because they believed existing sites may be causing irreversible damage to the seabed. It was also noted that this benthic impact can be felt as far as "hundreds of yards away from salmon farms".

1.4 Equipment as pollution

Netting and broken cage parts were cited as other inconvenient elements related to marine finfish aquaculture. While some of the pens have become tangled up with lobster cages, torn netting or broken tubing have also been observed floating around, causing problems with lobster cages or washing ashore. "Unlike lobster cages, salmon farms are not properly identified" (participants 106b). "The [aquaculture] companies should be required to have identifiable cages as this would help enforce proper maintenance, regulation, and clean-up of polluting equipment" (participant 108d).

Noise pollution by equipment was also mentioned fairly often in communities where marine finfish farms are close to populated shores. The sound of the machinery responsible for feeding the fish at regular intervals was considered bothersome.

For some, the sight of the equipment detracts from the visual beauty of Nova Scotia's shores. While this opinion was not raised during each encounter or was not shared by everyone during the focus groups, it was recurrent enough to warrant mention here.

1.5 Compatibility

The subject of compatibility was addressed by one of our semi-directed questions. We asked participants, "How might shell-fish aquaculture interfere with or disrupt the activities of other users of coastal waters?" The objective of this question was to help us compare finfish aquaculture with another kind of operation. As this was a prompted question, everyone offered a response, none of which deviated from the general notion that shell-fish aquaculture is greener, less invasive, less threatening than is finfish aquaculture.

When discussing the compatibility of different types of aquaculture, it was common for participants to state that marine finfish aquaculture equipment could work if used correctly. As noted above, land-based sites were often cited as the preferred solution to marine-based farms, but, on a few occasions, the question did produce another interesting piece of anecdotal information: there were some reports of good practices in other communities, especially, and most notably in the Annapolis Basin. It is possible that, in this community, dialogue between its residents and the industry has been better than in other communities and that the community's expressed wishes about cage placement were respected. Furthermore, it is possible that, as a result of community input, the sites in Annapolis Basin are less troublesome as they are better located and so the worst of the bio-waste is properly flushed out[24]. We stress that such statements were, however, too few to be generalized. What we can say is that future research should consider comparing any findings gathered in one region with those found in the Annapolis Basin, at least until these statements have been verified empirically.

2. Political, social, and economic concerns

Table 4 summarizes discussion elements that were not directly related to the environment. All of the terms found in Table 4 present a much stronger inherent internal cohesion than was observed with the ideas pertaining to the environment. Whether a participant mentioned government monitoring or Big Industry or job creation, these other ideas were not far behind. These concepts, like the previous list, were also mostly a consequence of the "recursive question", meaning that they were mentioned without any prompting by the Senior Research Associate.

24 According to respondents who reported on this subject, the aquaculture industry was forced into dialogue by community residents – had this not been the case, it is not clear that the situation would be as such. It is important to note that we did not verify these statements as it was not part of our research objectives. The statement about proper tidal flushing was also not verified for this same reason.

Table 4: List of recurrent categories pertaining to political, social, and economic concerns

	Port mouton	Shelburne	Yarmouth	Digby	Annapolis	Stakeholder 1	Stakeholder 2	Stakeholder 3	Stakeholder 4	Stakeholder 5
Big Industry	•	•	•	•	•	•	•	•	•	•
Government monitoring*	•	•	•	•	•	•	•	•	•	•
Job creation (myth)	•	•	•	•	•	•	•	•	•	•
Ignored lobster industry	•	•	•	•	•	•	•	•	•	•
Research*	•		•			•	•		•	•

N.B. Bullets represent concerns identified by participants.

**Sometimes prompted because of literature review.*

2.1 Big Industry

Whenever asked, "What comes to mind when we say salmon farming or finfish aquaculture?", if the respondents did not start with environmental concerns, they discussed their relationship with and perception of the aquaculture industry. There is a very strong sense, by participants, that the industry is only interested in profit, it is polluting the pristine waters off coastal areas, and it is tearing up communities without offering much in return. Accountability was also mentioned often when discussing the aquaculture industry. The strong feeling of mistrust that emerged whenever the industry was mentioned is not an easy political or social reality to contend with. Even when prompted, participants did not have much good to say in favour of the industry. This was especially obvious when we compared finfish aquaculture with other types of operations, such as shellfish aquaculture. As noted above, the consensus was that shellfish aquaculture is much more enviro-friendly and much less of a threat to lobster fishing.

2.2 Government monitoring

Among stakeholders, this concept was not always presented during the "recursive question". Inspired by the Doelle and Lahey report, it was sometimes prompted by our Senior Research Associate. The general sentiment, from both individual interviewees and focus groups, is that governing bodies do not have the resources required to properly enforce rules and regulation and, even if this were to change, that the aquaculture industry is not regulated as are the lobster and farming industries. These concerns go beyond the labelling of fishing equipment mentioned above (see *1.4. Equipment as*

pollution). Respondents felt that the aquaculture industry, in its striving for profits, gets away with all kinds of dangerous or unsavoury practices, such as claiming compensation for lost salmon that simply died because of freezing, using banned pesticides, blaming lobster fishermen for entangled traps, and dividing communities to gain political support. The general feeling was that the government cannot or will not do anything about these immoral or illegal practices; frustrations are accentuated by the continued financial support granted to the industry by the government. Many respondents called this support "government bail-outs".

2.3 Job creation (myth)

One of the main reasons that communities accept aquaculture installations is because they create jobs. Participants report that, with every salmon farm, new jobs are promised by both the government and the industry. These jobs are beneficial for the unemployed, for retaining people who would otherwise move out west for work, and they stimulate local economies, as expressed by participants. Jobs in aquaculture could be promising community development projects. It was very common for the respondents to state that job creation is an important political project and that it must be encouraged. What is bothersome for most, if not all participants, is that these promises remain promises; there is a lack of tangible evidence that jobs are created in Nova Scotia at the local level as promised. Even after many years of operation, the promise of jobs does not seem to translate into real jobs within the communities. How is it possible that provincial and local government subsidize such an industry when so little return can be observed?, asked a number of participants.

It should be noted that this topic came up during the initial recursive question, without prompt, as well as when our Senior Research Associate asked about the positive elements of finfish aquaculture. Jobs are respondents' refrain when talking about the positive spinoffs of aquaculture operations. A desire to see tangible results could be extremely powerful.

2.4 Ignored lobster industry

When another industry arrives in a community, existing businesses can feel pressured to change their regular operations. This is definitely the case for the lobster fishermen we talked to about the finfish aquaculture industry. Some mentioned an increase in marine traffic that can be cumbersome. In areas where marine finfish farms are near traditional fishing grounds, some displacement was reported. But most of the responses in this category of questions mostly offered a sense that governing bodies and the finfish aquaculture industry disregard the historical, social, and economic

contributions of the lobster industry. The impact of pollutants related to finfish aquaculture operations is felt to have a direct, negative impact on the lobster industry. The treatment of sea lice with pesticides designed to harm crustaceans is felt to indirectly threaten lobsters' health and longevity. It is hard, too, for lobster fishermen not to feel personally threatened by marine finfish aquaculture. The mere placement of marine finfish farms in their communities can immediately spark resentment. But combined with this issue are many other stressors. For example, lobster fishermen have a sense of not being listened to even if they are often consulted. They also commented on rumours and news reports that the salmon farming industry receives certain subsidies—for a loss of equipment or for a loss in production—that lobster fishermen do not receive. And so a clearer understanding of the participants' sentiments emerges: lobster fishermen feel underappreciated and they feel that their historical and ongoing contribution to community wealth and stability goes unrecognized.

2.5 Research

We decided to make this a separate category because it was just as often mentioned when people refused to participate in the project as when we asked them the last question of our survey. The question reads: "Keeping all that we have discussed in mind, where might we focus our studies to best respond to concerns about finfish aquaculture?" There is a general sense that a lot of research exists on the interaction between lobster and finfish aquaculture, but that this research is not being fairly considered by the industry and by governing bodies. The argument normally ties feelings of distrust and frustration to those of fatigue and apathy: some participants and non-participants admitted to having worked directly with the scientific community in participatory action research, or they helped gathered information by actively participating in focus groups or in community meetings, yet there was not a sense that these contributions improved the situation. (We chose not to argue with participants and non-participants here, as our mandate was simply to gather and record their concerns.)

There was a definite sense that more research needed to be done, as specified in the Doelle and Lahey report[25]. But there was also an expressed frustration that much good research seems to be disregarded. Appendix 2 presents a number of the studies alluded to or expressively named during the interviews and focus groups. This list is not an exhaustive literature review; it presents but a small picture of the research that participants are aware of and serves to suggest why, when invited to participate or when prompted to talk about research, they feel frustrated.

25 "The ultimate effectiveness of the regulation of aquaculture in Nova Scotia will depend on [the] research being done to address such gaps" (Doelle and Lahey, *op. cit.*, p. x).

3. Where might we focus our studies to best respond to concerns about finfish aquaculture?

When asked directly about where studies should focus to best respond to concerns about finfish aquaculture, responses ranged wildly. We believe this to be normal, as the question was not presented ahead of time; participants did not have time to prepare a structured response. The question had to be asked, though, to ensure that we were not misinterpreting concerns presented elsewhere during the study. What we present in Table 5 is therefore a combination of information gathered from sections one and two of this report as well as what was stated by lobster fishermen when asked directly about future research. If participants find that some information is missing, please remember that the wording may have changed (a result of our categorization). And if readers notice that some information has not been presented in the previous sections, please remember that this absence is the result of new ideas stimulated by this last and very direct question about focused research. Finally, we note that research on these many subjects already exists in one form or another. As specified by The Doelle and Lahey report, while it is important to implement good regulations, it is only through continued research that we can evaluate and correct bad practices, as well as develop and sustain good practices.

Table 5: Recommended Research Programs Based on Lobster Fishermen's and Key Community Stakeholders' Concerns about and Perceptions of Net-Pen Finfish Aquaculture *(Presented in no particular order)*

Impact of farm discharges, including organic waste (uneaten feed and faeces), inorganic waste (dissolved nutrients), pesticides and heavy metals on the benthic habitat, lobster populations, and other organisms. Specific areas of concern included:

- » Impact of heavy metals and antifouling agents (i.e. copper, zinc, cadmium) contained in feed on benthic invertebrates.
- » Impact of pesticides used for treatment of sea lice on benthic invertebrate:
- » reproductive ability and health of adult and larval lobster near salmon farms;
  - » pesticide accumulation in lobsters and other non-target organisms;
  - » wild salmon reproduction and mortality in rivers adjacent to salmon net-pen farms;
  - » proliferation of fish and shellfish as well as human pathogens in the aquatic environment.
- » Impact of organic waste (uneaten feed and faeces) on the benthic environment beneath and surrounding the farm site.
- » The impact of nutrient enrichment (i.e. eutrophication) due to heavy loading of organic and inorganic farm waste (i.e. ammonia, nitrate, phosphate, dissolved organic carbon) on the marine environment, specifically with respect to the occurrence of algal blooms and low oxygen levels.

An evaluation of standard operating procedures for site management with respect to fishermens concerns (e.g. tagging of pens, noise reduction).

An evaluation of the socio-economic effects of aquaculture in Nova Scotia.

Conclusion

By addressing some of the major concerns in Southern Nova Scotia's lobster-fishing communities about equipment used for marine finfish aquaculture, this report presents a clear and concise articulation of the worries that remain most pressing for the Nova Scotia lobster industry. After an open and transparent process involving 33 individuals who participated in one of five face-to-face interviews or one of five focus groups, we have summarized these concerns by grouping them into two meta-categories and ten subcategories. Under **Environmental concerns**, we note "*Feed, feces and dead water*", "*Pest, pesticide, and antifouling agents*", "*Benthic impact and recovery*", "*Equipment as pollution*", and "*Compatibility*" as key issues to be looked into further. We also grouped, under the meta-category of **Political, social, and economic concerns**, the following: "*Big Industry*", "*Government monitoring*", "*Job creation (myth)*", "*Ignored lobster industry*" and "*Research*". These categories, with the help of one final question regarding future research, produced three possible research programs, as listed in Table 5. Addressing these concerns in subsequent studies and research programs should sharpen the focus on issues with finfish aquaculture that are clearly important to lobster fishermen and should also ensure a long and sustainable future for Nova Scotia's inshore fishing industries.

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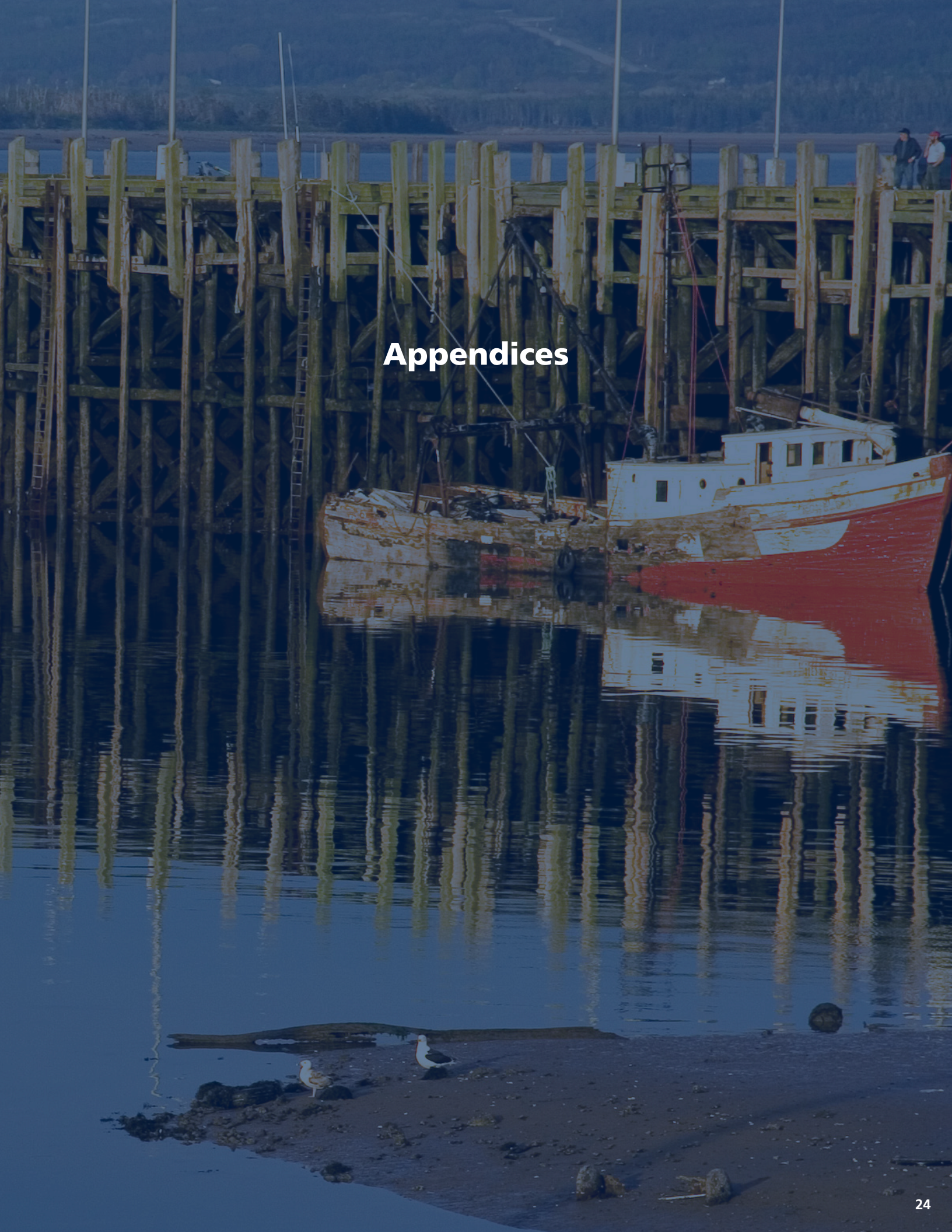

Appendices

Appendix 1: Survey Tools

Defining Public Concern about the Impact of Finfish Aquaculture on Lobsters and Lobster Fishing Communities in Nova Scotia: A Pilot Study

A collaborative research project by

Université Sainte-Anne and

Nova Scotia Fisheries and Aquaculture

Information Letter for Focus Groups

This pilot study has two objectives. The first is to develop a clear and concise understanding of what concerns are most pressing for the NS lobster industry with regard to finfish aquaculture. The second is to help set the foundation for future studies according to these concerns. Your participation in this study is strictly voluntary. You have the right to refuse to participate without fear that your relationship with people and agencies that you are working with may be affected.

If you decide to participate, it will take about two hours of your time. Please answer questions as honestly and as best as possible, but know that this is not a test. You are not required to have the "right answers" to participate and you are not required to answer any question that displeases you. You may also stop the process at any time without fear that your decision to do so may affect your relationship with people and agencies that you are working with.

During each meeting, the researcher will ask to use an audio recorder and will take notes. Recording the conversation will allow the researcher to listen to your story and comments more effectively. All signed consent forms, notes, and recordings will be securely locked in a filing cabinet at Université Sainte-Anne.

Your identity will not be revealed at any time throughout the research activities or reports. Please be aware, though, that any comments about the lobster industry or finfish aquaculture that you may have shared in public may allow others to identify you. As you have already shared these comments in public, we understand that you are probably comfortable with them. That said, it is important for us that you be aware of any such risk.

The results of the study will be provided to the Nova Scotia Fisheries and Aquaculture.

If you have any questions or concerns about the study or about being a participant, please call Roger Gervais, Ph.D., project coordinator (902-769-2114 ext. 7324), or Kenneth Deveau, Ph.D., V. P. Academic (902-769-2114 ext. 7307), at Université Sainte-Anne. You can also call the Research and Ethics Committee President, Marc Lavoie (902-769-2114 ext. 7174), if you have any concerns about the conduct of the study.

Defining Public Concern for Finfish Aquaculture on Lobsters and Lobster Fishing Communities in Nova Scotia: A Pilot Study

A collaborative research project by

Université Sainte-Anne and

Nova Scotia Fisheries and Aquaculture

Consent Form for Focus Groups

This pilot study has two objectives. The first is to develop a clear and concise understanding of what concerns are most pressing for the NS lobster industry related to finfish aquaculture. The second is to help set the foundation for future studies in regards to these concerns.

I understand that:

- My participation in this study is strictly voluntary.
- A refusal to participate will not affect my work with others or with any agency.
- If I decide to participate, it will take about two hours of my time.
- I am not required to have the right answers to participate in this study.
- I am not required to answer any question that displeases me.
- I may stop the process at any time without fear that my decision to do so might affect my relationship with people and agencies that I am working with.
- The interview will be recorded.
- All signed consent forms, notes and recordings will be securely locked in a filing cabinet at Université Sainte-Anne and destroyed at the end of the project.
- My identity will not be revealed at any time through the research activities or reports.
- All individual information I provide will be used only for research and will be held strictly confidential.
- I have been informed that any comments about the lobster industry or finfish aquaculture that I may have shared in public, may allow others to identify me.

I am aware that the results of the study will be provided to the Nova Scotia Fisheries and Aquaculture.

I accept to participate in this study and I am keeping one of the two signed copies of this letter.

Signature of Participant _____ Date _____

Defining Public Concern about the Impact of Finfish Aquaculture on Lobsters and Lobster Fishing Communities in Nova Scotia: A Pilot Study

A collaborative research project by
Université Sainte-Anne and
Nova Scotia Fisheries and Aquaculture

Questionnaire

Section 1 : Recursive interview

1. What words come to mind when we say “Salmon farming” or “Finfish Aquaculture”?

Section 2 : Semi-Structured interview

1. What are some of the negative long-term consequences of salmon farming that we may not have covered in the previous question?

2. What are some of the positive long-term consequences of salmon farming that we may not have covered in the previous question?

3. How might salmon farming interfere with or disrupt the activities of other users of coastal waters?

4. How might shell-fish aquaculture interfere with or disrupt the activities of other users of coastal waters?

5. What are some of the potential benefits and advantages of salmon farming that we may not have covered in the previous questions?

6. A report produced for the NSFA in Halifax underlined concerns about the inability of regulation, even of good regulations effectively enforced, to address problems. Is this also a concern here? In what way?

7. Keeping all that we have discussed in mind, where might we focus our studies to best respond to concerns about finfish aquaculture?

Background information

1. **Gender: _____**
2. **Date of birth:** _____ _____ _____

   D M Y
3. **Do you mind indicating the initials of your first, middle and last name?:**

   _____ _____ _____

   F M L
4. **What is your cultural background?**

   [Please circle the number that corresponds to the right answer.]

   Anglophone 1

   Francophone/ Acadian 2

   First Nation 3

   Other: (please specify) _____
5. **What education level have you reached?**

   [Please circle the number that corresponds to the right answer.]

   A few years of elementary school 1

   A few years of secondary school 2

   A secondary school diploma 3

   A college diploma 4

   A university degree (B.A., B.Sc., B.Ed., etc.) 5

   A postgraduate degree (M.A. Ph.D., etc.) 6
6. **Which category of lobster fishing best describes you?**

   [Please check off all applicable categories]

   Lobster fisherman.....1

   Avid Anglers 2

   Other: (please specify):_____

Appendix 2: List of cited research

Ernst W, Jackman P, Doe K, Julien G, MacKay K and Sutherland T (2001). "Dispersion and toxicity to non-target aquatic organisms of pesticides used to treat sea-lice on salmon in net pen enclosures". *Marine Pollution Bulletin*, 42, pp. 32–443.

Pesticides are used extensively in the finfish aquaculture industry to control sea lice infestations on farmed salmon. The most prevalent method of use is to enclose a net pen with an impervious tarpaulin and mix a pesticide solution within that enclosure. After treatment for short periods (1 h) the pesticide solution is released to the environment. Concerns have been raised that there is a potential risk to non-target aquatic organisms from those releases. The fate of dispersing pesticide solutions was measured after six simulated treatments in the Lower Bay of Fundy, New Brunswick. Three simulated treatments were done with azamethiphos and three with cypermethrin. Rhodamine dye was added to all pesticide solutions in order to facilitate tracking of the dispersing plume through real-time measurements of dye concentrations by a flow-through fluorometer coupled with a differential global positioning system (DGPS). Water samples were obtained from within the plumes at various times after release and analysed for pesticide content and toxicity to a benthic amphipod Eohaustorius estuaris. Dye concentrations were detectable for time periods after release which varied from 2 to 5.5 h. Distances travelled by the dye patches ranged from 900 to 3000 m and the dye concentrations at the final sampling period were generally 1/200–1/3000 the pre-release concentrations and cypermethrin concentrations were generally 1/1000–1/2000 the pre-release concentrations. Cypermethrin concentrations in water samples were closely correlated with dye concentrations, indicating that dye analyses were an accurate surrogate for cypermethrin concentrations. Most samples taken after the releases of azamethiphos were not toxic to test organisms in 48 h exposures and none were beyond 20 min post-release. By contrast, almost all samples taken after the release of cypermethrin, even up to 5-h post-release, were toxic. Data indicate the potential to cause toxic effects over areas of hectares from a single release of cypermethrin.

Grant, J. (2010). "Coastal communities, participatory research, and far-field effects of aquaculture". *Aquaculture Environment Interactions*, 1, pp. 85-93.

Marine aquaculture is controversial in coastal communities for a variety of reasons, including environmental and aesthetic concerns. Shellfish and especially finfish farming have the potential to cause eutrophication effects on the bottom, and reduce oxygen levels in the water column. Active participation of citizens in data gathering before and after development provides a mechanism of engagement in the science used for development decisions. I examine how participatory science can solve 2 problems: insight into far-field impacts of aquaculture, and entrainment of coastal stakeholders into the decision process. Working with a community group, I suggest sediment profile imaging as a method that could be employed by coastal residents, including participation in image analysis of the apparent redox potential discontinuity, a validated visual indicator of coastal benthic conditions. The implementation of rigorous science, with applicability to ecosystem health and capacity for public participation is key in ecosystem-based management.

Grant J, Bacher C, Cranford PJ, Guyondet T, Carreau M (2008). « A spatially explicit model of seston depletion in dense mussel culture". *Journal of Marine Systems*, 73, pp.155–168.

A fully-coupled biological–physical–chemical model of a coastal ecosystem was constructed to examine the impact of suspended mussel culture on phytoplankton biomass in Tracadie Bay, Prince Edward Island, Canada. Due to the extent of mussel culture there, we hypothesised that shellfish filtration would control the concentration and distribution of phytoplankton and other suspended particles in the bay. Circulation was delineated with a tidally-driven 2D numerical model and used to drive an ecosystem model with a focus on pelagic components including phytoplankton production, nutrients, detritus, and mussels. The benthos were treated as a sink. Nutrients and seston were forced by tidal exchange and river input, with phytoplankton additionally forced by light. Boundary conditions of seston and

nutrients were derived from field studies with an emphasis on the contrast between spring (high river nutrients, low temperature) and summer (low river inputs and high temperatures). Model output was used to map phytoplankton carbon over the bay for each season and in the presence of mussels and river nutrient input. Results indicate severe depletion effects of mussel culture on overall phytoplankton biomass, but no spatial pattern that can be attributed to grazing alone. Primary production generated by nutrient-rich river water created a mid-bay spike in phytoplankton that dominated the spatial pattern of chlorophyll-based carbon. Model results were validated with surveys from a towed sensor array (Acrobat) that confirmed the river influence and indicated bay-wide depletion of 29% between high and low water. Our model results indicate that the farm-scale depletion emphasised in previous studies cannot simply be extrapolated to seston limitation at the ecosystem level.

Hargrave BT (2005). *Environmental effects of marine finfish aquaculture*. Springer-Verlag, Berlin.

Environmental risks associated with large-scale marine finfish cage aquaculture have led to claims that the long-term sustainability of the industry is in doubt. Methods and models currently used to measure near and far-field environmental effects of finfish mariculture and to assess their implications for management are presented in 20 chapters arranged in four sections (Eutrophication, Sedimentation and Benthic Impacts, Changes in Trophic Structure and Function, and Managing Environmental Risks). Case studies show how models may be used to predict environmental changes and provide management tools to minimize potentially adverse environmental risks. The volume is of interest to those working towards sustainable development of mariculture, including environmental managers and decision-makers with regulatory responsibilities.

Hargrave, B.T. et al. (1997). "Assessing benthic impacts of organic enrichment from marine aquaculture". *Water, Air and Soil Pollution*, 99, pp. 641–650.

Benthic observations were carried out at 22 stations in the Western Isles region of the Bay of Fundy on the east coast of Canada to evaluate impacts at salmon aquaculture sites. Eleven sites were located under salmon net-pens and 11 sites (reference or control locations) were at distances > 50 m from net-pens. Total S- and redox potential (Eh) in surface sediment and benthic O2 uptake and CO2 release were sensitive indicators of benthic organic enrichment. High variability between replicate measurements of sediment gas exchange could reflect spatial patchiness in sedimentation of fecal waste and food pellets under fish pens. Biomass of deposit feeders was significantly increased at cage sites but total macrofauna biomass was similar at cage and reference locations. Surface sediment water content, modal grain size, pore water salinity and sulfate, and total biomass of macrofauna were the least sensitive indicators of enrichment.

Hargrave, B.T., Duplisea, D.E., Pfeiffer, E., Wildish, D.J., (1993). "Seasonal changes in benthic fluxes of dissolved oxygen and ammonium associated with marine cultured Atlantic salmon". *Marine Ecology Progress Series*, 96, pp. 249–257.

Benthic fluxes of dissolved oxygen and ammonium were measured at bi-weekly to monthly intervals during 1990-91 proximate to and under an array of pens holding Atlantic salmon Salmo salar Linn. in L'Etang Inlet, a macrotidal embayment in the Bay of Fundy, Canada. Hierarchical clustering of data indicated that the 7 stations could be divided into 3 groups (3 stations under the pen array, 2 at the perimeter of the array and 2 away from pens). Average rates of oxygen uptake and ammonium release for the 3 stations under the pens were 4 and 27 times higher, respectively, than values at the 2 stations distant from the cages. Maximum average rates of ammonium release (38 mmol m-2 d-1) in late July and oxygen uptake (99 mmol m-2 d-1) in early September for stations under the pens coincided with maximum water temperatures and sediment sulfide accumulation, respectively. Negative redox (Eh) potentials (< 0 mV) and reduced numbers of benthic polychaetes Capitella spp. also occurred in

sediments under pens between mid-July and September. Values of > 100 mM S= in sediment pore water during September could have been toxic to benthic fauna as well as to heterotrophic bacteria that produce substrates utilized by sulfate-reducing bacteria

Loucks, R. H., Ruth E. Smith, and E. B. Fisher (2014). "Interactions between finfish aquaculture and lobster catches in a sheltered bay". *Marine Pollution Bulletin*, 88, pp. 255-259.

Interactions between open-net pen finfish aquaculture and lobster catches in a sheltered bay in Nova Scotia, Canada, were investigated using fishermen's participatory research in annual lobster trap surveys over seven years.

Fishermen recorded lobster catches during the last two weeks of May from 2007 to 2013. Catches for each trap haul were recorded separately for ovigerous and market-sized lobsters. Catch trends within the bay were compared to regional trends. Results of correlation analyses indicated that ovigerous catch trends were strongly affected by the fish farm's feeding/fallow periods. There was no significant correlation between trends for bay and LFA lobster landings.

Patterns of lobster catch per unit effort extending over considerable distance in Port Mouton Bay appear to be influenced by proximity to the fish farm regardless of year-to-year variation in water temperatures and weather conditions. Odours and habitat changes surrounding open-net pen finfish operations are potential factors affecting lobster displacement.

Loucks, R.H., Smith, R.E., Fisher, C.V., Brian Fisher, E. (2012). "Copper in the sediment and sea surface microlayer near a fallowed, open-net fish farm". *Marine Pollution Bulletin*, 64, 1970–1973.

Sediment and sea surface microlayer samples near an open-net salmon farm in Nova Scotia, were analysed for copper. Copper is a constituent of the feed and is an active ingredient of anti-foulants. The salmon farm was placed in fallow after 15 years of production. Sampling was pursued over 27 months. Elevated copper concentrations in the sediments indicated the farm site as a source. Bubble flotation due to gas-emitting sediments from eutrophication is a likely process for accumulating copper in the sea surface microlayer at enriched concentrations. Elevated and enriched concentrations in the sea surface microlayer over distance from the farm site led, as a result of wind-drift, to an enlarged farm footprint. The levels of copper in both sediments and sea surface microlayer exceeded guidelines for protection of marine life. Over the 27 months period, copper levels persisted in the sediments and decreased gradually in the sea surface microlayer.

Wiber, M., Wilson, L., Young, S. (2012). "Impact of aquaculture on commercial fisheries: fishermen's local ecological knowledge". *Human Ecology*, 40 (1), pp. 29–40.

The Bay of Fundy along the southwest coast of New Brunswick, Canada is one of the most densely stocked finfish aquaculture areas in the world. An inshore multispecies fishery that dates back to the earliest European settlement shares these waters, and has been the economic mainstay of coastal communities. These inshore fishermen are increasingly displaced by the expanding aquaculture industry. A recent study conducted among fishermen in Southwest New Brunswick recorded their observations about the environmental impact of finfish aquaculture and the consequences for their commercial fishery. Fishermen all reported significant environmental degradation around aquaculture sites. Within 2 years of an operation being established, fishermen reported that gravid female lobsters as well as herring avoid the area, scallop and sea urchin shells become brittle, scallop meat and sea urchin roe becomes discolored. The use of chemicals to control sea lice on farmed salmon has also caused lobster, crab and shrimp kills. These and other concerns suggest that more comprehensive and detailed studies are required to establish the environmental and economic interactions of aquaculture and the inshore fishery, as well as on the stocks on which that fishery rely. The study also points to the need for more

effective use of fishermen's knowledge in designing such studies.

Wiber, M., Young, S., Wilson, L. (2011). *Aquaculture – Traditional Fishery Interactions in South West New Brunswick: Implications for Further Research*, vol. 1. OCN –Canada Policy Briefs.

In the winter of 2009, many lobsters were once again found dead from pesticide poisoning in several locations in Southwest New Brunswick (SWNB). Subsequent testing determined that a pesticide (Cypermethrin) that was not approved for marine use, but could be used to control sea lice in salmon aquaculture, had killed these lobsters. Several other lobster kills followed, and the resulting tension between the two industries reinforced the need for research that targets environmental impacts of aquaculture with respect to the habitat and health of commercial fish stocks. Since 2006, members of the Coastal Community University Research Alliance (CURA), a Maritimes-wide alliance investigating the role of communities in integrated management, have been examining the interaction of finfish aquaculture and the inshore fisheries in SWNB. In order gain some understanding of the fishermen's local ecological knowledge (LEK) on the problem, and to suggest directions for future targeted science, the Coastal CURA and Fundy North Fishermen's Association undertook a preliminary and small-scale study of ecological change in aquaculture areas as observed by inshore fishermen.

Wildish D, Hargrave B and MacLeod C (2003). "Detection of organic enrichment near finfish net-pens by sediment profile imaging at SCUBA-accessible depths". *Journal of Experimental Marine Biology and Ecology*, 285/286, pp. 403–413.

Sediment profile images (SPI) of cores collected by SCUBA diver were obtained using a modified Hargrave corer from fish farm sites in the Bay of Fundy, Canada and southeastern Tasmania, Australia. Shipboard and land based photography were used to obtain the SPI with a tripod mounted digital camera and image analysis by commercially available software. Computer images were analyzed to determine the variables used by Nilsson and Rosenberg [Mar. Ecol., Prog. Ser. 197 (2000) 139], modified to account for non-equilibrium conditions, to assess successional stages of organic enrichment. To validate the method, we concurrently sampled macrofaunal species composition and abundance and measured profiles of redox potentials and total sulphides by ion analysis. In each case, the null hypothesis that sediments collected directly under an active salmon net-pen were indistinguishable from a nearby reference site was rejected. The SPI method can successfully detect organic enrichment where impacts occur in soft sediments in geographically diverse locations.

Wildish DJ, Hargrave BT, Pohle G (2001). "Cost-effective monitoring of organic enrichment resulting from salmon mariculture". *ICES Journal of Marine Science*, 58, pp. 469–476.

Two methods of environmental monitoring proposed for the salmon mariculture industry are compared and contrasted on the basis of scientific and cost-effectiveness criteria: a technique based on macrofaunal community structure and one using process-oriented sediment geochemistry. For this purpose, field sampling was confined to one salmon farm and a nearby reference site in the Bay of Fundy. Both methods produced significant differences between farm and reference sites, as well as meeting other appropriate scientific criteria. The geochemical method was based on field measurements of sedimentary Eh, by redox electrode, and sedimentary sulphide after fixing the sediment in a sulphur anti-oxidant buffer and ion analyses with Ag/Ag sulphide and combination reference electrode. Both measures can be completed in the field from the sampling vessel. Results suggested that the geochemical method was of significantly lower cost than the technique based on macrofaunal community structure. This is because of the lengthy laboratory time required to determine the identity and abundance of macrofaunal taxa. Both methods can categorize the sedimentary organic impact as normal, oxic, hypoxic, or anoxic, which depends ultimately on the dominant microflora present. This, in turn, depends on the rate of carbon reaching the sediment, as well as its utilization by biological and physical processes.

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