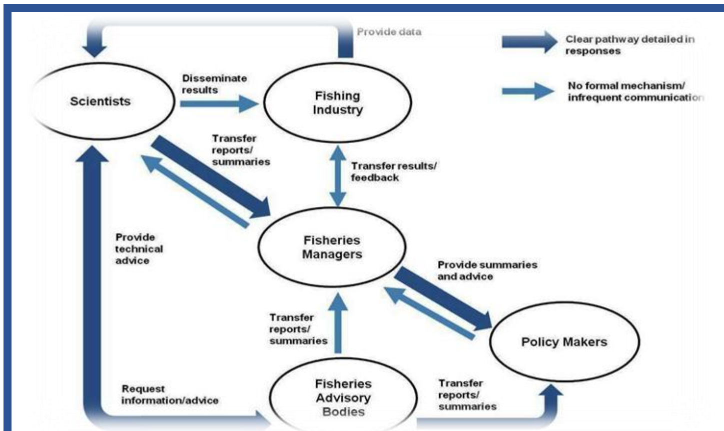
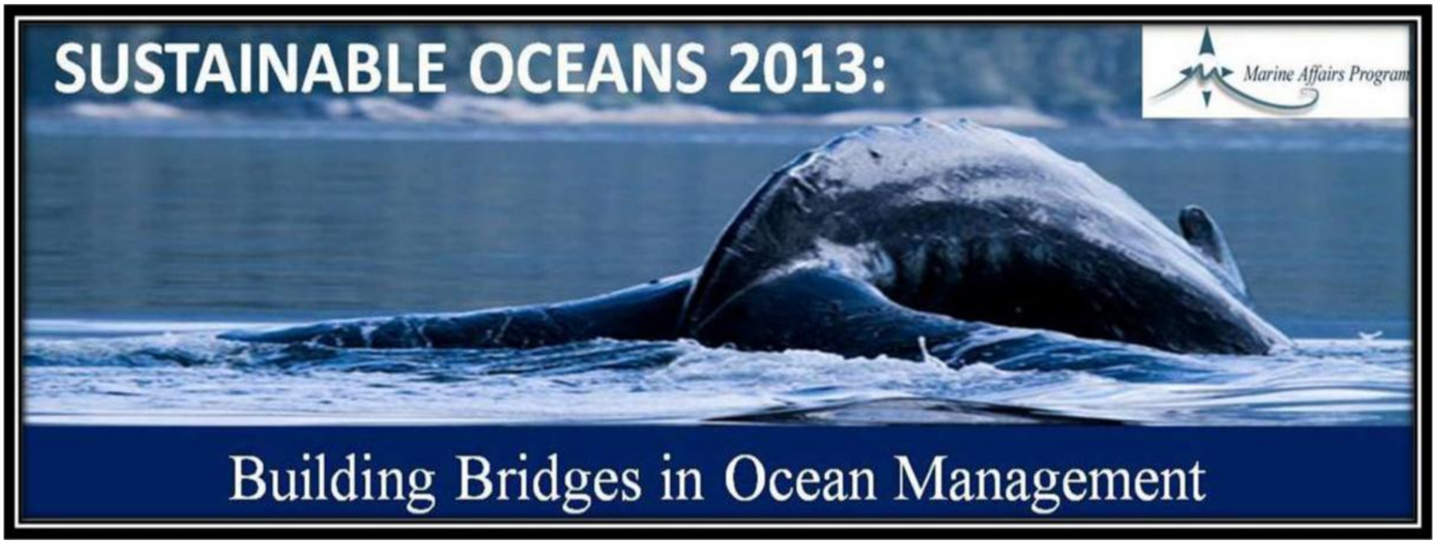
MARINE AFFAIRS TECHNICAL REPORT 11

Building Bridges in Ocean Management: Connecting the Policy, Science and Public Spheres



Marine Affairs PROGRAM
DALHOUSIE UNIVERSITY
Inspiring Minds
www.marineaffairsprogram.dal.ca
marine.affairs@dal.ca
902-494-3555

Acknowledgements



A sincere thanks to sponsors and supporters: the Sobey Fund for Oceans, Dalhousie Association of Graduate Students, Nexus Coastal, AGAT Laboratories, Aquaculture Association of Nova Scotia, Dalhousie Faculty of Management Alumni Relations, Marine Affairs Student Society, MBA Cooperate Residency Program, and the Dean's office, Faculty of Management. We are very grateful to all the presenters, participants, artists, chairs, judges, rapporteurs, volunteers, and the Marine Affairs Program who contributed their time and talent to make this a memorable event.

The Sobey Fund for Oceans is a unique partnership between the Marine Affairs Program, Dalhousie University and WWF Canada

This report should be cited as:

J. MacIntosh and J. Stoner. (Eds.). (2013). *Building Bridges in Ocean Management: Connecting the Policy, Science and Public Spheres.* Halifax, NS: Dalhousie University. (Marine Affairs Technical Report #11). Available at Marine Affairs Program: http://marineaffairsprogram.dal.ca/Publications

Front cover photo credits: Soomai, Wells, & MacDonald, 2011 (top left); Atlantic Fishermen, 2013, http://www.atlanticfishermen.com/stories.asp?od=6552 (top right); Held, M., 2012 (bottom left); Mombourquette, D., 2013 (bottom right)

Table of Contents

Introduction from the Editors

This issue of the Marine Affairs Technical Series is a compilation of four papers that were presented during the Sustainable Oceans Conference 2013: Building Bridges in Ocean Management. The conference was held April 12th and 13th at Dalhousie University, hosted by the Master of Marine Management class of 2013 and acted as a key activity for the Sobey Fund for Oceans. The overarching theme for the conference was “connecting the science, policy and public spheres” and aimed to create a platform of cross-sectoral dialogue between government and industry representatives, local citizens, scientists, non-profit organizations, and students.

The four papers included herein represent a snapshot of the work that was presented during the oral and poster presentation series, which provided an opportunity for students at both the graduate and undergraduate level to present their work as it related to building bridges in ocean management. The presentations were focused on three thematic areas: responsible industry practices, stakeholder engagement and public participation, and communicating information for effective ocean governance. Each paper skilfully addresses a unique ocean management issue and together they highlight the diverse array of topics that were addressed during the sessions. Two of the four papers - An Integrated Analysis of The Expansion of Salmon Farming on the Eastern Shore of Nova Scotia by Avdic et al. and Understanding the Science-Policy Interface: Measuring Use and Influence of Information in Policy Making by Suzuette Soomai – received awards for their quality and distinctiveness at the conference.

Suzette Soomai, PhD candidate with the Interdisciplinary PhD Program at Dalhousie University, authored the first paper included in this series: Understanding the Science-Policy Interface: Measuring Use and Influence of Information in Policy Making. In recognition that communication and information flow between the scientific and policy spheres is an important component to sustainable development, this paper sets out to study the degree of awareness, use and influence of scientific information in the policy-making process. By drawing on case studies from Trinidad and Tobago, Nova Scotia and the Gulf of Maine this research highlights that marine and coastal environmental information is most useful in the policy-making process if presented in diverse forms (i.e. direct or indirect communication, print or digital, reports/summaries/fact sheets) that are targeted to the specific audience. This paper, which was presented as an oral presentation under the theme of communicating information for effective ocean governance, aptly defines and seeks to addresses the critical issue of effective communication between various parties involved in oceans management. Appropriately, Ms. Soomai received the Building Bridges in Oceans Management award at the conference for this work.

The second paper included in this series is Narwhal co-management in Nunavut: Deepened collaboration needed to improve partnership, process and outcome by Mirjam Held, a candidate with the Interdisciplinary PhD Program at Dalhousie University. This paper provides an assessment of the shortcomings of the current co-management process in place for narwhal management in Nunavut, Canada. Additionally, a series of recommendations are included, which aim to advance power sharing and knowledge co-production in the current co-management regime to promote effective management. This paper was presented at the conference during the poster presentation session under the theme of stakeholder engagement and public participation.

The third paper is written by Vanja Avdic, Scott Biggar, Karen Devitt, Katie Paroschy, and Robin McCullough, all of whom are candidates in the Master of Resource and Environmental Management program in the School of Resource and Environmental Studies at Dalhousie University. Entitled An Integrated Analysis of The Expansion of Salmon Farming On The Eastern Shore of Nova Scotia, this paper takes an interdisciplinary approach to analyzing the current conflict related to the expansion of open net-pen salmon farming in Nova Scotia by reviewing the social-political, biophysical and legal components of this debate. Through thorough analysis of the issue including a literature review and interviews, the authors conclude that greater respectful communication among parties and clearer regulations and legislation are essential to alleviating the tensions between all interested stakeholders. This paper was presented at the conference during the poster presentation session and was the recipient of the People's Choice award.

The final paper included herein, Creating A False Shortage Within A Fishery: Can It Be Accomplished And If So What Are The Benefits?, was written by Dan Mombourquette who is an M.Sc candidate at St. Mary's University. This paper theorizes the potential for, and benefits of, creating a false shortage within capture fisheries. The reasoning for creating a false shortage is explained using both the price-quantity theory of microeconomics and the theory of fisheries bioeconomics, while case studies of the Spanish hake (merluza sp.) and Canadian silver hake (Merluccius bilinearis) are presented to articulate the idea. The author concludes by providing a set of recommendations that would need to be in place to ensure the success of this market-based strategy to fisheries conservation. This paper was presented as an oral presentation within the theme of responsible industry practice.

Together these four papers touch on a variety of the concerns that currently plague the oceans, but they commonly address the need for better communication amongst stakeholders and call upon the oceans community to develop solutions that are not only innovative and bold, but also encompassing and respectful of the many groups that depend on the oceans. Both the challenges and recommendations highlighted in these papers are reflective of common themes that emerged through the various conference events including the Keynote address, panel discussion, interactive workshop and the 'dreamboard'. In the words of Sarika Cullis-Suzuki, the keynote speaker, "our own beginnings come from the ocean, and our survival hinges on its fate. Yet through overexploitation and misuse, we've fundamentally altered it. As we confront this new, endangered ocean, we must accept accountability, reflect on our collective responsibility, and redefine our relationship with it."

We hope that this Technical Series is both thought provoking and encouraging, and that it lends to further conversations and interdisciplinary discussions on the importance of building bridges in ocean management.

Sincerely,

Jessica MacIntosh and Jenna Stoner
Masters of Marine Management, 2013

Informed Governance

Understanding the Science-Policy Interface: Measuring Use and Influence of Information in Policy-Making

Suzuette Soomai[a], Candidate, Interdisciplinary PhD Program

[a] Faculty of Graduate Studies, Dalhousie University, 1459 Oxford Street, Halifax, Nova Scotia, Canada, B3H 4R2

email: suzuette.soomai@dal.ca

Winner of the overall "Building Bridges in Ocean Management" award at the Sustainable Oceans conference, 2013

Suzuette Soomai was a government fisheries scientist in Trinidad and Tobago and a member of scientific working groups coordinated by the Food and Agriculture Organisation (FAO) of the United Nations (UN) and the Caribbean Regional Fisheries Mechanism (CRFM) for Latin American and the Caribbean. Suzuette has a BSc (Hons) in Biology and a Master of Philosophy (MPhil) degree in Zoology from the University of the West Indies, Trinidad and Tobago and a Master of Marine Management (MMM) from Dalhousie University. She is currently an Interdisciplinary PhD Candidate at Dalhousie University and her research seeks to understand the role of fisheries scientific information in policy making within national, regional, and international contexts. Her research is guided by the Environmental Information: Use and Influence research initiative in the Faculty of Management. Suzuette joined this research team while working on her MMM graduate project which was a preliminary study of the scientific information produced by national fisheries departments in association with the FAO and the CRFM.

Abstract

Strengthening information flow at the science-policy interface is now considered a priority for urgent action to achieve sustainable development. However, understanding the current role that scientific information plays in marine environmental policy and decision-making is not commonly considered to be an issue for urgent and targeted attention. Case studies of governmental organizations producing marine environmental information demonstrate the use of a suite of methods to gain a comprehensive understanding of the awareness, use, and influence of information in environmental policy-making. Such understanding can enhance the use of environmental information in policy settings and raise the overall visibility of scientific information in sustainable ocean management.

1.1 Introduction

Scientific studies highlight the global decline in the health of the world's coasts and oceans and the need for action related to e.g., the existing and inherent effects of climate change, overfishing, loss of marine biodiversity, increased marine pollution, and uncontrolled coastal development, to name a few (e.g., FAO, 2012; GESAMP, 2001). Governmental and intergovernmental organizations haveproduced vast quantities of scientific information on stresses on the oceans aimed at guiding public policy for sustainable development (MacDonald, Wells, Cordes, Hutton, Cossarini, & Soomai, 2010)

Evidence-based policy-making recognizes the need for advice in decision-making and has influenced the production of scientific knowledge by governmental organizations. However, proof of the movement of scientific information into action remains limited (Mitchell, Clark, Cash, & Dickson, 2006). The apparent disconnect between the information and knowledge produced by scientists and the information and knowledge used by policy-makers in decision-making science and policy-making is a concern – largely since declining environmental trends are still apparent in spite of the availability of technical reports (Sutherland et al., 2012). Strengthening information flow at the science-policy interface is now considered a priority for urgent action to achieve sustainable development and globally countries have committed to supporting actions to improve exchange of and access to information (Brito & Stafford Smith, 2012; UNGA, 2012).

1.2 Objectives

It is well recognized that environmental policy development and decision-making are complex processes given the nature of modern environmental issues that are now operating on global levels (Ascher, Steelman, & Healy, 2010; Mitchell, 2010). What receives much less recognition is the vital role of marine information management in the process (Soomai, MacDonald, & Wells, 2013). In spite of increased knowledge and international commitment, understanding and enhancing the role that scientific information plays in marine environmental policy and decision-making is not commonly considered to be an issue for urgent and targeted attention and the role is not clearly defined (Soomai et al., 2013). This paper posits that research on the awareness, use, and influence of scientific information in policy-making is worthy of detailed study rather than being considered to be implicit in management processes. Research aimed at gaining an understanding of the enablers and barriers to the use and influence of marine environmental information at the science-policy interface are guided by models and concepts of communication of information.

Figure 1 illustrates the complexities of the generation, transmission, and use of environmental information in policy making. Competing needs of multiple stakeholders, at national and international levels, can complicate the policy-making process. Information from various sources, e.g., non-governmental organizations, government, and local knowledge, is aggregated and filtered according to institutional constraints, organizational norms and cultures, personal and professional biases of various actors, e.g., managers, public, and media. The filtered information then enters the realm of policy- and decision-making which generates new knowledge that feeds into new information production by the various agencies.

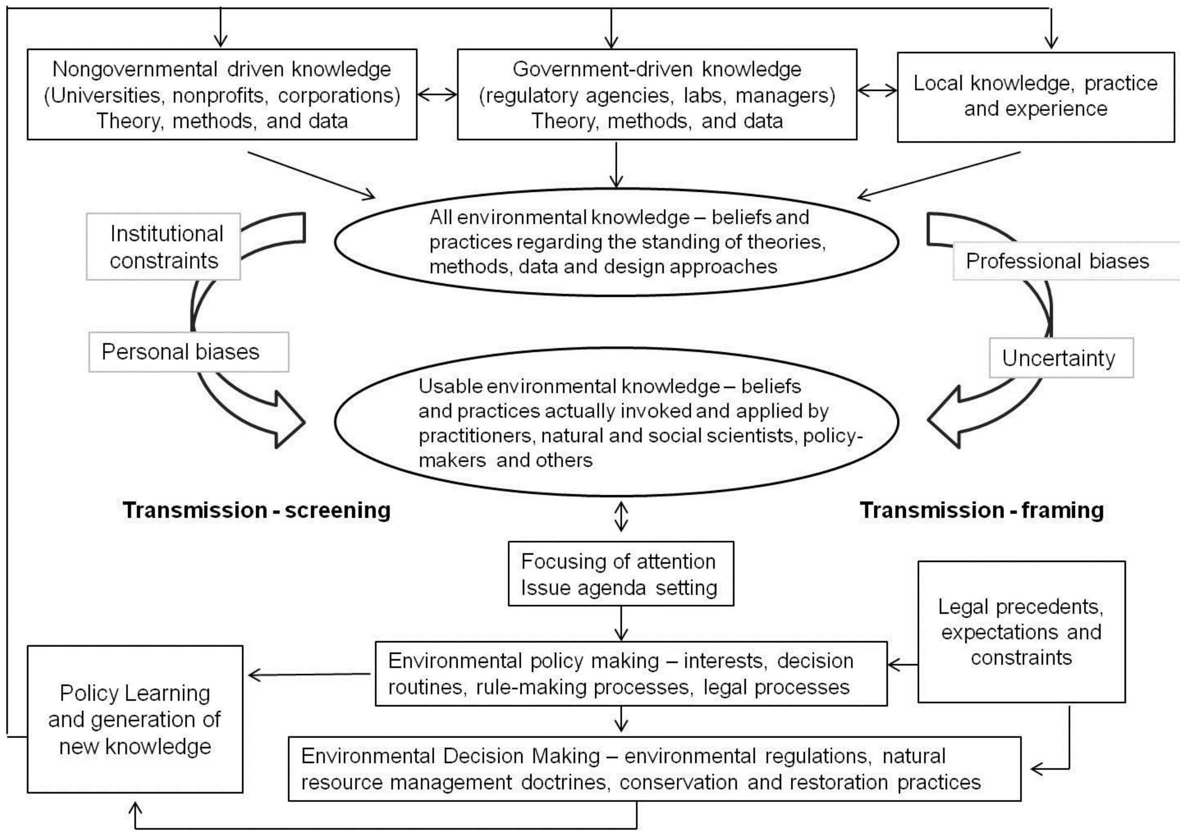


Figure 1. Model of the generation and transmission of information. (Source: Ascher, Steelman, & Healy, 2010)

Typologies of information use and influence are often generalizations and clear distinctions cannot be made to explain how research evidence is actually used. Figure 2 illustrates two main categorizations of use: direct or instrumental use, indirect or conceptual use (Nutley, Walter, & Davies, 2007). In direct or instrumental use, scientific evidence is used in decision making to reach a specific solution. In indirect or conceptual use, evidence influences or informs how policy-makers and practitioners think about issues, problems, or potential solutions. Nutley, Walter, and Davies (2007) describe a two-way flow of information where the stages of research use in policy-making exist as an iterative process or continuum model.

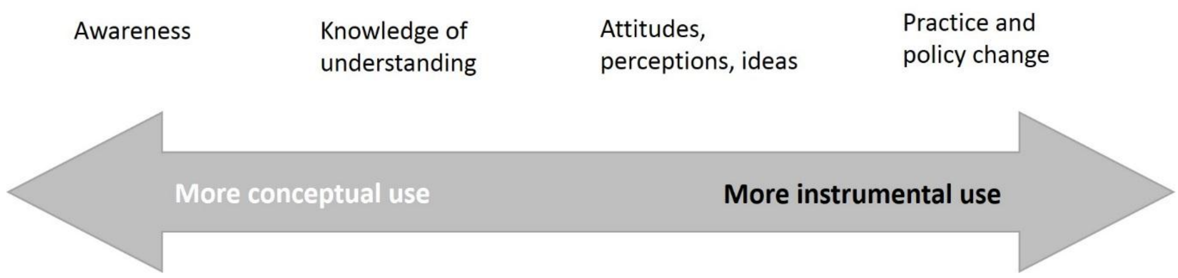


Figure 2. Model of information use. (Source: Nutley, Walter, & Davies, 2007)

1.3 Justification for research

Case studies of governmental organizations producing marine environmental information can be used to understand how information is produced, how it is used, and how it influences environmental policy-making. Opportunities and barriers in the policy-making process can be identified. Research findings can assist organizations to maximize the value of their publications by exercising efficient transfer of information to reach diverse audiences and to encourage public participation in policy making processes. Such research can identify the communication gaps and the key groups and actors to connect in the science, policy, and public spheres. The research findings can also be informative and relevant since funding for environmental research is often limited and accountability of public expenditures is increasingly expected (Soomai, MacDonald, & Wells, 2013).

1.4 Methodology

This paper also uses examples of case studies from Trinidad and Tobago, Nova Scotia, and the Gulf of Maine/Bay of Fundy region to demonstrate the use of a suite of methods to understand the awareness, use, and influence of coastal and marine environmental information, including fisheries information, in public policy settings (Soomai, Wells, & MacDonald, 2011; Soomai, MacDonald, & Wells, 2013). Data collecting methods used in the three case studies include surveys (interviews and questionnaires) of multiple stakeholders, e.g., policy- and decision-makers, scientists, industry, and the public; web analytics, media scans, and citation analysis.

The first case study focused on opportunities and barriers for using information contained in stock assessment reports of the FAO/Western Central Atlantic Fisheries Commission (WECAFC) Working Group on the Shrimp and Groundfish Resources on the Brazil-Guianas Continental Shelf. These assessments were completed in the 1990s and 2000s by national scientists from countries located in north-east South America. The assessments provide technical details on the status of commercial shrimp and fish stocks and provide management advice for fisheries managers. The case study of this Latin American and Caribbean fishery was conducted in May to July 2009 using a survey questionnaire directed at five key groups in Trinidad and Tobago and Venezuela: fishing industry, scientists, fisheries managers, policy makers, fishery advisory bodies (Soomai, 2009; Soomai, Wells, & MacDonald, 2011). The survey asked questions on awareness and use of the stock assessment reports. Results provide insights into the reasons for the frequent lack of uptake of management advice as well as the flow of information among the groups.

The second case study involved *The 2009 State of Nova Scotia's Coast Report*, produced by the Government of Nova Scotia, Canada (Government of Nova Scotia, 2009; Soomai, MacDonald, & Wells, 2011a). The goal of the *Report* was to provide an overview of the condition of the province's coast and information on six priority coastal issues (working waterfronts, sea level rise, coastal habitats, coastal development, water quality, and coastal ecosystems). The Report was released in December 2009 in three formats: a 245-page technical report, a 21-page summary, and six four-page fact sheets. It was available in print and in digital format on the government's web page. The provincial government was particularly interested in promoting awareness of coastal issues in the general public, and encouraging and increasing public participation in development of a new coastal policy. The case study was conducted from March to December 2010 in collaboration with the provincial government (Soomai, MacDonald, & Wells, 2011a). A suite of qualitative and quantitative methods was used to examine the awareness, use, and influence of *Report* by the public from the date of its release, including surveys (questionnaires and interviews), analysis of Web site access data, citation analysis, analysis of holdings of library collections, and a review of local print media coverage after the launch of the *Report*.

The third case study involved *The State of the Gulf of Maine Report*, produced by the Gulf of Maine Council on the Marine Environment (GOMC) to inform decision makers on the main issues affecting the Gulf of Maine/Bay of Fundy region and released in June 2010 (GOMC, 2010; Soomai, MacDonald, & Wells, 2011b). *The State of the Gulf of Maine Report* is produced in a modular format composed of a context paper and issue-oriented theme papers (to date, climate change and its effects on humans; climate change and its effects on ecosystems, habitats, and biota; coastal ecosystems and habitats; marine invasive species; and emerging issues), published in digital format only and are accessible from the GOMC Web site. The case study was conducted between January and May 2011 to determine awareness and use of *The State of the Gulf of Maine Report* by members of the Council, Working Group, and readers of the *Gulf of Maine Times* (Soomai, MacDonald, & Wells, 2011b). Three stand-alone online surveys were developed and administered in Opinio software.

1.5 Main findings

The findings identified aspects of the communication of scientific information to wide audiences aimed at increasing public participation in decision making. For instance, the case study of *The 2009 State of Nova Scotia's Coast Report* showed that several communication methods and multiple mechanisms of report distribution are needed to reach diverse audiences. Both direct communication (e.g., notification letters), and indirect (e.g., information transferred through government and NGO networks) were needed. Also with regard to *The 2009 State of Nova Scotia's Coast Report,* both print and digital means of distribution were shown to be necessary, as well as the release of the reports in less technical versions (summary and fact sheets). Social networks were important for increasing community awareness of the reports as email networks of the non-governmental organizations as well as the government were instrumental in increasing awareness among their established networked groups (Soomai, MacDonald, & Wells, 2011a).

Overall, respondents believed that digital formats were useful for decision making since it facilitated dissemination, distribution, and updating of information about Nova Scotia and the Gulf of Maine/Bay of Fundy (Soomai, MacDonald, & Wells, 2011a; 2011b). While survey respondents were supportive of the theme paper format of *The State of the Gulf of Maine Report*, its availability only in digital format on GOMC's Web site was considered to be a limiting factor in its distribution and awareness (Soomai, MacDonald, & Wells, 2011b).

In the Caribbean fishery study, Figure 3 shows the flow of information in fisheries management. The flow of information, or the communication, is strongest between the fisheries advisory bodies and the scientists due to the provision of technical advice and focus on production of information (Soomai, Wells, & MacDonald, 2011). While the flow of information is strong from fishermen to scientists, i.e., provision of data, the communication of results to the fishing industry is limited. The distribution of information is also strong between scientists and fishery managers as scientists present findings and technical advice to the fishery manager. However, fisheries managers do not directly advise scientists on the types of assessments that are needed. Responses identified a gap in communication between the policy makers and scientists and the policy makers and the fishing industry. The fishing industry and fisheries managers commented on the high technical detail of the reports.

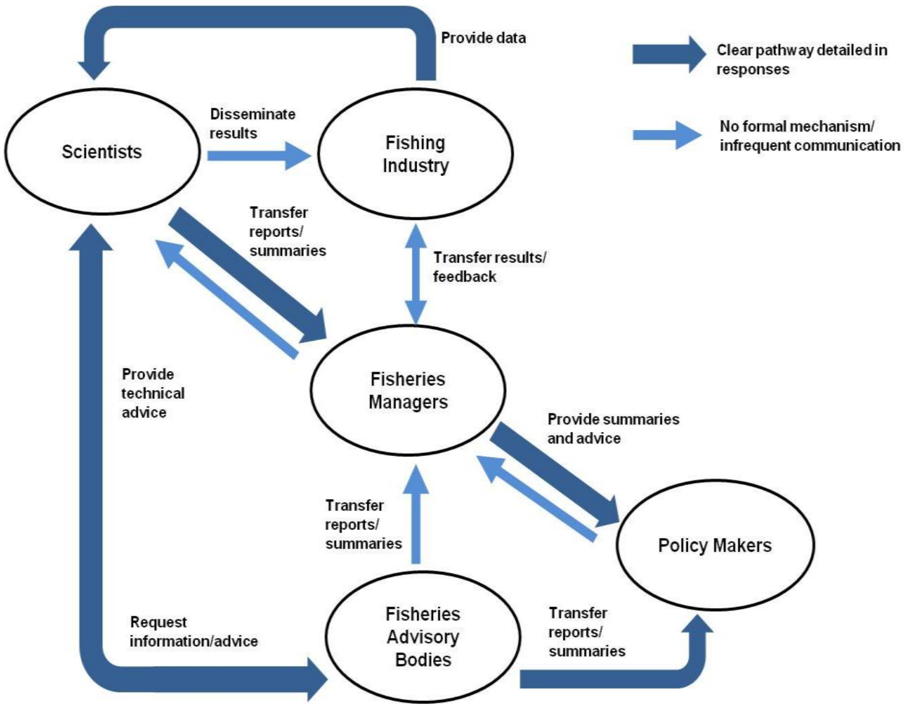


Figure 3. Flow of information among stakeholders involved in fisheries management (Source: Soomai, Wells, & MacDonald, 2011).

With regard to *The 2009 State of Nova Scotia's Coast Report* and *The State of the Gulf of Maine Report*, evidence of indirect benefits was recorded, such as increased collaboration and networking within and among the governmental and other types of organizations. The influence of the reports is seen mostly in increased awareness and knowledge about environmental issues by multiple stakeholders (Soomai, MacDonald, & Wells, 2011a; 2011b). For the most part, information reached the "interested public" rather than the "general public" (Soomai, MacDonald, & Wells, 2011a; 2011b). For instance, survey respondents were more apt to be part of the interested members of the public, i.e., individuals who were previously aware of the reports and were involved in its production in one or more ways, or who were part of existing social networks with links to coastal issues, or who were already active in coastal zone conservation and protection are included in this category. As a consequence, the "interested public" may be better able to inform policy development.

1.6 Key messages/next steps

Using a range of methods allowed the survey of a diverse group of stakeholders involved in fisheries and coastal zone management. No one method can give an overall measure of awareness, use, and influence of scientific reports unless the information contained in a report is intended for a specific audience (Soomai, MacDonald, & Wells, 2011a). For continued tracking of usage of reports, other methods such as content analysis (e.g., of media reports and social media) and network analysis could be included in future analyses to allow a more in depth analysis of use and will indicate influence in policy making. The methodologies can be applied in the marine context as well as other fields of study where challenges to communicate information at the science- policy interface also exist.

The findings can assist organizations with prolific publishing histories to maximize their information's value to wide audiences by creating efficient transfer of information so that the public finds the “right” information and are encouraged to participate in policy and decision-making. Dissemination of information to wide audiences is critical to facilitate paradigm shifts in use and influence of scientific information to encourage public participation in policy making processes (Soomai, MacDonald, & Wells, 2013). While use may be easy to record, influence remains difficult to measure.

1.7 References

Ascher, W., Steelman, T., & Healy, R. (2010). *Knowledge and environmental policy: Reimagining the boundaries of science and politics*. Cambridge, MA: MIT Press.

Brito, L. & Stafford Smith, M. (2012). State of the planet declaration. *Planet Under Pressure: New Knowledge Towards Solutions*. London, UK, 26-29 March, 2012.

FAO. (2012). State of the world fisheries and aquaculture. Rome: Food and Agriculture Organisation.

GESAMP, 2001. Sea of Troubles. GESAMP Reports and Studies 71. International Maritime Organization, London, United Kingdom.

Government of Nova Scotia. (2009). *The 2009 state of Nova Scotia's coast technical report*. Retrieved from http://www.gov.ns.ca/coast

Gulf of Maine Council on the Marine Environment (GOMC), 2010. The Gulf of Maine in context: State of the Gulf of Maine report. http://www.gulfofmaine.org/state-of-the-gulf/docs/the-gulf-of-maine-in-context.pdf (accessed 04.05.12).

MacDonald, B.H., Wells, P.G., Cordes, R.E., Hutton, G.R.G., Cossarini, D.M., Soomai, S.S., 2010. The use and influence of information produced as grey literature by international, intergovernmental marine organizations: overview of current research, in: Farace, D.J., Schöpfel, J. (Eds.), *Grey Literature in Library and Information Studies*. De Gruyter Saur, Berlin, pp. 167-180.

Mitchell, R. B., Clark, W. C., Cash, D. W., & Dickson, N.M. (2006). Information and influence. In R. B. Mitchell, W. C. Clark, D. W. Cash, & N. M. Dickson, (Eds.), *Global environmental assessments: Information and influence*, (pp. 307-338). Cambridge, MA: MIT Press.

Mitchell, R. B. (2010). *International politics and the environment*. London: SAGE Publishing Ltd.

Nutley, S., Walter, I., & Davies, H. T. O. (2007). *Using evidence: How research can inform public services*. Bristol: The Policy Press.

Soomai, S. (2009). Information and influence in fisheries management: A preliminary study of the shrimp and groundfish resources in the Brazil-Guianas Continental Shelf. (Unpublished MMM graduate project). Halifax, Nova Scotia: Dalhousie University.

Soomai, S. S., MacDonald, B. H., & Wells, P. G., (2011a). *The 2009 State of Nova Scotia's Coast Report: An initial study of its use and influence.* Halifax: Dalhousie University.

Soomai, S. S., MacDonald, B. H., & Wells, P. G., (2011b). *The State of the Gulf of Maine Report: An initial study of awareness, use and influence.* Halifax: Dalhousie University.

Soomai, S. S., Wells, P. G., & MacDonald, B. H. (2011). Multi-stakeholder perspectives on the use and influence of "grey" scientific information in fisheries management. *Marine Policy 35*, 50-62.

Soomai, S. S., MacDonald, B. H., & Wells, P. G. (2013). Communicating environmental information to the stakeholders in coastal and marine policy-making: Case studies from Nova Scotia and the Gulf of Maine/Bay of Fundy region. *Marine Policy, 40*, 176–186.

Sutherland W. J. , Bellingan, L. , Bellingham, J.R. , Blackstock, J. J. , Bloomfield, R. M. , et al. (2012). A collaboratively-derived science-policy research agenda. *PLoS ONE, 7*(3), e31824.

United Nations General Assembly (UNGA) (2012). *The future we want*. Sixty-sixth session, Agenda item 19: Sustainable development. A/66/L.56.

Public Engagement

Narwhal co-management in Nunavut: Deepened collaboration needed to improve partnership, process and outcome

Mirjam Held[a], Candidate, Interdisciplinary PhD Program

[a] Faculty of Graduate Studies, Dalhousie University, 1459 Oxford Street, Halifax, Nova Scotia, Canada, B3H 4R2
email: m.held@dal.ca

Mirjam has a background in geography, marine biology, and education and is a recent graduate of the Marine Affairs Program at Dalhousie University (MMM 2012). For her graduate project, which ideally combined her interests in co-management, marine mammals, the Arctic, social justice and Aboriginal issues, she analyzed the narwhal co-management in Nunavut and proposed measures to improve the collaboration in areas where it is currently falling short of its objectives. Mirjam has recently been accepted into the TOSST Research School at Dalhousie University and will soon start her PhD as part of the Fish-WIKS project (Fisheries - Western and Indigenous Knowledge Systems). She is excited to investigate how the Inuit knowledge system can enhance the current regime of decision-making and consequently improve fisheries management in Nunavut.

Abstract

Since the ratification of the Nunavut Land Claims Agreement (NLCA) in 1993, narwhal harvesting in Nunavut has been governed by a formalized co-management regime. The Nunavut Wildlife Management Board, a body created under the NLCA, has decision-making power, while the ultimate management authority remains with Fisheries and Oceans Canada as marine mammals are a federal responsibility. Calling for an effective system of wildlife management that complements Inuit harvesting rights, fosters public participation, and reflects the traditional and current patterns of Inuit harvesting and wildlife management, the NLCA provides an adequate framework for co-management. However, co-management processes take a long time to mature and the Nunavut narwhal co-management regime is no exception. While there have been attempts to devolve management responsibility to the local level, cooperation between the co-management partners is challenged by a lack of capacity among the local and regional hunters organizations as well as a lack of trust. The assessment of the shortcomings of the current co-management process revealed issues regarding communication, power sharing and the limited inclusion of Inuit knowledge and values in the decision-making process. A number of recommendations on advancing narwhal co-management are proposed, including capacity building among hunters, a true commitment to adaptive co-management which will facilitate social learning, and the engagement of a facilitator to assist in developing collaborative and effective ways of collecting and sharing information. Such co-production of knowledge would help the Nunavut narwhal co-management partners to form their recommendations and decisions on a more inclusive and equitable knowledge base. Only a co-management regime whose partners are truly committed to power sharing and knowledge co-production

will be environmentally, socially and economically sustainable, thus allowing both the narwhals and the Inuit that depend on them to prosper.

2.1 Introduction

Inuit have sustainably hunted narwhals for centuries (Savelle, 1994), and to this day the narwhal is an important cultural, nutritional and economic resource for the Inuit in Nunavut. Since 1993 when the Nunavut Land Claims Agreement (NLCA) was ratified, narwhal hunting in Nunavut has been managed under a formalized co-management regime. Co-management is a balancing act between government and community control that entails a certain degree of power sharing between the government and the resource users and that recognizes and legitimizes traditional local management systems (Pomeroy & Berkes, 1997).

The purpose of this paper is to provide management advice for the improvement of the current Nunavut narwhal co-management process. This management regime is not fulfilling the expectations of neither policy makers nor the resource users despite the fact that all co-management partners share the same ultimate goal, namely to protect and conserve the narwhal in order to allow for continuous sustainable harvesting by the Inuit hunters. A set of recommendations is proposed based on an in-depth analysis of the present implementation of narwhal co-management in Nunavut.

The research presented here is qualitative and inductive. It is mainly the result of a desktop study, but it benefitted from informal meetings with various stakeholders in the narwhal co-management process. Data collection included published policy documents and Fisheries and Oceans Canada (DFO) science advice reports as well as draft management documents and supporting information (such as letters, comments and responses) available from the Nunavut Wildlife Management Board's online meetings and hearings repository. The analytic framework encompassed the wider field of co-management theory as well as the relevant literature on traditional ecological knowledge and *Inuit Qaujimajatuqangit* (*IQ*) and their use in resource management. As traditional knowledge held by Inuit encompasses more than factual environmental and ecological knowledge, the Inuit in Nunavut have coined *IQ* as a more overarching term. *IQ* includes the social and cultural context of traditional knowledge, the process by which knowledge is evaluated and passed on to younger generations (Dowsley, 2009) as well as Inuit beliefs about how the world works and the values that guide ethical behaviour in human interactions with the environment, including animals (Nunavut Wildlife Management Board [NWMB], n.d.b).

The Nunavut narwhal co-management regime was assessed using a deficiency analysis (*i.e*. a SWOT analysis that focuses on the weaknesses and limitations) that compared the current implementation of narwhal co-management in Nunavut with the intended goals and outcomes of the process. Reflecting the main areas where the Nunavut narwhal co-management is not living up to its full potential, the assessment focused on power sharing and social learning processes within the co-management regime. Where gaps between theory and practise were identified, recommendations are presented that have the potential to alleviate the shortcomings.

2.2 The narwhal, an important resource in Nunavut

The narwhal (*Monodon monoceros* Linnaeus, 1758) is a medium-sized odontocete (toothed whale) that is found exclusively in the Arctic. The narwhals that frequent Canadian waters are distinguished into two populations based on their summering grounds: the Northern Hudson Bay population and the Baffin Bay population

(Committee on the Status of Endangered Wildlife in Canada [COSEWIC], 2004). The existence of distinct subpopulations or stocks has been proposed (Stewart, 2008), but exact delineations are currently not feasible. Narwhals have distinct summering and wintering grounds and have been found to exhibit high site fidelity to them as well as to migratory routes (Heide-Jørgensen, Dietz, Laidre, & Richard, 2002, Heide-Jørgensen *et al*., 2003). The latest aerial surveys of the narwhals in their Canadian summering grounds have yielded population estimates of at least 60,000 animals for the Baffin Bay population (Richard *et al*., 2010) and about 12,500 animals for the Northern Hudson Bay population (Asselin, Ferguson, Richard, & Barber, 2012). These abundance estimates, however, are afflicted with a great deal of uncertainty (Asselin *et al*., 2012; Richard *et al*., 2010). The narwhal is a deep-diving (Laidre, Heide-Jørgensen, Ermold, & Steele, 2010), gregarious (COSEWIC, 2004) and very loquacious (Ford & Fisher, 1978) cetacean that has a slow reproduction rate (COSEWIC, 2004; Richard, 2009). Its most prominent characteristic is a 2-3 metre long ivory tusk which is in fact a tooth growing in a counter-clockwise spiral from the upper left jaw of adult males (Reeves & Tracey, 1980). Narwhals feed predominantly on Greenland halibut (*Reinhardtius hippoglossoides*) and the squid species *Gonatus fabricii* (Laidre & Heide-Jørgensen, 2005). They do not have many natural predators.

Inuit in the Canadian Arctic traditionally hunted narwhals with harpoons from kayaks (Ross, 1975), using large floats made of entire sealskins to keep the stricken whale afloat and add drag (Boas, 1888/1964). Today, narwhals are still hunted in the open water, but also from the floe edge and in ice cracks (Dale, 2009; Roberge & Dunn, 1990). They are shot with a rifle and secured and retrieved using a grappling hook, block and tackle and/or a boat (Lee & Wenzel, 2004; Roberge & Dunn, 1990). *Mattaq*, the narwhal skin with some blubber attached to it is an important and valued food item (Freeman, 2005). Narwhal meat used to be fed to the sled dog teams (before they were replaced by snowmobiles), and the ivory tusks were fashioned into tools and sometimes carvings (Freeman *et al*., 1998; Reeves & Mitchell, 1981; Smith, 1991). Since the establishment of permanent trading posts in the Canadian Arctic more than a hundred years ago, narwhal tusks have been traded for food, goods and cash (Ross, 1975; Reeves, 1992; Reeves & Mitchell, 1981).

For Inuit, the importance of narwhal hunting extends beyond providing food and revenue; it is a crucial factor in the maintenance of cultural identity and social relationships. Inuit identify themselves as hunters, but this does not infer superiority over their prey (Laugrand & Oosten, 2010). The narwhal, as all animals that are hunted by Inuit, is regarded as a sentient being that has a soul and demands respectful treatment (*cf*. Dowsley & Wenzel, 2008; Laugrand & Oosten, 2010; Pelly, 2001; Tyrrell, 2007). Hunted food is shared among families and kin (Ford & Beaumier, 2011; Gombay, 2010a; Vaughan, 1994), and thus is crucial in creating and forwarding relationships (Freeman *et al*., 1998; Gombay, 2010b). Hunting also plays an important role in maintaining ecological knowledge and facilitates the transfer of skills and values to the younger generations (Hovelsrud, McKenna, & Huntington, 2008; Kishigami, 2005).

For centuries, Inuit in the Canadian Arctic have been managing their narwhal harvests. In 1971, the Canadian Government enacted, in accordance with the *Fisheries Act*, the *Narwhal Protection Regulations* which assigned annual catch quotas first to individual hunters and later to communities (Armitage, 2005; Richard & Pike, 1993). The quota system was not well received by Inuit hunters as the quotas were assigned rather arbitrarily, not adjusted through time and non-transferable (Armitage, 2005; Diduck, Bankes, Clark, & Armitage 2005). Pursuant to the quotas, tags were issued by DFO to communities and re-distributed to hunters who had to attach a tag to every landed narwhal, a system that is still in place today (DFO, 2012d; *Marine Mammal Regulations*, 1993).

Apart from fisheries regulations, there are other laws and regulations that govern narwhal management in Canada, such as the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). The narwhal is listed on Appendix II of CITES which regulates the import and export of species that could become threatened with extinction if trade is not closely controlled (CITES, 2012; CITES, n.d.). Thus, narwhals, including all parts and derivatives of the species, need to be accompanied by a permit from the exporting country when traded for commercial purposes (CITES, 1973, Article IV, section 2). Such a permit is only to be issued when the national government of the exporting state has advised that the export will not be detrimental to the survival of wild populations and, thus, it is referred to as a non-detriment finding (NDF) (CITES, 1973; DFO, 2012c). The regulatory climate around narwhal management in Nunavut has, in many ways, challenged the efforts and efficacy of current actions. Subsistence needs and conservation requirements need to be balanced while adhering to a host of national and international legislation.

2.3 Narwhal co-management in Nunavut under the NLCA

After two decades of negotiations between the Government of Canada and the Tungavik Federation of Nunavut, the organization that negotiated on behalf of the Inuit of what is now Nunavut, the NLCA came into force in 1993, followed by the creation of the Nunavut Territory in 1999 (Fenge & Quassa, 2009; *Nunavut Act*, 1993; *Nunavut Land Claims Agreement Act*, 1993). In addition to settling Inuit land and water rights in Nunavut (based on traditional use and occupancy), the NLCA includes, *inter alia*, provisions for wildlife harvesting. It calls for an effective system of wildlife management that complements Inuit harvesting rights, fosters public participation, and reflects the traditional and current patterns of Inuit harvesting, thus providing an adequate framework for co-management (Department of Indian Affairs and Northern Development [DIAND] & Tungavik Federation of Nunavut [TFN], 1993, Sections 5.1.2(e), 5.1.3(a)(i) and 5.1.3(b)(ii)). To this end, the NLCA established the Nunavut Wildlife Management Board (NWMB), a nine-member co-management board that is the main instrument of wildlife management in Nunavut (DIAND & TFN, 1993, Sections 5.2.1 and 5.2.33). While the ultimate responsibility for wildlife management still lies with the federal government, the authority of the NWMB goes well beyond the power and functions of co-management boards established under earlier land claims agreements in other parts of the Canadian Arctic (Goodman, 1997; Government of Nunavut Department of Environment, 2006). In the case of the narwhal, the federal Minister of Fisheries and Oceans can only alter or reject a decision of the NWMB if it conflicts with conservation of the species and/or public health and safety (Goodman, 1997; DIAND & TFN, 1993, Section 5.3.3).

The responsibilities of narwhal co-management in Nunavut are split between the NWMB, DFO, and the local and regional hunters associations. The duties of the NWMB include participating in research, establishing, modifying or removing levels of total allowable harvest (TAH) (*i.e.* the overall amount of a stock or population of wildlife that the NWMB decides can be lawfully harvested under the provisions of the NLCA) and non-quota limitations (*e.g.* harvesting restrictions regarding area, season or gear type), and ascertaining basic needs levels (BNLs) (*i.e.* levels of harvesting by Inuit required to meet their basic needs) (DIAND & TFN, 1993). The board's decisions affect peoples' rights or interests, and, hence, public hearings are held in the run-up of any forthcoming decision (NWMB, n.d.a). Community-based Hunters and Trappers Organizations (HTOs) oversee the harvesting by Inuit by allocating and enforcing BNLs and regulating harvesting practices and techniques through informal agreement or by enacting by-laws (DIAND & TFN, 1993, Section 5.7.3; Richard & Pike, 1993). As BNLs have not been set yet, HTOs are responsible for allocating community quotas and for reporting on annual narwhal harvests to DFO (DFO, 2012*d*). Additionally, each of the three regions of Nunavut has a Regional Wildlife Organization (RWO) which is responsible for wildlife management at the regional level (DIAND & TFN, 1993, Sections 5.7.4 and 5.7.6), while DFO acts as the regulator and organizational lead with regard to aquatic species listed under CITES (DFO, 2012d; Environment Canada, 2011).

The Government of Nunavut (GN) and Nunavut Tunngavik Incorporated (NTI) are not considered formal co-management partners because their mandates do not include marine mammal management. Both organizations, however, have an appointee on the NWMB and are actively involved in the decision-making process through consultations and hearings. As a public government for all Nunavummiut, the GN is affected by the decisions of the NWMB and the narwhal harvesting in general with regard to socio-economic impacts such as income, health and safety and thus has an interest in narwhal management (W. Lynch, personal communication, May 30, 2012). NTI is an Inuit organization that superseded the Tungavik Federation of Nunavut (the spelling of Tun(n)gavik changed over the years) and has been representing the Inuit of Nunavut as a party to the NLCA since the agreement came into force in 1993 (DIAND & TFN, 1993, Section 1.1.1). NTI is responsible for ensuring that both the Inuit and the federal and territorial governments fulfill their responsibilities and obligations as set out in the NLCA*, i.e.* that the implementation of the NCLA truly benefits the Inuit (NTI, n.d.). The responsibilities of the narwhal co-management partners and the linkages among each other are depicted in Figure 1.

Co-management processes take a long time to mature and the Nunavut narwhal co-management is no exception. Upon the request of many communities to change the entire narwhal management regime, the NWMB initiated an experiment exploring the potential of community-based narwhal co-management (Armitage, 2005; DFO, 2012d). While the trial, which ran from 1999 to 2007 (DFO, 2012d), represented a truly collaborative effort (Diduck *et al*., 2005), it nevertheless failed. In the communities that took part in the experiment narwhal quotas were removed, a change that resulted in significant increases in landed narwhals (Armitage, 2005; DFO, 2012d). Consequently, DFO swiftly re-established harvest limits that could be carried over to the following year (Armitage 2005; DFO, 2012d). This intervention, mainly the result of poor communication among the various stakeholders, was highly contentious and negatively affected the mutual trust among the co-management partners (Armitage, 2005).

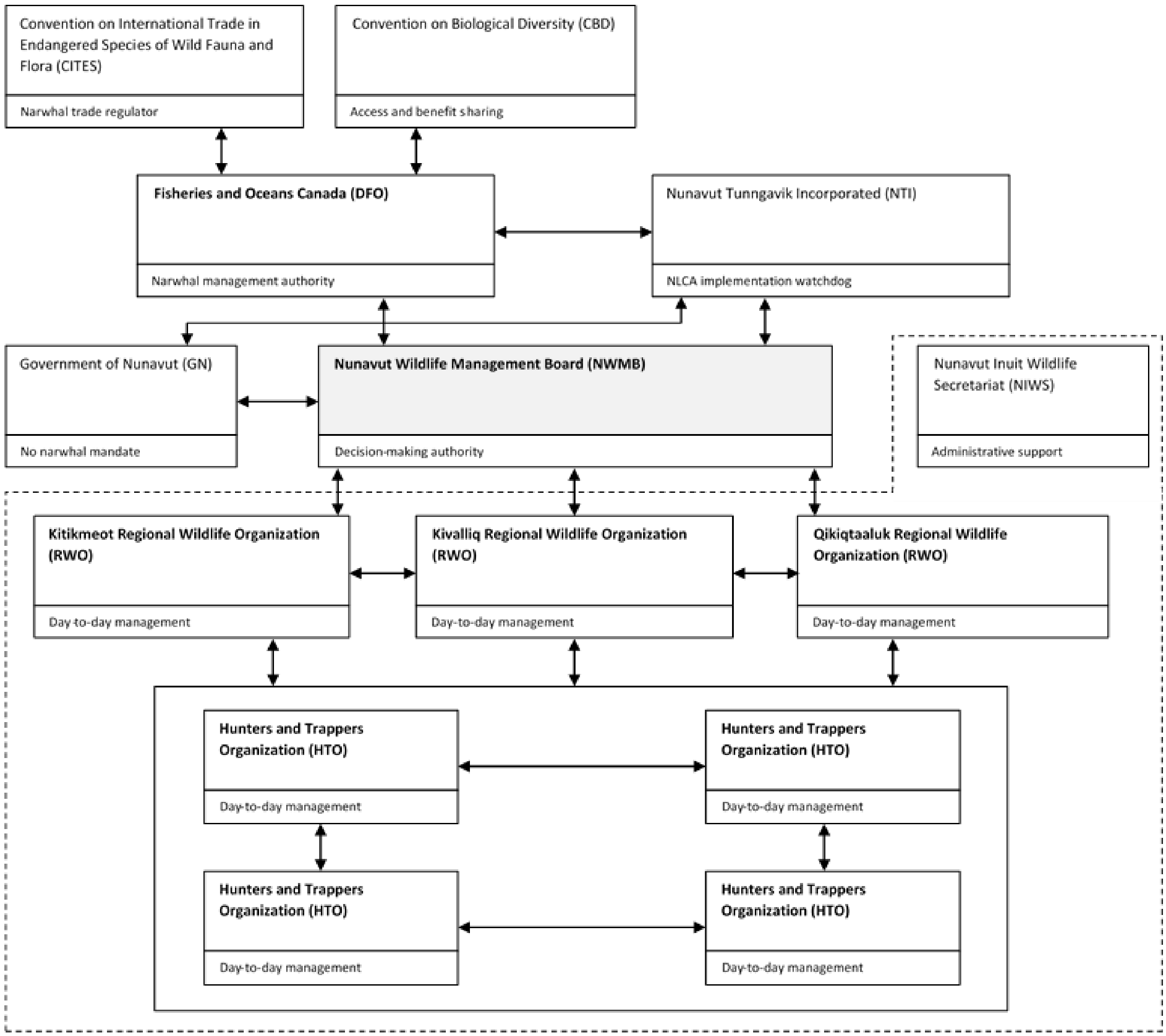


Figure 1. The Nunavut narwhal co-management partners (formal partners in bold), their responsibilities and linkages. Adapted from Armitage, 2005 and Blakney, 2009.

The current Nunavut narwhal co-management regime is basically a continuation of the quota and tag system first established in 1971. However, the co-management partners and other stakeholders, with NTI leading the way, agree that changes are needed to further align narwhal management with the provisions of the NLCA (DFO, 2012g; NTI, 2012a). Thus, during the past few years, the Nunavut narwhal co-management partners have been mainly concerned with two related issues: the establishment of total allowable harvest and basic needs levels. In order to reduce potential overexploitation of a narwhal population that is hunted in several communities, DFO is suggesting using summering aggregations (stocks) of narwhals as management units (DFO, 2008; DFO, 2009). Based on the most recent population and stock abundance estimates (Asselin & Richard, 2011; Asselin *et al.*, 2012; DFO, 2012a; Richard *et al*., 2010), DFO put forward recommendations for the total allowable landed catch (TALC) for each management unit (DFO, 2008; DFO 2012d) along with a decision tool to allocate these TALCs through the seasons (Richard, 2011). These proposed management measures have been submitted for approval to the NWMB as part of an Integrated Fisheries Management Plan (IFMP) which was drafted by DFO on behalf of all co-management partners (DFO, 2012d; DFO, 2012g). The public hearing took place in late July 2012, and the board's decision is expected to be released in the fall of 2012 (NTI, 2012b). If established, the TALCs would replace the existing community quotas (DFO, 2012g). A public hearing on BNLs, which were originally supposed to be established by the NWMB within a year of the creation of the board, is scheduled for September 2012 (NWMB, 2012)[1].

An extra challenge was added in December 2010 when DFO withheld CITES NDFs for several of the proposed management units (DFO, 2012g), thus banning international trade of narwhal tusks from these areas. This prohibition dissatisfied the hunters from an economic point of view. But they, along with NTI, were particularly alienated as they had not been consulted and the decision was based on management units that had not yet been discussed nor adopted (NTI, 2012a). Based on updated analyses and using the latest abundance estimates (Asselin & Richard, 2011; DFO, 2012c), DFO has since retrospectively issued NDFs for most management units so that Grise Fiord is currently the only community affected by an export ban (NTI, 2012c).

2.4 Analysis and discussion of issues facing narwhal co-management

The assessment of the shortcomings of the current co-management process revealed four issues, namely power sharing, communication, disagreement with regard to how exactly narwhal co-management is to be executed under the provisions of the NLCA, and the limited inclusion of Inuit knowledge and values in the decision-making process.

While there have been attempts to devolve management responsibility to the local level, **cooperation** between the co-management partners is challenged by a lack of capacity among the local and regional hunters organizations (Nunavut Inuit Wildlife Secretariat, n.d.; W. Lynch, personal communication, May 30, 2012). On the other hand, the NWMB is now well established as the decision-making authority. Although not formal co-management partners, the GN and NTI are actively involved in the Nunavut narwhal co-management process, offering advice, collecting *IQ* and making sure Inuit rights are fulfilled (Government of Nunavut Department of Environment, 2012). All stakeholders have continuously proven their willingness to collaborate. Examples of this demeanour are the continuation of the community-based co-management experiment after the emergency closure of the narwhal fishery in one of the participating communities (Armitage, 2005; Diduck *et al*., 2005) as well as the recent agreement to collaborate on drafting an IFMP following the breakdown of trust triggered by DFO not issuing CITES non-detriment findings for several narwhal stocks (DFO, 2012g). Even so, not all management functions are being performed jointly, particularly data gathering and analysis as well as recommending TAH levels, which are primarily done by DFO. Ideally, co-management regimes link local-level actors and governments through shared decision-making power. This collaboration is thought to be indispensable in order to achieve sustainable development (United Nations Conference on Environment and Development [UNCED], 1992, Section III, Chapter 23) and should not only include management but also extend

[1] Meanwhile, the proposed IFMP has been approved by both the NWMB and the Minister of Fisheries and Oceans and is now in effect, *i.e.* the TALCs for each management unit have been set (NTI, 2013; Nunatsiaq News, 2013). The BNLs have been set to equal the total allowable harvest, *i.e.* the sum of the TALCs (S. Arnold, personal communication, May 17, 2013).

to research (DIAND & TFN, 1993, Section 5.1.2(h); Wiber, Berkes, Charles, & Kearney, 2004; Wiber, Charles, Kearney, & Berkes, 2009).

Having different worldviews as well as different cultural and institutional backgrounds with regard to both oral and written **communication**, the narwhal co-management stakeholders have repeatedly struggled to find common ground. The emergency closure of the narwhal hunt in Qikiqtarjuaq in 2000 (*cf*. Armitage, 2005; Diduck *et al*., 2005), the withholding of CITES NDFs for several narwhal stocks in 2010, and the legal action subsequently taken by NTI against the federal government (*cf*. DFO, 2012g) are expressions of poor communication which resulted in a breakdown of **trust**. But there is hope, for, according to the literature, one of the benefits of co-management arrangements is the fact that collaboration and social learning foster trust building and the formation of social networks of researchers, communities and policy makers (Armitage *et al*., 2009). Such a collaborative regime, however, is slow to develop (*cf*. Jentoft, 2005; Pomeroy & Berkes, 1997); but once matured, it can provide the flexibility and creativity needed to deal with uncertainty and rapidly changing social-ecological systems as well as conflict resolution (Armitage *et al*., 2009).

Furthermore, not all co-management partners are in agreement about the **interpretation of key concepts** such as community consultations and the consideration of *IQ*. These two concepts are mandated by the NLCA (although not explicitly) because its objectives and guiding principles concerning wildlife management (DIAND & TFN, 1993, Sections 5.1.2(e) and 5.1.3) cannot be achieved without consulting with Inuit and without incorporating *IQ*. Indeed, all stakeholders have adopted the practice of consulting with the Inuit prior to making recommendations or decisions. Before submitting the draft IFMP for narwhal to the NWMB, DFO representatives from the GN, NTI and NWMB took part as observers and engaged in community consultations (DFO, 2012b; DFO, 2012f; White, 2012). However, it remains unclear to what extent the concerns and knowledge of the Inuit were considered in the proposed IFMP (DFO, 2012g; NTI, 2012a). DFO's objectives for the consultations can be interpreted to the effect that DFO views consultations mainly as a means to inform the hunters about management decisions and to provide them with an opportunity to voice their concerns as opposed to a truly reciprocal relationship between the stakeholders (DFO, 2012e; White, 2012). However, in a co-management regime with Inuit, Western scientific knowledge and *IQ* must be considered equally (Nakashima, 1993). NTI, the GN and the NWMB advocate for the inclusion of *IQ* in narwhal management decision-making (Government of Nunavut Department of Environment, 2012; NTI, 2012a; NWMB, n.d.b). The prevalent conceptualization among scientists and policy makers is, however, that traditional ecological knowledge can only be considered relevant when validated by Western science (Casimirri, 2003).

The fourth issue is the **confrontation of Western scientific knowledge and *IQ***. DFO traditionally bases its recommendations and decisions on internally peer-reviewed science (*e.g.* DFO, 2009; DFO, 2012c). But no matter how diligently the review process is carried out, this conventional method of knowledge production has its limitations. Although estimates have been peer reviewed, it does not make them any more certain especially in a rapidly changing socio-ecological system (Armitage *et al*., 2009). *IQ* on the other hand, is less susceptible to assumptions as it is knowledge that has been handed down through the centuries and that embodies fundamental ideas and values of Inuit life and culture (Laugrand & Oosten, 2010). With regard to wildlife management, *IQ* can offer information about long-term observations of a species, its behaviour and habitat as well as the socio-cultural importance of a resource. Despite the informative nature of *IQ*, which is neither published nor peer-reviewed, it is rarely included in the decision-making process of wildlife management despite the NLCA's mandate.

2.5 Conclusions and recommendations

The analysis of the main issues facing narwhal co-management in Nunavut brings forth a number of conclusions and respective recommendations. In the past 19 years, formalized narwhal co-management has continuously profited from trial and error and adaptations that resulted from this approach, but has not fully matured as of yet. In order to advance narwhal co-management in Nunavut, the currently limited power sharing among co-management partners, particularly DFO and the HTOs, needs to be extended. Yet the devolution of power and responsibilities to the HTOs and also the RWOs needs to be accompanied by capacity building. This type of investment has the potential to improve the entire co-management process from the bottom up as the presence of strong community leaders has been found to be a key element of successful fisheries co-management (Gutiérrez, Hilborn, & Defeo, 2011; Jentoft, 2005; Pinkerton, 1989).

Formalizing the inclusion of NTI and the GN in the narwhal co-management regime could also enhance cooperation. Although they do not have jurisdiction over marine mammals, both groups are actively involved in the co-management process. Their formal inclusion would better reflect the composition of the nine members of the NWMB and provide equal conditions for all the partners, thus eliminating tendencies to take sides and reducing frustration. After all, the stakeholders pursue the same ultimate goal. Thus, being on par with each other could increase the sense of unity among the co-management partners, which in turn would facilitate increased cooperation and power sharing.

Generally, the process would likely benefit from the involvement of a facilitator. While the NWMB could assume this role, it might be more effective to turn to an outsider. Linking different governance levels and knowledge systems is a challenging task that requires an active role from all co-management partners. Facilitators can assist the stakeholders in developing collaborative and effective ways of collecting and sharing information (Halls *et al.*, 2005). This is particularly true when there are conflicts and tensions due to dissimilar cultural backgrounds (Borrini-Feyerabend, Farvar, Nguinguiri, & Ndangang, 2000), which is the case in the Nunavut narwhal co-management regime.

There is a need to rebuild trust and to collaborate on establishing a positive atmosphere of conversation. According to the literature, one of the outcomes of adaptive co-management is building trust through collaboration and social learning (Armitage *et al.*, 2009). The latter is an iterative and democratic process to adapt to social and ecological change (Woodhill, 2002, as cited in Armitage, Marschke, & Plummer, 2008). Through such a flexible and creative learning process, the Nunavut narwhal co-management partners could learn from mistakes, adapt to new research findings, and integrate *IQ* in decision-making, all without losing the objectives of narwhal co-management. Admittedly, this is not an easy task and requires that all co-management partners are willing to engage in such a learning process without bias. Empowerment of the resource users and the inclusion of a facilitator would foster increased collaboration and thus social learning, which in turn would foster meaningful consultations, *i.e*. engaging in relationships in which the knowledge and values of all partners are equally respected and considered.

Differing interpretations of key concepts lead to misunderstandings, thereby promoting conflict, hampering the effectiveness of collaboration and eroding trust. Thus, clarification regarding the meaning of "consulting with Inuit" and "considering *IQ*" is needed – a task that should be taken on collaboratively by all stakeholders. This would be beneficial for the co-management partners as it is they who would have to proceed according to definitions agreed upon.

In the current Nunavut narwhal co-management process, *IQ* and Western scientific knowledge are not considered equally. Some co-management partners seem to view the two knowledge systems as competitive rather than complementary. To facilitate a revision of this view a new way of gathering and using both scientific and traditional knowledge is needed. Co-production of knowledg**e** is a method that could help the narwhal co-management partners to form their recommendations and decisions on a more inclusive and equitable knowledge base. Knowledge co-production is a collaborative effort to bring various sources and types of knowledge together in order to understand and address a specific problem (Dale & Armitage, 2011). At present, *IQ* is typically incorporated during the data collection phase of Western scientific research, and when knowledge is shared its integration and application are very limited. Engaging in the co-production of knowledge means that diverse interpretations of knowledge are explored collaboratively and in an open and honest manner (Dale & Armitage, 2011). Such a dialogue, which is more likely to happen with the help of a facilitator, is the key to producing, from the integration of scientific knowledge and *IQ*, a new way of thinking and a new knowledge base that is needed to address the social-ecological complexities inherent to narwhal management.

Although not a co-management panacea, social learning and the co-production of knowledge under the guidance of an experienced facilitator seem to be valid solutions to an array of issues currently facing narwhal co-management in Nunavut. These new processes cannot be implemented, however, without the willingness and buy-in of all stakeholders. Currently, the co-management partners are hindered by their dissimilar worldviews and cultures to truly engage in power sharing and knowledge co-production, but as they all share the same ultimate goal, there is hope that the entirety of narwhal knowledge can be used for the collective good of the species and the Inuit that depend on it.

Acknowledgements

I am indebted to Janelle Kennedy, Wayne Lynch and all the representatives of narwhal co-management partners that took the time to elucidate the complex nature of the Nunavut narwhal co-management arrangement as established under the NLCA. I also thank Dr. John Kearney for his thoughtful comments on an earlier draft of this manuscript. This work was supported by the Fisheries and Sealing Division of the Nunavut Department of Environment and the Marine Affairs Program at Dalhousie University.

2.6 References

Armitage, D. R. (2005). Community-based narwhal management in Nunavut, Canada: Change, uncertainty, and adaptation. *Society and Natural Resources, 18*, 715-731. doi:10.1080/08941920591005124

Armitage, D., Marschke, M., & Plummer, R. (2008). Adaptive co-management and the paradox of learning. *Global Environmental Change, 18*, 86-98. doi:10.1016/j.gloenvcha.2007.07.002

Armitage, D. R., Plummer, R., Berkes, F., Arthur, R. I., Charles, A. T., Davidson-Hunt, I. J., … Wollenberg, E. K. (2009). Adaptive co-management for social-ecological complexity. *Frontiers in Ecology and the Environment, 7*, 95-102. doi:10.1890/070089

Asselin, N.C., & Richard, P. R. (2011). Results of narwhal (*Monodon monoceros*) aerial surveys in Admiralty Inlet, August 2010. *DFO Canadian Science Advisory Secretariat Research Document, 2011/065.* Retrieved from http://www.dfo-mpo.gc.ca/Csas-sccs/publications/resdocs-docrech/2011/2011_065-eng.pdf

Asselin, N. C., Ferguson, S. H., Richard, P. R., & Barber, D. G. (2012). Results of narwhal (*Monodon monoceros*) aerial surveys in northern Hudson Bay, August 2011. *DFO Canadian Science Advisory Secretariat Research Document, 2012/037.* Retrieved from http://www.dfo-mpo.gc.ca/Csas-sccs/publications/resdocs-docrech/2012/2012_037-eng.pdf

Blakney, S. L. (2009). *Connections to the land: The politics of health and wellbeing in Arviat Nunavut* (Doctoral dissertation). Retrieved from http://hdl.handle.net.ezproxy.library.dal.ca/1993/3903

Boas, F. (1964). *The Central Eskimo*. Lincoln, NE: University of Nebraska Press. (Original work published 1888).

Borrini-Feyerabend, G., Farvar, M. T., Nguinguiri, J. C., & Ndangang, V. A. (2000). *Co-management of natural resources: Organising, negotiating and learning-by-doing*. Heidelberg, Germany: Kasparek Verlag. Retrieved from http://portals.wi.wur.nl/msp/?page=1256

Casimirri, G. (2003). *Problems with integrating traditional ecological knowledge into contemporary resource management*. Paper submitted to the XII. World Forestry Congress, 2003, Québec City, Canada. Retrieved from http://www.fao.org/DOCREP/ARTICLE/WFC/XII/0887-A3.HTM

Committee on the Status of Endangered Wildlife in Canada [COSEWIC]. (2004). *COSEWIC assessment and update status report on the narwhal* Monodon monoceros *in Canada*. Ottawa, ON: COSEWIC. Retrieved from http://www.registrelep-sararegistry.gc.ca/virtual_sara/files/cosewic/sr_narwhal_e.pdf

Convention on International Trade in Endangered Species of Wild Fauna and Flora [CITES], 1973, amended 1979. Retrieved from http://www.cites.org/eng/disc/E-Text.pdf

Convention on International Trade in Endangered Species of Wild Fauna and Flora [CITES]. (2012). *Appendices I, II and II valid form 3 April 2012*. Retrieved from http://www.cites.org/eng/app/2012/E-20120403.pdf

Convention on International Trade in Endangered Species of Wild Fauna and Flora [CITES]. (n.d.) *The CITES Appendices*. Retrieved from http://www.cites.org/eng/app/index.php

Dale, A. T. (2009). Inuit Qaujimajatuqangit *and adaptive co-management: A case study of narwhal co-management in Arctic Bay, Nunavut* (Doctoral dissertation). Retrieved from Theses and Dissertations (Comprehensive), http://scholars.wlu.ca/etd/931

Dale, A., & Armitage, D. (2011). Marine mammal co-management in Canada's Arctic: Knowledge co-production for learning and adaptive capacity. *Marine Policy, 35*, 440-449. doi:10.1016/j.marpol.2010.10.019

Department of Fisheries and Oceans Canada [DFO]. (2008). Total allowable harvest recommendations for Nunavut narwhal and beluga populations. *DFO Canadian Science Advisory Secretariat Science Advisory Report, 2008/035*. Retrieved from http://www.dfo-mpo.gc.ca/CSAS/Csas/Publications/SAR-AS/2008/SAR-AS2008_035_e.pdf

Department of Fisheries and Oceans Canada [DFO]. (2009). Stock definition of belugas and narwhals in Nunavut. *DFO Canadian Science Advisory Secretariat Science Advisory Report, 2009/079.* Retrieved from http://www.dfo-mpo.gc.ca/CSAS/Csas/publications/sar-as/2009/2009_079_e.pdf

Department of Fisheries and Oceans Canada [DFO]. (2012a). Abundance and total allowable landed catch for the Northern Hudson Bay narwhal population. *DFO Canadian Science Advisory Secretariat Science Advisory Report, 2012/028*. Retrieved from http://www.dfo-mpo.gc.ca/csas-sccs/Publications/SAR-AS/2012/2012_028-eng.pdf

Department of Fisheries and Oceans Canada [DFO]. (2012b). *Baffin Bay narwhal tour: What we heard*. Retrieved from http://www.nwmb.com/index.php?option=com_docman&task=cat_view&gid=206&Itemid=80&lang=inu&limitstart=40

Department of Fisheries and Oceans Canada [DFO]. (2012c). Evaluation of Canadian narwhal hunt sustainability with respect to making a CITES non-detriment finding. *Canadian Science Advisory Secretariat Science Advisory Report, 2011/073*. Retrieved from http://www.dfo-mpo.gc.ca/csas-sccs/Publications/SAR-AS/2011/2011_073-eng.pdf

Department of Fisheries and Oceans Canada [DFO]. (2012d). *Integrated Fisheries Management Plan (IFMP) for narwhal in the Nunavut Settlement Area (*Monodon monoceros*), working draft (revision #6), April 24, 2012*. Retrieved from http://www.nwmb.com/index.php?option=com_docman&task=cat_view&gid=206&Itemid=79&lang=en&limitstart=40

Department of Fisheries and Oceans Canada [DFO]. (2012e, January 30). *Narwhal co-management community consultation meetings - March 2012*. Retrieved from http://www.nwmb.com/index.php?option=com_docman&task=cat_view&gid=206&Itemid=79&lang=en&limitstart=20 (021-TAB 18)

Department of Fisheries and Oceans Canada [DFO]. (2012f). *Northern Hudson Bay narwhal tour: What we heard*. Retrieved from http://www.nwmb.com/index.php?option=com_docman&task=cat_view&gid=206&Itemid=80&lang=inu&limitstart=40

Department of Fisheries and Oceans Canada [DFO]. (2012g). *Submission to the Nunavut Wildlife Management Board for Decision: Review and approval of the Integrated Fisheries Management Plan for narwhal in the Nunavut Settlement Area (effective January 2013) and establishment of measures to give effect to the narwhal management regime outlined in the plan*. Retrieved from http://www.nwmb.com/index.php?option=com_docman&task=cat_view&gid=206&Itemid=79&lang=en (TAB 00)

Department of Indian Affairs and Northern Development [DIAND], & Tungavik Federation of Nunavut [TFN]. (1993). *Agreement between the Inuit of the Nunavut Settlement Area and Her Majesty the Queen in right of Canada*. Ottawa, ON: DIAND and TFN.

Diduck, A., Bankes, N., Clark, D., & Armitage, D. (2005). Unpacking social learning in social-ecological systems: Case studies of polar bear and narwhal management in northern Canada. In F. Berkes, R. Huebert, H. Fast, M. Manseau, & A. Diduck (Eds.), *Breaking ice: Renewable resource and ocean management in the Canadian North* (pp. 269-290). Calgary, AB: University of Calgary Press.

Dowsley, M. (2009). Community clusters in wildlife and environmental management: Using TEK and community involvement to improve co-management in an era of rapid environmental change. *Polar Research, 28*, 43-59. doi:10.1111/j.1751-8369.2008.00093.x

Dowsley, M., & Wenzel, G. (2008). "The time of the most polar bears": A co-management conflict in Nunavut. *Arctic, 61*, 177-189. Retrieved from: http://pubs.aina.ucalgary.ca/arctic/Arctic61-2-177.pdf

Environment Canada. (2011). *Canadian Wildlife Service: Strategic Plan 2000 (CW-9801-B)*. Retrieved from http://www.ec.gc.ca/publications/default.asp?lang=en&xml=4f81cb73-c9c2-42e6-b669-178637bdca1e

Fenge, T., & Quassa, P. (2009). Negotiating and implementing the Nunavut Land Claims Agreement. *Policy Options, 30* (7), 80-86. Retrieved from http://www.irpp.org.ezproxy.library.dal.ca/po/archive/jul09/fenge.pdf

Ford, J. D., & Beaumier, M. (2011). Feeding the family during times of stress: Experience and determinants of food insecurity in an Inuit community. *The Geographical Journal, 177*, 44-61. doi:10.1111/j.1475-4959.2010.00374.x

Ford, J. K. B., & Fisher, H. D. (1978). Underwater acoustic signals of the narwhal (*Monodon monoceros*). *Canadian Journal of Zoology, 56*, 552-560. doi:10.1139/z78-079

Freeman, M. M. R. (2005). "Just one more time before I die": Securing the relationship between Inuit and whales in the Arctic regions. In N. Kishigami, & J. M. Savelle (Eds.), Indigenous use and management of marine resources, *Senri Ethnological Studies, 67*, 59-76. Osaka, Japan: National Museum of Ethnology.

Freeman, M. M. R., Bogoslovskaya, L., Caulfield, R. A., Egede, I., Krupnik, I. I., & Stevenson, M. G. (1998). *Inuit, whaling, and sustainability*. Walnut Creek, CA: AltaMira Press.

Gombay, N. (2010a). Community, obligation, and food: Lessons from the moral geography of Inuit. *Geografiska Annaler: Series B, Human Geography, 92*, 237-250. Retrieved from: http://onlinelibrary.wiley.com.ezproxy.library.dal.ca/doi/10.1111/j.1468-0467.2010.00350.x/pdf

Gombay, N. (2010b). *Making a living: Place, food, and economy in an Inuit community*. Saskatoon, SK: Purich Publishing.

Goodman, D. (1997). Land claim agreements and the management of whaling in the Canadian Arctic. In *Proceedings of the 11th International Abashiri Symposium: Development and Northern Peoples, Abashiri, Japan, 3-4 October 1996* (pp. 39-50). Abashiri, Japan: Hokkaido Museum of Northern Peoples. Retrieved from http://www.highnorth.no/library/Policies/National/la-cl-ag.htm

Government of Nunavut Department of Environment. (2006). *Wildlife management*. Retrieved from http://www.gov.nu.ca/env/wild.shtml

Government of Nunavut Department of Environment. (2012, July 4). *Letter to the Nunavut Wildlife Management Board in response to NWMB's public notice*. Retrieved from http://www.nwmb.com/index.php?option=com_docman&task=cat_view&gid=207&Itemid=79&lang=en

Gutiérrez, N. L., Hilborn, R., Defeo, O. (2011). Leadership, social capital and incentives promote successful fisheries. *Nature, 470*, 386-389. doi:10.1038/nature09689

Halls, A. S., Arthur, R. I., Bartley, D., Felsing, M., Grainger, R., Hartmann, W., … Walmsley, S. (2005). Guidelines for designing data collection and sharing systems for co-managed fisheries: Part 1, practical guide. *FAO Fisheries Technical Paper, 494/1*. Rome, Italy: Food and Agriculture Organization of the United Nations (FAO). Retrieved from ftp://ftp.fao.org/docrep/fao/008/a0230e/a0230e00.pdf

Heide-Jørgensen, M. P., Dietz, R., Laidre, K. L., & Richard, P. (2002). Autumn movements, home ranges, and winter density of narwhals (*Monodon monoceros*) tagged in Tremblay Sound, Baffin Island. *Polar Biology, 25*, 331-341. doi:10.1007/s00300-001-0347-6

Heide-Jørgensen, M. P., Dietz, R., Laidre, K. L., Richard, P., Orr, J., & Schmidt, H. C. (2003). The migratory behaviour of narwhals (*Monodon monoceros*). *Canadian Journal of Zoology, 81*, 1298-1305. doi:10.1139/Z03-117

Hovelsrud, G. K., McKenna, M., & Huntington, H. P. (2008). Marine mammal harvests and other interactions with humans. *Ecological Applications, 18* (2), S135-S147. Retrieved from http://www.jstor.org/stable/40062161

Jentoft, S. (2005). Fisheries co-management as empowerment. *Marine Policy, 29*, 1-7. doi:10.1016/j.marpol.2004.01.003

Kishigami, N. (2005). Co-management of beluga whales in Nunavik (Arctic Quebec), Canada. In N. Kishigami, & J. M. Savelle (Eds.), Indigenous use and management of marine resources, *Senri Ethnological Studies, 67*, 121-144. Osaka, Japan: National Museum of Ethnology.

Laidre, K. L., & Heide-Jørgensen, M. P. (2005). Winter feeding intensity of narwhals (*Monodon monoceros*). *Marine Mammal Science, 21*, 45-57. Retrieved from http://staff.washington.edu/klaidre/docs/LaidreandHJ_2005b.pdf

Laidre, K. L., Heide-Jørgensen, M. P., Ermold, W., & Steele, M. (2010). Narwhals document continued warming of southern Baffin Bay. *Journal of Geophysical Research, 115*, C10049. doi:10.1029/2009JC005820

Laugrand, F. B., & Oosten, J. G. (2010). *Inuit shamanism and Christianity: Transitions and transformations in the twentieth century*. McGill-Queen's Native and Northern Series, 59. Montreal, QC and Kingston, ON: McGill-Queen's University Press.

Lee, D. S., & Wenzel, G. W. (2004). Narwhal hunting by Pond Inlet Inuit: An analysis of foraging mode in the floe-edge environment. *Etudes/Inuit/Studies, 28* (2), 133-157. Retrieved from http://id.erudit.org/iderudit/013200ar

Marine Mammal Regulations, SOR/1993-56. Retrieved from http://laws-lois.justice.gc.ca/PDF/SOR-93-56.pdf

Nakashima, D. J. (1993). Astute observers on the sea ice edge: Inuit knowledge as a basis for Arctic co-management. In J. T. Inglis (Ed.), *Traditional ecological knowledge: Concepts and cases* (p. 99-110). Ottawa, ON: International Development Research Centre Books.

Nunatsiaq News. (2013, May 14). *Nunavut's new narwhal management plan now in effect*. Retrieved from http://www.nunatsiaqonline.ca/stories/article/65674nunavuts_new_narwhal_management_plan_now_in_effect/

Nunavut Act, S.C. 1993, c. 28. Retrieved from http://laws-lois.justice.gc.ca/PDF/N-28.6.pdf

Nunavut Inuit Wildlife Secretariat. (n.d.). *About NIWS*. Retrieved from http://www.niws.ca/_en/_niws/index.html

Nunavut Land Claims Agreement Act, S.C. 1993, c. 29. Retrieved from http://laws-lois.justice.gc.ca/PDF/N-28.7.pdf

Nunavut Tunngavik Incorporated [NTI]. (2012a). *Comments on the proposed narwhal management plan, total allowable harvests, and non-quota limitations.* Retrieved from http://www.nwmb.com/index.php?option=com_docman&task=cat_view&gid=207&Itemid=79&lang=en

Nunavut Tunngavik Incorporated [NTI]. (2012b, July 27). *Inuit and DFO still attempting to reach consensus on narwhal plan* (Press release). Retrieved from http://www.tunngavik.com/files/2012/07/NR-12-32-SUM-ENG-Draft-Narwhal-Management-Plan.pdf

Nunavut Tunngavik Incorporated [NTI]. (2012c, June 5). *Narwhal tusk trade restriction lifted in all but one community.* Retrieved from http://www.tunngavik.com/blog/2012/06/05/narwhal-tusk-trade-restriction-lifted-in-all-but-one-community/

Nunavut Tunngavik Incorporated [NTI]. (2013, January 31). *Integrated fisheries management plan for narwhal approved* (Press release). Retrieved from http://www.tunngavik.com/blog/2013/01/31/integrated-fisheries-management-plan-for-narwhal-approved/

Nunavut Tunngavik Incorporated [NTI]. (n.d.). *About NTI*. Retrieved from http://www.tunngavik.com/about/

Nunavut Wildlife Management Board [NWMB]. (2012). *Notice of reinstatement of Nunavut Wildlife Management Board public hearing*. Retrieved from http://www.nwmb.com/index.php?option=com_docman&task=cat_view&gid=167&Itemid=79&lang=en

Nunavut Wildlife Management Board [NWMB]. (n.d.a). *Introduction: Public hearings and meetings.* Retrieved from http://www.nwmb.com/index.php?option=com_content&view=article&id=119&Itemid=76&lang=en

Nunavut Wildlife Management Board [NWMB]. (n.d.b). IQ *program and database*. Retrieved from http://www.nwmb.com/index.php?option=com_content&view=article&id=109-iq-program-and-database&catid=151-current-initiatives&lang=en

Nunavut Wildlife Management Board [NWMB]. (n.d.c). *Public hearings registry 2012: Proposed Integrated Fisheries Management Plan for narwhal in the Nunavut Settlement Area, including the establishment of total allowable harvests, basic needs levels and non-quota limitations (July 24th-26th).* Retrieved from http://www.nwmb.com/index.php?option=com_docman&task=cat_view&gid=205&Itemid=79&lang=en

Pelly, D. F. (2001). *Sacred hunt: A portrait of the relationship between seals and Inuit*. Vancouver, BC: Greystone Books

Pinkerton, E. (1989). Introduction: Attaining better fisheries management through co-management – prospects, problems, and propositions. In E. Pinkerton (Ed.), *Co-operative management of local fisheries: New directions for improved management and community development* (pp. 5-33). Vancouver, BC: University of British Columbia Press.

Pomeroy, R. S., & Berkes, F. (1997). Two to tango: The role of government in fisheries co-management. *Marine Policy, 21*, 465-480. doi:10.1016/S0308-597X(97)00017-1

Reeves, R. R. (1992). Recent developments in the commerce in narwhal ivory from the Canadian Arctic. *Arctic and Alpine Research, 24*, 179-187. Retrieved from http://www.jstor.org/stable/1551538

Reeves, R. R., & Mitchell, E. (1981). The whale behind the tusk. *Natural History, 90* (8), 50-57.

Reeves, R. R., & Tracey, S. (1980). *Monodon monoceros*. *Mammalian Species, 127*, 1-7. Retrieved from http://www.jstor.org/stable/3503952

Richard, P. (2009). *Marine mammals of Nunavut*. Iqaluit, NU: Nunavut Department of Education.

Richard, P. R. (2011). Allocation model for landed catches from Baffin Bay narwhal stocks. *DFO Canadian Science Advisory Secretariat Research Document, 2011/056*. Retrieved from http://www.dfo-mpo.gc.ca/csas-sccs/Publications/ResDocs-DocRech/2011/2011_056-eng.pdf

Richard, P. R., Laake, J. L., Hobbs, R. C., Heide-Jørgensen, M. P., Asselin, N. C., & Cleator, H. (2010). Baffin Bay narwhal population distribution and numbers: Aerial survey in the Canadian high Arctic, 2002-04. *Arctic, 63*, 85-99. Retrieved from http://pubs.aina.ucalgary.ca/arctic/Arctic63-1-85.pdf

Richard, P. R., & Pike, D. G. (1993). Small whale co-management in the Eastern Canadian Arctic: A case history and analysis. *Arctic, 46*, 138-143. Retrieved from http://pubs.aina.ucalgary.ca/arctic/Arctic46-2-138.pdf

Roberge, M. M., & Dunn, J. B. (1990). Assessment of the subsistence harvest and biology of narwhal (*Monodon monoceros L.*) from Admiralty Inlet, Baffin Island, N.W.T., 1983 and 1986-89. *Canadian Technical Report of Fisheries and Aquatic Sciences, 1747*. Winnipeg, MB: Department of Fisheries and Oceans, Central and Arctic Region.

Ross, W. G. (1975). Whaling and Eskimos: Hudson Bay 1860-1915. *National Museum of Man Publications in Ethnology, 10*. Ottawa, ON: National Museums of Canada.

Savelle, J. M. (1994). Prehistoric exploitation of white whales (*Delphinapterus leucas*) and narwhals (*Monodon monoceros*) in the eastern Canadian Arctic. *Meddelelser om Grønland, Biosciences, 39*, 101-117.

Smith, E. A. (1991). Inujjuamiut *foraging strategies: Evolutionary ecology of an Arctic hunting economy*. New York, NY: Aldine de Gruyter.

Stewart, R. E. A. (2008). Redefining walrus stocks in Canada. *Arctic, 61*, 292-308. http://pubs.aina.ucalgary.ca/arctic/Arctic61-3-292.pdf

Tyrrell, M. (2007). Sentient beings and wildlife resources: Inuit, beluga whales and management regimes in the Canadian Arctic. *Human Ecology, 35*, 575-586. doi:10.1007/s10745-006-9105-2

United Nations Conference on Environment and Development [UNCED]. (1992). *Agenda 21: The United Nations programme of action from Rio*. Retrieved from http://www.un.org/esa/dsd/agenda21/index.shtml

Vaughan, R. (1994). *The Arctic: A history*. Phoenix Mill, UK: Alan Sutton.

White, A. (2012). A synthesis of narwhal (*Monodon monoceros*) scientific advice and Inuit knowledge collected during Nunavut community consultations (May 25-31, 2011). *DFO Canadian Science Advisory Secretariat Research Document, 2012/001*. Retrieved from http://www.nwmb.com/index.php?option=com_docman&task=cat_view&gid=206&Itemid=79&lang=en (006-TAB 4)

Wiber, M., Berkes, F., Charles, A., & Kearney, J. (2004). Participatory research supporting community-based fishery mangement. *Marine Policy, 28*, 459-468. doi:10.1016/j.marpol.2003.10.020

Wiber, M., Charles, A., Kearney, J., & Berkes, F. (2009). Enhancing community empowerment through participatory fisheries research. *Marine Policy, 33*, 172-179. doi:10.1016/j.marpol.2008.05.009

Public Engagement

An Integrated Analysis of the Expansion of Salmon Farming on the Eastern Shore of Nova Scotia

Vanja Avdic, Scott Biggar, Karen Devitt, Robin McCullough and Katie Paroschy, Candidates, Master of Resource and Environmental Studies[a]

[a]School for Resource and Environmental Studies, Dalhousie University, 6100 University Avenue, Halifax, Nova Scotia, Canada, B3H 4R2
email: R.McCullough@dal.ca

Back Row (L-R): **Scott Biggar, Karen Devitt, Vanja Avdic, Front Row (L-R): Katie Paroschy Robin McCullough.** ***Winners of the People's Choice Award at the Sustainable Oceans Conference 2013.***

Robin McCullough is currently completing her Master's in Resource and Environmental Management from Dalhousie University's School of Resource and Environmental Management. She has a Bachelor of Science degree in Economics with a minor in Environmental Studies. Her area of focus in graduate school has been marine related resources such as fisheries and aquaculture as well as integrated coastal zone management. Robin recently did contract work with RPS Energy as a marine mammal and seabird observer for Shell Canada Limited, living on a seismic research vessel offshore Canada for five weeks. Robin also has experience working at NGO's as an intern and within government as a program officer.

Katie Paroschy graduated with a B.Sc. from the Environmental and Resource Science Program at Trent University in 2009 and the Ecosystem Management Technology program at Sir Sandford Fleming College in 2011. During her undergraduate degree, Katie completed an honours thesis on equipment used to assess small fish populations in Muskoka, Ontario lakes. In the winter of 2013 Katie worked with a wonderful group of fellow MREM students to complete an integrated analysis of the expansion of salmon farming on the Eastern shore of Nova Scotia. This project allowed her to develop a strong understanding of the environmental, social and economic concerns associated with salmon farming. Katie feels that this work has contributed to other's understanding of the issues as well.

Scott Biggar is currently finishing his Masters of Resource and Environmental Management at Dalhousie. His most recent work experience has included international fisheries policy research for the World Wildlife Fund (WWF), along with developing a feasibility study for electric buses in Nova Scotia for the Ecology Action Centre. His work with WWF is ongoing, now with a focus on the impacts of offshore oil and gas development on the Scotian shelf.

Karen Devitt is currently completing her final semester of a Masters of Resource and Environmental Management degree at Dalhousie. She recently completed a four month internship with the National Environment Research Program's (NERP) Marine Biodiversity Hub at Charles Darwin University (CDU), Australia, where she assisted with research on management techniques for rare and threatened estuarine and freshwater elasmobranches. Her work with NERP and CDU is ongoing and currently focusing on the representation of Sawfish species in Australia's protected area network.

Abstract

The United Nations Food and Agriculture Organization (FAO) estimates that by 2025 the annual demand for seafood will outstrip the capacity of wild fisheries by 50 million tonnes or more. Given that coastal areas along the Nova Scotia (NS) coastline are suitable for ocean-based Atlantic salmon (Salmo salar) farming, the provincial government plans to expand the industry in the hopes of increasing job prospects, and economic development in rural coastal communities. Despite potential economic opportunities, expansion of open net-pen salmon farming in NS, specifically that of Snow Island Salmon Inc. on the Eastern Shore, has been met with opposition from a variety of stakeholders, many of whom believe the environmental impacts of salmon farming pose risks to their livelihoods and enjoyment of the coastline. Our research indicates there are several factors that have led to this conflict. We recommend that the social-political, biophysical, and legal components all be taken into consideration in order to alleviate the tension between all interested stakeholders. Ultimately, greater respectful communication among parties along with clearer regulations and legislation are essential.

Acknowledgements

We would like to thank Heather Castleden, Peter Tyedmers, Tony Walker, interview participants, and our classmates for their valuable input.

Note to Readers

To read our complete report regarding the expansion of salmon along the Eastern Shore of Nova Scotia, please email mrem.aquaculture@gmail.com.

3.1 Introduction

Global consumption of fish has doubled since the 1970s and by 2030 the Food and Agriculture Organization (FAO) predicts aquaculture will account for more than half of the fish being consumed by humans (FAO, 2013a; Naylor & Burke, 2005). Aquaculture involves farming marine and freshwater species such as finfish, shellfish, and aquatic plants in land-based or open-ocean production systems (e.g. Ayer & Tyedmers, 2009; Department of Marine Resources, 2006). Aquaculture of marine carnivorous finfish, such as Atlantic salmon (*Salmo salar*) has grown by approximately nine percent annually, while the value has increased by approximately five percent per year since the 1990s (Naylor & Burke, 2005).

In Nova Scotia, aquaculture contributes $45 million in annual revenues and supports approximately 120 jobs in the finfish farming industry (DFA, 2012). NS's small market offers limited local opportunities and the industry depends on exporting salmon and other marine products for profits, growth, and employment, as well as helping to meet the growing demand for seafood (DFA, 2012).

In May of 2012, the NS government released its Aquaculture Strategy. The provincial government sees aquaculture as a means of developing an internationally competitive industry in NS, and as an opportunity to stimulate job growth in rural coastal communities (DFA, 2012). Despite the promise of increased employment, salmon farming in Canada and NS has not been expanding at rates similar to those in other countries (Bruce Hancock of the Aquaculture Association of NS [AANS], personal communication, March 26, 2013). This report investigates the conflict over the proposed expansion of salmon farming along the Eastern Shore of NS by Snow Island Salmon Inc. (herein referred to as Snow Island). We consider the socio-political, biophysical, and law and policy dimensions of salmon farming that have given rise to the challenges and opportunities of salmon farming on the Eastern Shore of NS.

3.1.1 Snow Island Case Study

Loch Duart Ltd., a Scottish salmon farming company, expanded operations to NS by purchasing an existing open net-pen salmon farm at Owl's Head Harbour on the Eastern Shore (Fig. 1) (Loch Duart, n.d.). This site has been in operation since 2008, and is now operated by Loch Duarts' subsidiary company Snow Island.

Snow Island's current operations are in close proximity to the communities of Ship Harbour and Sheet Harbour. Both communities have experienced reductions in population, and employment rates in 2006 were below the provincial average (Community Counts, 2012). Supporters of the company believe Snow Island will bring economic growth to the area by keeping people in the community. Furthermore, Snow Island has stated they will hire locally whenever possible, providing competitive wages and benefits (Snow Island, n.d.).

Farm management strategies practiced by Snow Island are based off Loch Duart's "Best Practices" production system (Loch Duart, n.d.). Snow Island states their farms use lower stocking densities of 10 kg/m^3 to 15 kg/m^3 (SIMCorp., 2011). Snow Island fallows their sites for at least 12 months between production cycles, allowing the substrate to recover, fish waste to disperse, and to ensure the site remains optimal for salmon production (Purser & Forteath, 2003). However, it is important to note that the time required for substrate recovery depends on husbandry practices, environmental conditions, and can range from six months to several years (Purser & Forteath, 2003). The "Best Practices" production system also prohibits the use of net antifoulants, which are commonly used in the industry to maintain net cage quality and adequate water flow (SIMCorp., 2011). Antifoulants often contain heavy metals that are highly toxic to other organisms (Cripps & Kumar, 2003). Snow Island does not practice prophylactic use of antibiotics and antibiotics are only used when fish welfare is threatened. According to their Spry Bay and Shoal Bay Environmental Impact Assessments (EIA), they will inform their customers when and if antibiotics have been used on their fish (SIMCorp., 2011). Additionally, Snow Island reports that they have not had any incidence of sea lice or fish escapes at their Owl's Head site (Snow Island, n.d.).

The company applied for three additional leases along the Eastern Shore (Beaver Harbour, Spry Harbour, and Shoal Bay) (Fig. 1). Snow Island retracted the Beaver Harbour application and the Shoal Bay application was recently rejected by the provincial government, both due to "moderate risks" to wild salmon populations (Erskine, 2013).

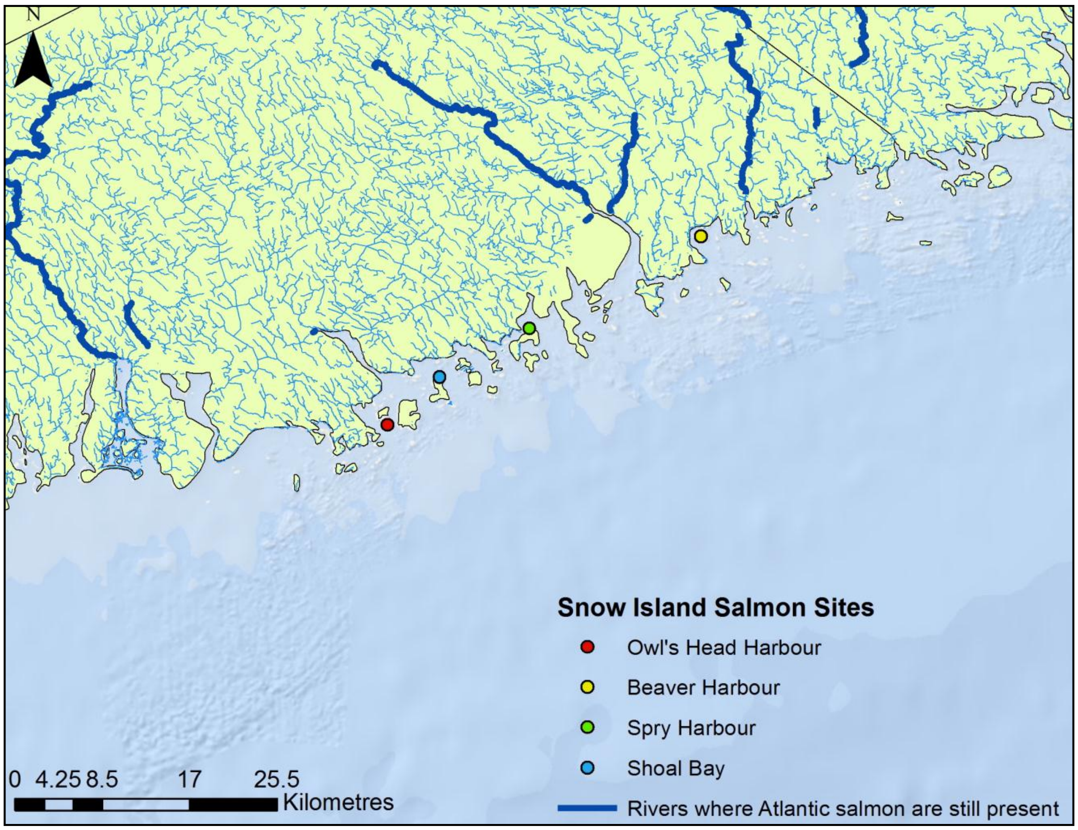


Figure 1: Snow Island's current and proposed open net-pen salmon farm sites

Snow Island currently operates one farm site at Owl's Head Harbour (red dot). Other proposed sites in Beaver Harbour, Spry Harbour, and Shoal Bay are also shown. Rivers with wild Atlantic salmon populations are highlighted with blue lines (base layers provided by Dalhousie GIScience Centre and Atlantic Salmon Federation (ASF) (2012)).

Despite Snow Island's history with regards to sea lice and fish escapes as well as their farm management practices, their proposal has been met with fierce opposition. A NS Department of Fisheries and Aquaculture

(DFA) survey conducted in 2010 found a lack of public support to be the greatest barrier to further development of the industry in the province (DFA, 2010). For the province and industry to move forward, understanding the opposition and the barriers are essential.

3.2 Research Methods

3.2.1 Literature Review Method

An extensive literature review was conducted to better understand the challenges and opportunities associated with open net-pen salmon farming on the Eastern Shore of NS and other jurisdictions.

3.2.2 Interview Process

To better understand the opportunities and challenges associated with open net-pen salmon farming along the Eastern Shore of NS, interviews with key stakeholders were conducted. Interview methodologies were approved by the Dalhousie Faculty of Management Ethics Review Board. Key stakeholders were selected through existing channels of information such as internet company profiles, community groups, government listings, and media reports. In order to represent the diverse interests that exist in the aquaculture debate, participants were selected to include representatives from academia, tourism, the provincial government, aquaculture industry, and community members who are keenly aware of the proposed development (Table 1). Consent was obtained from all interview participants (see Appendix A for a sample consent form). Interviews were designed to gain insight and information on community engagement, risk perceptions, views on the salmon farming industry, governing bodies, and how industry and government can address the current conflicts (Appendix B). All interviews were recorded, transcribed, and analyzed.

3.3 Results

3.3.1 Biophysical Concerns

There are numerous biophysical concerns related to open net-pen salmon farming. These include effects from escaped fish, chemical usage, and waste accumulation (Fig. 2). Due to the high density of fish found in salmon farm pens, farmers often require the use of chemicals such as, antifoulants, antibiotics, and pesticides to manage pen conditions, diseases, and parasites (Fig. 2) (Burridge, Weis, Cabello, Pizarro, Bostick, 2010). The chemicals can have negative impacts on the surrounding environment. As previously discussed, antifoulants are composed of heavy metals that are able to persist and can be toxic to many marine organisms (Burridge et al., 2010). Pesticides used to kill sea lice are known to be toxic to other crustaceans, such as lobster. In NS there have been instances of illegal pesticide use by open net-pen salmon farming companies, causing lobster kills (Wiber, Young, & Wilson, 2012).

Table 1. Name and affiliation of interview participants (n = 11)

Name	Affiliation
Bruce Hancock	Executive Director, Aquaculture Association of NS
Christophe Herbinger	Dalhousie Professor, Department of Biology
Kaija Lind	Aquaprime Mussel Ranch Ltd.
Lisa Dahr	Manager Industry Relations & Professional Development, TIANS
Leo Muise	Executive Director, Fisheries and Aquaculture, NS
Cecilia Engler	PhD Candidate, Dalhousie Law
Jeffrey Hutchings	Killam Professor, Faculty of Science, Dalhousie University
Christopher Milley	Adjunct professor, Dalhousie University Department of Marine Affairs Environmental Consultant, Nexus Coastal Resource Management
Ginny Boudreau	Manager, Guysborough County Inshore Fishermen's Association
Bill Williams	Vice President, Association for the Preservation of the Eastern Shore
Scientist Team	Friends of Port Mouton Bay
Mike Spencer **	Manager, NS Arctic Charr

*** Consent was given to use the information provided by Mike Spencer during a tour of the NS Arctic Charr closed containment facility*

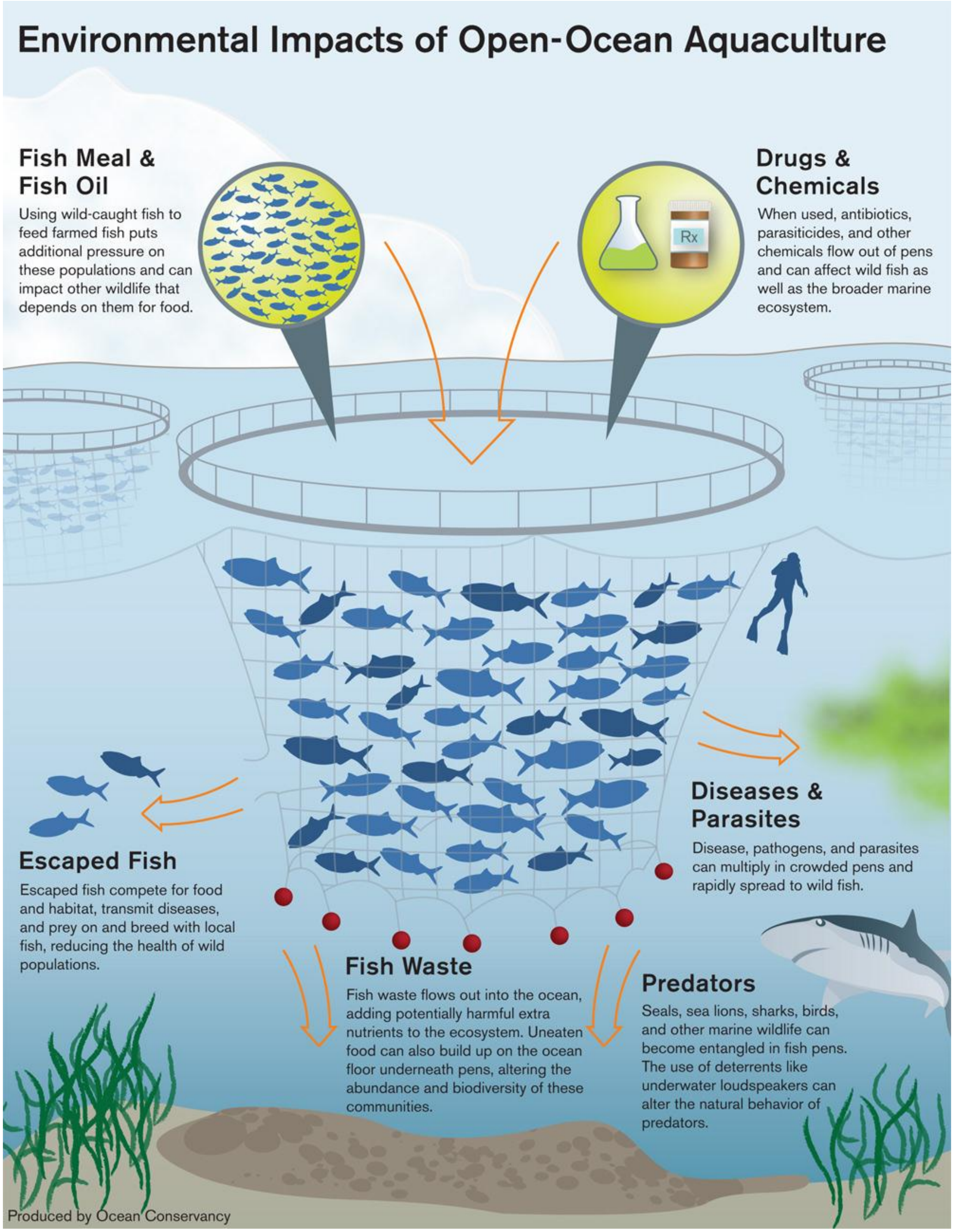


Figure 2. Diagram of open net-pen salmon farming
Figure obtained from http://tocdev.pub30.convio.net/news-room/aquaculture/oc-testifies-offshore-aqua.html.

In an attempt to mitigate the potential negative effects of salmon farming, the provincial government has developed an Environmental Monitoring Program (EMP) (DFA, 2011). The effects of waste accumulation on the benthic environment, impacts of farm escaped fish, and the EMP are discussed in detail below.

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) suggests that all populations of Atlantic salmon in Nova Scotian waters are endangered and their recovery is threatened by salmon farming (COSEWIC, 2010). The development of open net-pen salmon farming on the Eastern Shore of NS is of particular concern for wild salmon as Snow Island's proposed farm sites are in close proximity to rivers with wild salmon runs (Fig. 1). In particular, the area provides important habitat for the Southern Upland population of Atlantic salmon. This population is of particular concern as mature individuals have declined by 61% over the last three generations (COSEWIC, 2010). Interactions between farmed and wild salmon threaten native populations through behavioural and genetic disruptions, and disease transmission (Weir & Grant, 2005). Disease can spread from wild salmon to caged salmon as they swim through the area, and *vice versa* (Krkošek, Lewis, & Volpe, 2005).

As previously mentioned, Snow Island applied for three permits along the Eastern Shore of NS. Figure 1 depicts the approximate location of Snow Island's current farm and the three proposed farm locations, as well as rivers in the area where small populations of Atlantic salmon are still present. The provincial government rejected the Shoal Bay farm application as Fisheries and Oceans Canada (DFO) expressed concern about potential impacts on wild populations (DFA, 2013a). Given that escaped salmon tend to travel within 500 km of the release point (Thorstad et al., 2008), interactions between wild and farm fish in nearby rivers as well as other rivers in NS is possible.

3.3.2 Site Selection and the Benthic Environment

Good site selection is essential for minimizing environmental impacts from an open net-pen salmon farming operation (Wu, 1995). The identification of good sites is a complex spatial problem, and if done poorly can result in a polluted ecosystem, stressed fish, decreased production, economic losses, and a disgruntled public (Belle & Nash, 2008, p. 265; Longdill, Healy & Black, 2008; Naylor et al., 2000). Important site characteristics that are taken into account include water quality, depth, current speed, flow patterns, storm exposure, bottom type, primary productivity, temperature, dissolved oxygen, presence of natural predators, pest and pathogen distribution, and nearby human activities (Belle & Nash, 2008, p. 267).

Currents are an essential assessment component when selecting a site for open net-pen salmon farming. Low current speeds of 3 cm/s to 6 cm/s indicate that a site can be very to moderately sensitive to environmental damage from a salmon farm (Carroll, Cochrane, Fieler, Velvin & White, 2003). At these speeds, salmon waste is not sufficiently dispersed and the benthic environment can be severely degraded (Belle & Nash, 2008, p. 275). Food particles and fecal pellets containing nitrogen, phosphorus, urea, and ammonia build up and can cause changes in nutrient cycling, benthic species assemblages, and biodiversity (Brooks & Mahnken, 2003; Ervik et al., 1997; Longdill, et al., 2008). High chemical loads lead to anoxic conditions in which biodiversity is significantly reduced and water quality is threatened (Belle & Nash, 2008, p. 271; Brooks & Mahnken, 2003).

To protect the benthic community, erosional sites are preferred (Belle & Nash, 2008, p. 274). Further solutions to protect the benthic environment include using remote sensing technologies to monitor the feeding behaviour of penned fish to ensure that the amount of excess food is minimal and fallowing sites for an extended period of time (Belle & Nash, 2008, p. 273). As indicated above, Snow Island has claimed that they will follow such procedures (SIMCorp., 2012).

3.3.3 Environmental Monitoring Program

To address environmental concerns surrounding aquaculture, the DFA established the NS EMP (DFA, 2011). Sediment samples measure sulphide, redox, organic content, and porosity (Table 2) (DFA, 2006), then compared to the baseline data or Environmental Quality Definitions (EQD's) (Appendix C). A high sulphide level indicates habitat degradation resulting from anaerobic conditions (DFA, 2006; NBG, 2006) and is the primary indicator used.

Table 2. Description of the benthic characteristics measured by the Environment Monitoring Program

Measurement	Unit	Description	Significance
Sulphide	µM	Total dissolved levels in sediments are the main parameter used to determine direct impact of an aquaculture operation	Sulphides are an indicator of habitat degradation due to organic waste loading
Redox	mV	Redox is the measure of the potential of water for oxidation or reduction. Low redox levels are a sign of poor water quality and limited decomposition of organic matter	Measurements are used to supplement sulphide measurements. The optimum redox is around 300mV for salmon
Organic Content	%	Organic content is a measure of organic loading	The organic matter content of sediment is an important factor in determining the extent of sorption and the level of organic content of sediment greatly influences benthic plant, animal and microorganism populations
Porosity	%	A measure of the void spaces in the sediment. The void spaces contain water and oxygen	Determines recent sediment deposition from a salmon farm

Table adapted from DFA (2006) and NBG (2006)

Sites classified as depositional (where waste is not sufficiently dispersed by the currents), must be monitored more often than erosional sites because oxic conditions are required to maintain a healthy benthic environment. DFO is responsible for reviewing this data and determining if each site complies with the *Fisheries Act, 1985*. Section 35(1) of the Fisheries Act prohibits the harmful alteration, disruption or destruction of fish habitat, however should environmental degradation be detected at a farm site applicants can request authorization from DFO to circumvent this article.

The EMP takes a risk-based approach, meaning that as the risk to environmental health increases, the frequency of monitoring increases as well. Because of this approach and other shortfalls of the EMP, it has been criticized by marine biologist Inka Milewski (2013) and Scientists of the Friends of Port Mouton Bay (FPMB) (personal communication, March 20, 2013). For example, it does not address biodiversity, environmental conditions such as current speeds, heavy metal concentrations within the sediment, or dissolved contaminants such as urine that can promote algae growth (FPMB, 2011; Milewski, 2013; Olsen & Olsen, 2008).

3.3.4 Spry Harbour Site Suitability

Information gained in the interviews and recent media reports reveal that a number of stakeholders believe Snow Island's proposed sites are unsuitable for salmon farming. Bill Williams, who has years of experience fishing in the area, expressed concern that the currents near the proposed Spry Harbour site are not strong enough to carry away fish feces, excess feed, and chemicals (personal communication, March 12, 2013).

The EIA and *Baseline Assessment and Current Data Report of Spry Harbour* provides data on the quality of the site (SIMCorp., 2011; 2012). The biophysical data in these documents indicate that the Spry Harbour site would be a poor location for salmon farming due to the presence of *Beggiatoa*, a muddy substrate, and a slow current speed. *Beggiatoa* is a bacteria that lives in sulphur-rich environments and was found at seven of the 10 sample stations (Belle & Nash, 2008, p. 290; SIMCorp., 2011; 2012). *Beggiatoa* degrades organic carbon, reducing the sulfate and nitrate while producing ammonia and hydrogen sulfide gases which can negatively impact water quality and threaten the health of the farmed salmon (Brooks & Mahnken, 2003). A fine-grained muddy bottom was noted by Snow Island divers during the pre-site assessment. These conditions exist because the current speed has an average of only 4 cm/s (SIMCorp., 2012), indicating that the site is depositional. The introduction of a salmon farm will only exaggerate these conditions and lead to degradation of the benthic environment (Belle & Nash, 2008, p. 274; Carroll et al., 2003).

3.4 Socio-political Concerns

Like all coastal communities, Nova Scotians are culturally and economically tied to their coastal environments, and when changes are proposed public interest is stimulated (Fraser & Beeson, 2003; Kaiser & Stead, 2002; Mazur, 2004). Some stakeholders are concerned that the potential economic gains from salmon farming will be overshadowed by negative impacts on other industries--namely commercial fisheries and tourism. These diverse concerns can be divided into four broad categories: risk perceptions, sense of place, stakeholder engagement, and Local Ecological Knowledge (LEK).

Understanding risk perceptions is essential for gaining public support for government policies and natural resource development (Mazur & Curtis, 2008). However, understanding risk becomes challenging when individuals and societal groups have different values and beliefs concerning acceptable human interactions with the environment (Mazur, 2004).

Open net-pen salmon farming relies on coastal and ocean resources. Communities and other stakeholders that also rely on these resources are often concerned about the social and environmental impacts caused by the industry (Kaiser & Stead, 2002; Mazur, 2004). The NS Aquaculture Strategy has no plan to address the perceived risks and thusly, community and public acceptance has been limited and mistrust will likely aid in prolonging the current conflict (DFA, 2012). This theme was common in the interviews we conducted and is summarized by the following quote: "What are the real risks? If you don't tell me I'm going to imagine them anyway whether they are real or not" (G. Boudreau, manager of Guysborough County Inshore Fishermen's Association, personal communication, April 8, 2013). Studies in Mexico and Greece have shown that the aquaculture industry is more accepted by communities when the socioeconomic benefits are obvious and communities are well informed about the environmental impacts (Hugues-Dit-Ciles, 2000; Katranidis, Nitsi & Vakrou, 2003).

During the February 2013 public consultation for the Snow Island proposed sites "[the public] were given an hour to ask questions on something that was going to change the outlook of this piece of shore forever" (B. Williams, personal communication, March 12, 2013). When developing natural resources, there is a need to account for the values of those living near the resource, as was found by Peckham, Duinker, and Ordonez (2013). Furthermore, Falconer, Hunter, Telfer, and Ross (2013) attempted to address the displeasing visual appearance of salmon farm sites, which are a major concern to local residents, through the use of Geographic Information Systems (GIS). GIS could have been used for site selection along the Eastern Shore, and input from the local community should have been taken into consideration. Public consultation should have also been a priority, as it can enhance the legitimacy and social acceptance of a resource management scheme (Adams, 2004. Furthermore, stakeholder involvement enhances the quality of environmental decisions through utilization of variety of knowledge sources, including local ecological knowledge (Reed, 2008).

3.5 Law and Policy Concerns

Approximately 73 pieces of Canadian legislation govern aquaculture (Hutchings et al., 2012). As illustrated by the flowchart in Appendix D, the licensing and leasing of salmon farm sites is complex and involves many branches of government (Hutchings et al., 2012). Recent changes to the *Canadian Environmental Assessment Act, 2012* (CEAA) have altered this process and led to gaps in environmental protection. Previously, authorizations under the *Fisheries Act, 1985* and the *Navigable Waters Protection Act, 1985*, would have triggered an Environmental Impact Assessment (EIA) for an aquaculture operation, as both authorizations were recognized under s. 59 of the *Canadian Environmental Assessment Act, 1992*. As the CEAA now stands, federal EIAs for aquaculture operations are only conducted if requested by the Minister of the Environment (s. 14(2)). Under the current licensing and leasing regulations, baseline benthic data must be collected and a CEAA compliant report with supporting data has to be prepared (Appendix D). With the current CEAA changes, involvement of important federal departments appears to be limited. Under the *Fisheries and Coastal Resources Act, 1996* once the Minister has approved the application, a licence and lease are valid for 10 years and during that time the applicant has exclusive property rights, though the Minister may enforce changes in practice or withdraw the lease and license at any time (DFA, 2013b).

The Spry Harbour application was submitted prior to the changes made to the CEAA and therefore the EIA was submitted in compliance with the lease and licensing application requirements, such as the *Guide to Information Requirements for Marine Finfish site and Aquaculture Applications Draft* (NB DAA et al., 2007). Unfortunately, in this *Guide* a clear framework around assessing and creating mitigation strategies for potential environmental impacts or human safety risks are missing.

At the federal level, the aquaculture industry is regulated by 17 departments (DFO, 2012). DFO plays the largest role regulating fish and fish habitat under s. 35(1) of the *Fisheries Act, 1985* (FAO, 2013b). Newfoundland and New Brunswick have provincial aquaculture acts and prior to 2010, the aquaculture industry in British Columbia was also governed by a provincial act. NS does not have an Act but has an Aquaculture Strategy and a Memorandum of Understanding (MOU), a non-legislative agreement that has been signed between DFO and DFA. Furthermore, Canada is the only major producer of farmed seafood without a national Aquaculture Act (BC Shellfish Growers Association (BCSGA), 2011; DFO, 2012). The Canadian Aquaculture Industry Alliance (CAIA) (2011) has called for a national Aquaculture Act to consolidate the various pieces of legislation. The formation of this Act is viewed as a means for clearer rights and responsibilities for the industry and ensures enforcement of these responsibilities and accountability (BCSGA, 2011).

3.6 Survey Results
Table 3 summarizes concerns, benefits, and risks of salmon farming according to our interviewees.

Main Concern	Risk	Benefit
Farm fish escapement (4)	Poor management (6)	Economic (4)
Misinformation (4)	Biological challenges that pose risks to farmers (4)	Employment (4)
Disease (3)	Can impact wild populations (4)	Food security (3)
Gaining social license to operate and the perception and place of the industry in society (2)	Zoning for sites: is it recreational, tourist or working waterfront? (1)	Efficient way to produce protein to feed our growing population (3)
Rationalizing aquaculture as a cultural activity (i.e. okay in some places, but not here) (1)	Negative effect on the coast valued by tourists (1)	Development of rural communities and economy (3)
Current regulations make it difficult for small to medium size business (1)	No risks (1)	People more aware of the usefulness of eating fish (2)
Sites no longer covered under the Environmental Assessment Act, and no form of comprehensive evaluation (1)	Aesthetics (3)	No real benefits (2)
Public perception (2) Lack of public acceptance (1)		
Effect on tourism industry (1)		
Externalization of waste (1)		
Lack of enforcement (1)		

Table 3: Key opinions of interviewees when asked their main concerns of open net-pen salmon farming and what they believe the risks and benefits to be (n=11). Numbers in brackets indicate the occurrence of a specific answer.

3.7 Discussion and Recommendations

Our survey results reveal the dichotomy of the conflict. For example, when asked about the main risks, some interviewees cited poor management, biophysical challenges to farmers, and other environmental risks while one interviewee stated there are no risks. The same trend presented itself when we asked about potential benefits. Economic and employment benefits topped the list, while one participant stated there are none. Another set of questions dealt with everyday effects on communities and local environment. To better understand the everyday effects on communities and local environment, future work will need to include more interviews with community members who are living in places with salmon farms or in places where salmon farms are proposed.

Many of our interviewees cited environmental risks as their main concern regarding open net-pen salmon farming (Table 3), and echoed the concerns presented in the literature about what has occurred in other countries. Another issue that has arisen in NS is the accumulation of wastes below and around salmon farm sites and the effect these wastes have on the benthic and surrounding environments (Fig. 2). Open net-pen salmon farm research conducted in Port Mouton, NS highlighted the significant accumulation of waste and a decrease in benthic biodiversity (Scientist Team of Friends of Port Mouton Bay [FPMB], personal communication, March 20, 2013).

Other environmental risks, such as disease transmission to wild populations was also mentioned by interviewees several times. Snow Island may be mitigating this particular risk by using lower stocking densities. Lower stocking densities lowers the risk of disease transmission among individuals in the cage, thus reducing possible transmission from escaped farm fish to wild populations (Owens, 2003). However further steps should be taken in ensuring that farms are as far as possible from known wild populations to further reduce the risk of farm and wild fish interactions (World Bank, 2006).

The remainder of our survey questions dealt with community engagement and the future of salmon farming on the Eastern Shore. Various answers were given for how stakeholders can better engage and communicate with each other. Nearly all participants replied with different answers to the questions, however, when asked if they believed if communication between stakeholders has effectively put people's concerns at ease, all 11 participants answered "no".

Moving forward, Snow Island must place greater emphasis on speaking with community members and using an integrated approach to coastal management. Such information sharing can save the company time and money. An integrated management approach would involve a stakeholder committee with representatives from all coastal groups to foster respectful, open dialogue and a committee facilitator to ensure all voices are heard.

We recommend the NS DFA revise the *Guide to Information Requirements for Marine Finfish site and Aquaculture Applications 2007 Draft* and provide guidelines that specifically address all potential risks associated with marine finfish sites. Such additions to the *Guide* could have led to a more detailed and transparent EIA for the Snow Island proposed sites. Enhancing the EMP will also improve understanding of the environmental impacts from salmon farms and allow for better mitigation. As illustrated above, there is also support for a national Aquaculture Act in Canada. Research of the current legislation and existing conflict indicates that a national Aquaculture Act could provide better clarity on industry requirements and be beneficial for all stakeholders.

Finally, many believe the solution to minimizing social and environmental conflicts over open net-pen salmon farming is to move more production to closed containment systems (House of Commons, 2013). Currently, many species of fish, including Atlantic salmon, are being produced in closed containment systems in NS, Canada, and around the world. The two most common technologies that have emerged in Canada to isolate the salmon rearing environment from the natural environment are ocean-based solid wall containment and land-based recirculation aquaculture systems (RAS) (Fig. 5) (House of Commons, 2013). Though closed containment will account for many of the negative environmental impacts caused by open net-pen aquaculture, vast amounts of energy along with other inputs are required for successful operation. As a result, closed containment systems have a large ecological footprint and are rarely economically viable.

3.8 Conclusion

It would be beneficial to resolve aquaculture conflicts on NS’s Eastern Shore for economic, environmental, and cultural reasons. Some of the recommendations from this report address means for ensuring the environmental and commercial viability of NS’s aquaculture sector. If aquaculture is going to meet global dietary demands and contribute to provincial economic development, industry, and government must take responsibility for sustainable management.

Due to the important role that aquaculture is predicted to play in feeding the world's growing population, and coupled with the complexity of farming a carnivorous species in public spaces, our study provides a necessary step by beginning a dialogue surrounding best management practices. As highlighted by this report, the biophysical, social, law and policy conflicts that have arisen in NS and other jurisdictions cannot be addressed as separate issues. Strong relationships exist between them, and concerns from one dimension have impacts on the others. Clearer regulations, improved environmental monitoring and mitigation, and finally, engagement and dialogue between stakeholders are necessary to address the conflicts that we have explored.

3.9 References

Adams, B. (2004). Public meetings and the democratic process. *Public Administration Review*, *64*(1), 43-54. doi: 10.1111/j.1540-6210.2004.00345.x

Ayer, N.W. & Tyedmers, P.H. (2009). Assessing alternative aquaculture technologies: life cycle assessment of salmonid culture systems in Canada. *Journal of Cleaner Production, 17*, 362-373. doi:10.1016/j.jclepro.2008.08.002

BCSGA (BC Shellfish Growers Association). (2011). *Canadians overwhelmingly support a national aquaculture Act*. Abacus Data. Retrieved from http://bcsga.ca/wp-content/uploads/2011/04/CAIA_-_April_20_2011_FINAL.pdf

Belle, S.M. & Nash, C.E. (2008). Better management practices for net-pen aquaculture. In C.S. Tucker and J.A. Hargreaves (Ed.), *Environmental best management practices for aquaculture* (pp. 261-331). Iowa, USA: Wiley Blackwell.

Brooks, K. M. & Mahnken, C. V. (2003). Interactions of Atlantic salmon in the Pacific Northwest environment: II. Organic wastes. *Fisheries Research*, *62*(3), 255-293. doi:10.1016/S0165-7836(03)00064-X

Burridge, L., Weis, J.S., Cabello, F., Pizarro, J. & Bostick, K. (2010). Chemical use in salmon aquaculture: A review of current practices and possible environmental effects. *Aquaculture,* 306, 7-23. doi:10.1016/j.aquaculture.2010.05.020

CAIA (Canadian Aquaculture Industry Alliance). (2011). *Pre-budget submission to the House of Commons standing committee on finance.* Retrieved from the Canadian federal goverment website: http://www.parl.gc.ca/Content/HOC/Committee/411/FINA/WebDoc/WD5138047/411_FINA_PBC2011_Briefs%5CCanadian%20Aquaculture%20Industry%20Alliance%20E.html

Canadian Environmental Assessment Act, SC. (1992 c 37). Retrieved from Canlii http://canlii.ca/t/kwcj

Canadian Environmental Assessment Act, SC. (2012, c 19). Retrieved from Canlii: http://canlii.ca/t/51zdg

Carroll, M.L., Cochrane, S., Fieler, R., Velvin, R. & White, P. (2003). Organic enrichment of sediments from salmon farming in Norway: Environmental factors, management practices and monitoring techniques. *Aquaculture, 226*, 165-180. doi:10.1016/S0044-8486(03)00475-7

Community Counts. (2012). Map centre. Retrieved on April 21st, 2013 from: http://www.gov.ns.ca/finance/communitycounts/map_centre/com.html#

COSEWIC. (2010). COSEWIC assessment and status report on the Atlantic Salmon, *Salmo salar* (Nunavik population, Labrador population, Northeast Newfoundland population, South Newfoundland population, Southwest Newfoundland population, Northwest Newfoundland population, Quebec Eastern North Shore population, Quebec Western North Shore population, Anticosti Island population, Inner St. Lawrence population, Lake Ontario population, Gaspe-Southern Gulf of St. Lawrence population, Eastern Cape Breton population, NS Southern Upland population, Inner Bay of Fundy population, Outer Bay of Fundy population) in Canada. Committee on the Status of Endangered Wildlife in Canada. Retrieved from http://www.sararegistry.gc.ca/virtual_sara/files/cosewic/sr_atlantic_salmon_2011_eng.pdf

Cripps, S. & Kumar, M. (2003). Environmental and other impacts of aquaculture. In J.S. Lucase and P.C. Southgate (Ed.), *Aquaculture: Farming aquatic animals and plants*, (pp. 86-87). Oxford: Blackwell Publishing

Department of Marine Resources. (2006). *State of Maine: What is aquaculture?* Retrieved from the Department of Marine Resources website: http://www.maine.gov/dmr/aquaculture/what_is_aquaculture.htm.

DFA (Department of Fisheries and Aquaculture of NS). (2013a). *Fish farm application not approved for Shoal Bay*. Retrieved from http://novascotia.ca/news/release/?id=20130313004

DFA (NS Department of Fisheries and Aquaculture). (2013b). *Aquaculture licence.* Retrieved from NS Permits Directory website http://www.gov.ns.ca/snsmr/paal/fish/paal186.asp

DFA (NS Department of Fisheries and Aquaculture). (2012). *Aquaculture strategy: creating sustainable wealth in rural and coastal NS*. Retrieved from the NS Fisheries and Aquaculture website: http://www.gov.ns.ca/fish/NS-Aquaculture-Policy.pdf

DFA (Department of Fisheries and Aquaculture) (2011). *Environmental monitoring program framework for marine aquaculture in NS*. Retrieved from the Department of Fisheries and Aquaculture website: http://www.gov.ns.ca/fish/aquaculture/ns-emp-framework-march2011.pdf

DFA (Department of Fisheries and Aquaculture). (2010). *Public confidence in aquaculture.* Retrieved from http://www.gov.ns.ca/fish/aquaculture/cdt/publicconf.shtml

DFA (Department of Fisheries and Aquaculture). (2006). *NS aquaculture environmental monitoring program*. Retrieved from the Department of Fisheries and Aquaculture website: http://www.gov.ns.ca/fish/aquaculture/EMPSummaryReport.pdf

DFO (Department of Fisheries and Aquaculture). (2012). *Legislation: regulating aquaculture in Canada.* Retrieved from the Department of Fisheries and Ocean website: http://www.dfo-mpo.gc.ca/fm-gp/sustainable-durable/aquaculture/regulations-legislation-eng.htm

Erskine, B. (2013, March 13). Eastern Shore fish farm bid rejected. *The Chronicle Herald*. Retrieved from http://thechronicleherald.ca/business/969277-eastern-shore-fish-farm-bid-rejected

Ervik, A., Hansen, P.K., Aure, J., Strigebrandy, A., Johannessen, P. & Jahnsen, T. (1997). Regulating the local environmental impact of intensive marine fish farming I. the concept of the MOM system (Modelling-Ongrowing fish farms – Monitoring). *Aquaculture, 158*, 85-94.

Falconer, L., Hunter, D., Telfer, T. & Ross, L. (2013). Visual, seascape, and landscape analysis to support coastal aquaculture site selection. *Land Use Policy 34*: 1-10.

FAO (Food and Agriculture Organization of the United Nations). (2013a). *Participation and transparency in fisheries management*. Retrieved from website: www.fao.org/fishery

FAO (Food and Agriculture Organization). (2013b). *Canada: national aquaculture legislation overview.* Retrieved from http://www.fao.org/fishery/legalframework/nalo_canada/en#tcNB0019

Fisheries Act, RSPEI. (1985, c F-13.01). Retrieved from Canlii http://canlii.ca/t/k62x

Fisheries and Coastal Resources Act, SNS. (1996, c 25). Retrieved from Canlii http://canlii.ca/t/5202x

FPMB (Friends of Port Mouton Bay). (2011). *Port Mouton Bay lobster trap survey 2010-11*. Retrieved from the FPMB website: http://www.friendsofportmoutonbay.ca/docs/Lobster-Trap-Survey-2011-Port-Mouton-Bay.pdf

Fraser, J.A. & Beeson, K. (2003). *The salmon aquaculture forum: Discussion paper on practices and findings*. Pacific Fisheries Resource Conservation Council. Retrieved from http://www.fish.bc.ca/salmon-aquaculture-forum-discussion-paper-practices-findings

House of Commons. (2013). *Standing Committee on Fisheries and Oceans. The Federal Role in Aquaculture: Report of the Standing Committee on Fisheries and Oceans.* March 2013. Retrieved from the Parliament of Canada website: http://www.parl.gc.ca

Hugues-Dit-Ciles, E. K. (2000). Developing a sustainable community-based aquaculture plan for the Lagoon of Cuyutlan through a public awareness and involvement process. *Coastal Management*, *28*(4), 365-383. doi: 10.1080/08920750050133610

Hutchings, J.A., Cote, I.M., Dodson, J.J., Fleming, I.A., Jennings, S., Mantua, N.J., Peterman, R.M., Riddell, B.E., Weaver, A.J. & VanderZwaag, D.L. (2012). *Sustaining Canadian marine biodiversity: responding to the challenges posed by climate change, fisheries, and aquaculture.* Expert panel report prepared for the Royal Society of Canada, Ottawa.

Kaiser, M. & Stead, S.M. (2002). Uncertainties and values in European aquaculture: communication, management and policy issues in times of “changing public perceptions”. *Aquaculture International*, *10*(6): 469-490. doi:10.1023/A:1023963326201

Katranidis, S., Nitsi, E. & Vakrou, A. (2003). Social acceptability of aquaculture development in coastal areas: the case of two Greek Islands. *Coastal Management*, *31*(1), 37-53. doi:10.1080/08920750390168291

Krkošek, M., Lewis, M. A. & Volpe, J. P. (2005). Transmission dynamics of parasitic sea lice from farm to wild salmon. *Proceedings of the Royal Society B: Biological Sciences*, *272*(1564), 689-696. doi: 10.1098/rspb.2004.3027

Loch Duart. (n.d.) *Press release/Briefing note: Loch Duart Ltd invests in Snow Island Salmon NS, Canada*. Retrieved from http://www.lochduart.com/assets/Snow_island_news.pdf

Longdill, P.C., Healy, T.R. & Black, K.P. (2008). An integrated GIS approach for sustainable aquaculture management area site selection. *Ocean & Coastal Management, 51*, 612-624. doi:10.1016/j.ocecoaman.2008.06.010

Mazur, N. A., & Curtis, A. L. (2008). Understanding community perceptions of aquaculture: lessons from Australia. *Aquaculture International*, *16*(6), 601-621. doi:10.1007/s10499-008-9171-0

Mazur, N. A. (2004). *Community perceptions of aquaculture: Related social research*. Australia: Bureau of Rural Sciences. Retrieved from the Australian government website: http://adl.brs.gov.au/brsShop/data/PC12784.pdf

Milewski, I. (2013). *NS environmental monitoring program for finfish aquaculture: an update (2006-2011)*. Retrieved from http://www.ecologyaction.ca/content/nova-scotia-fish-farms-impacting-environment-report

Navigable Waters Protection Act, RSC. (1985, c N-22). Retrieved from Canlii <http://canlii.ca/t/jxfv>

Naylor, R. & Burke, M. (2005). Aquaculture and ocean resources: raising tigers of the sea. *Annual* Review of *Environment* and *Resources*, *30*, 185-218. doi:10.1146/annurev.energy.30.081804.121034

Naylor, R.L., Goldburg R.J,. Primavera, J.H., Kautsky, N., Beveridge M.C.M., Clay J., Folke, C., Lubchenco, J., Mooney, H. & Troell, M. (2000). Effect of aquaculture on world fish supplies. *Nature, 405*(29), 1017–24. doi:10.1038/35016500

NB DAA, NS DAA, & DFO (New Brunswick Department of Agriculture and Aquaculture, NS Department of Agriculture and Aquaculture & Fisheries and Oceans Canada, Maritimes Region). (November 2007). *Guide to information requirements for marine finfish site aquaculture applications draft*. Retrieved from the DFO website: http://www.dfo-mpo.gc.ca/aquaculture/ref/AAPceaafin-eng.htm

NBG (New Brunswick Government). (2006). *Standard operating practices for the environmental monitoring of the marine finfish cage aquaculture industry in New Brunswick.* Retrieved from http://www2.gnb.ca/content/dam/gnb/Departments/env/pdf/MarineAquaculture-AquacoleMarin/StandardOperatingPracticesFinfish.pdf

Olsen, Y. & Olsen, L.M. (2008). Environmental impact of aquaculture on coastal planktonic ecosystems. In K. Tsukamoto, T. Kawamura, T. Takeuchi, T. D. Beard, Jr. and M. J. Kaiser (Eds.), *Fisheries for Global Welfare and Environment*, 5th *World Fisheries Congress*, (pp. 181-196). Tokyo: TERRAPUB.

Owens, L. (2003). Diseases. In J.S. Lucase and P.C. Southgate (Ed.), *Aquaculture: Farming aquatic animals and plants*, (pp. 199-214). Oxford: Blackwell Publishing. Pacific Northwest environment II. Organic wastes. *Fisheries Research 62,* 255-293.

Peckham, S., Duinker, P. & Ordóñez, C. (2013) Urban forest values in Canada: Views of citizens in Calgary and Halifax, *Urban Forestry & Urban Greening,* ISSN 1618-8667, 10.1016/j.ufug.2013.01.001. Retrieved from http://www.sciencedirect.com/science/article/pii/S1618866713000034

Purser, J. & Foreath, N. (2003). Salmonids. In J.S. Lucase and P.C. Southgate (Ed.), *Aquaculture: Farming aquatic animals and plants*, (pp. 295-320). Oxford: Blackwell Publishing.

Reed, M.S. (2008). Stakeholder participation for environment management: A literature review. *Biological Conservation,* 141, 2417-2431. doi.10.1016/j.biocon.2008.07.014

SIMCorp (Sweeney International Marine Corp.) (2012). *Baseline assessment and current data report: proposed site #1371 Spry Harbour*. Retrieved fromhttp://www.simcorp.ca/eiapdf/Shoal%20Bay%201370%20Baseline%20Nov29_11%20FINAL.pdf

SIMCorp (Sweeney International Marine Corp.) (2011). *Environmental impact assessment: Proposed aquaculture site #1371 Spry Bay West*. Retrieved from http://www.simcorp.ca/eiapdf/Spry%20Harbour%20EIA%20Nov25_11%20FINAL.pdf

Snow Island. (n.d.). *Our approach: Environment*. Retrieved from http://snowisland.ca/environment/our-approach/

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 Temahefte Special Report. Retrieved from http://www.nina.no/archive/nina/pppbasepdf/temahefte/036.pdf

Weir, L. K. & Grant, J. W. (2005). Effects of aquaculture on wild fish populations: a synthesis of data. *Environmental Reviews*, *13*(4), 145-168. doi: 10.1139/A05-012

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

World Bank. (2006). Aquaculture environment and health. In *Changing the Face of the Waters: The Promise and Challenge of Sustainable Aquaculture,* (pp. 23-35). Washington: The International Bank for Reconstruction and Development.

Wu, R.S.S. (1995). The environmental impact of marine fish culture: towards a sustainable future. *Marine Pollution Bulletin, 31*(4-12), 159-166. DOI: http://dx.doi.org/10.1016/0025-326X(95)00100-2

Appendix A

Research Study: **Investigating the expansion of salmon farming on the Eastern Shore of Nova Scotia**

Conducted by Master of Resource and Environmental Management Students

Informed Consent

Student Researchers: Katie Paroschy, Karen Devitt, Robin McCullough, Vanja Avdic and Scott Biggar

Supervised by: Faculty in the School for Resource and Environmental Management, Dalhousie University. Contact: Dr. Heather Castleden at heather.castleden@dal.ca or 902.494.2966.

Research Question: Have the socio-political, biophysical, and policy dimensions addressed the social, environmental and economic challenges and opportunities of salmon aquaculture expansion on Nova Scotia's Eastern Shore?

Purpose of Research: To assess the biophysical, socio-political, and legal/policy dimensions of salmon farming expansion on the Eastern shore of Nova Scotia.

Participation and Withdrawal

You can choose whether to be in this study or not. If you volunteer to be in this study, you may withdraw at any time up until April 10th 2013; there is no penalty for withdrawing and you do not need to state your decision for doing so. If you feel uncomfortable with the content of the discussion during the interview, you are free to pass on answering that question or terminate your participation in the study.

Confidentiality and Anonymity

Participants will be sharing their experiences and opinions. Your views will be compiled and analyzed along with that of the other participants, but will not be linked back to you in any way. While you will not be directly named and all efforts will be made to remove identifiable information, it may be possible, because of the nature of the comments and community size, that your statements may be identifiable in the final report. Because of this, the student researchers cannot guarantee complete anonymity. To minimize your risks in terms of participation, we will ask that you only share information that you are comfortable sharing.

Results: Results will be shared in a report and public presentation once all the research is completed. Direct quotes of what you say may be used in our final report and/or presentation in April 2013. This presentation is open to the public and the final report will be posted on the School's website. Any direct quotes from your participation will be available for your review up until April 5th, and anonymity, if requested, will be maintained by using a pseudonym (fake name). As a participant in our research, a copy of our final report will be available to you if you request one.

Rights of Research Participants

You may withdraw your consent at any time and discontinue participation. This study has been approved by the Faculty of Management Ethics Review Board at Dalhousie University. If you have questions regarding your rights as a research participant, please contact Dr. Fiona Black, Associate Dean (Research), Dalhousie University, at fiona.black@dal.ca.

Consent (only circle statements that you agree with):

I AGREE to participate in this study.

I give permission to digitally record the interview.

I give permission to be identified as a participant and quoted by name.

I give permission to use a fake name in conjunction with any quotes.

I would like to receive a copy of the final report, sent to this address:

Participant Signature: ____

Date: ____________________

Appendix B

SCHOOL FOR RESOURCE AND ENVIRONMENTAL STUDIES

DALHOUSIE UNIVERSITY
Inspiring Minds

Research Study: Investigating the expansion of salmon farming on the Eastern Shore of Nova Scotia

Conducted by Master of Resource and Environmental Management Students

Interview Questions

1. What do you perceive to be the most important issue about aquaculture in general, in Canada, in Nova Scotia, here in X?

2. What would you say are the primary benefits of aquaculture? The primary risks?

   Have you observed any ecological effects caused by aquaculture operations?

   How do you think aquaculture affects communities and the day to day lives of residents?

3. Do you think that communication between stakeholders (community members, businesses etc.) has been effective at putting peoples' concern at ease?
   Probe: Where can there be improvement?
   Probe: Can you list any examples?

4. Given your position, how can a company like Snow Island Aquaculture address public concerns?

5. How would you describe the best scenario for aquaculture operations management?
   Probe: By government?
   Probe: By industry?

6. Thinking about the future, what do you think the role of aquaculture will be in your community 10 years from now?

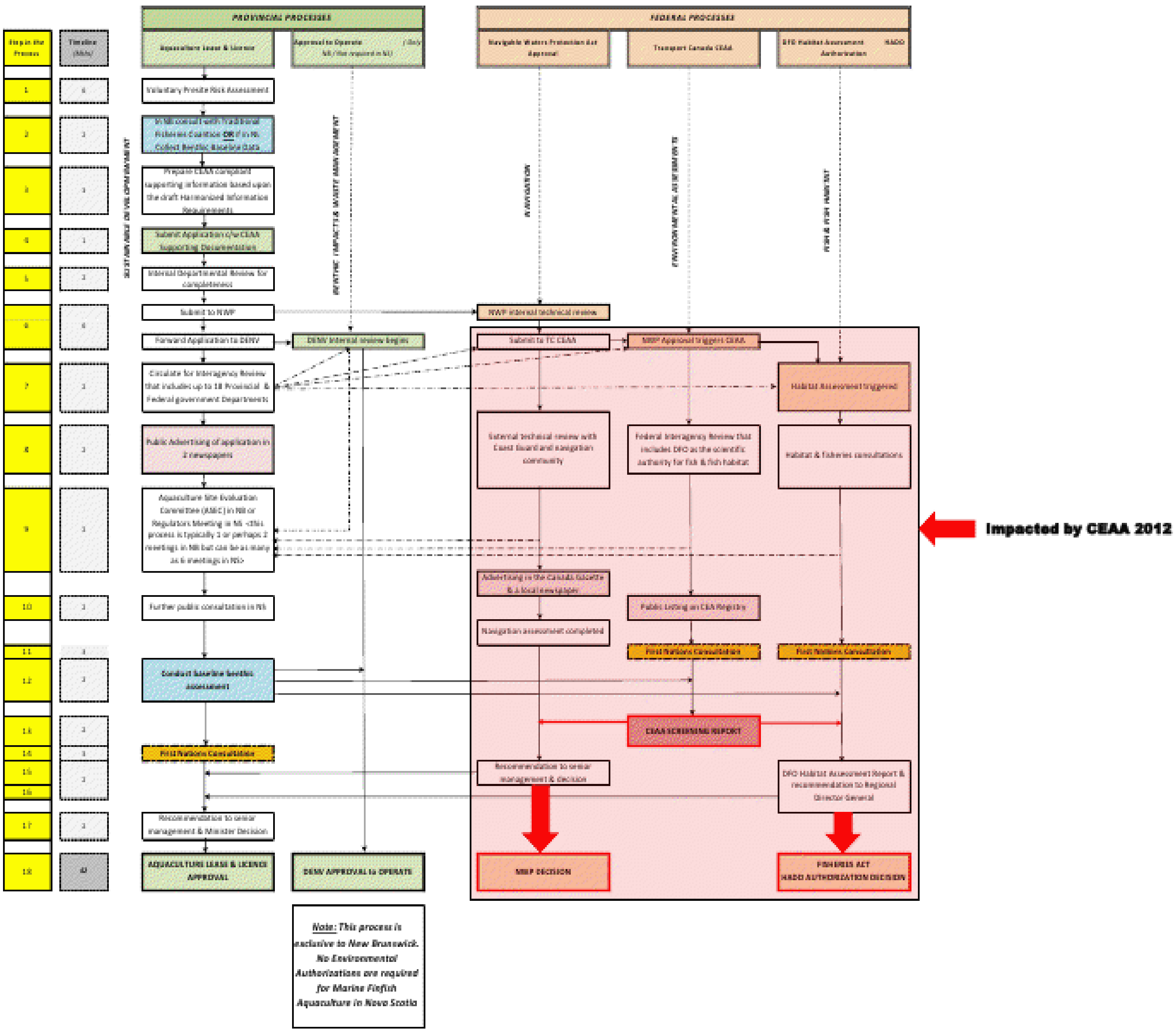
Appendix C

Table 4. Environmental Quality Definitions for the NS Aquaculture EMP. Table adapted from DFA (2011a)

	Sediment Classification		
Measurement	**Oxic**	**Hypoxic**	**Anoxic**
Sediment colour	Tan to depth >0.5cm	Tan to < 0.5 cm with some black sed. at surface	Surface sediments black
Microbial presence	No sulphur bacteria present	Patchy sulphur bacteria	Widespread bacterial mats
Macrofaunal	Wide array of infauna and epifauna	Mixed group of mostly small infauna	Small infauna only
Sulphide, µM	< 750 (A)	1500 to 3000 (A)	> 6000
	750 to 1500 (B)	3000 to 6000 (B)	
Redox (Eh), mV	>100 (A)	-50 to -100 (A)	<-100
	100 to -50 (B)	-100 to -150 (B)	
Organic content, %	<= reference	1.5 to 2X ref.	>2X ref.
Porosity, %	< = reference	1 to 10X ref.	>10X ref.

Appendix D

New Site Application Review Processes



Responsible Industry Development

Creating a false shortage within a fishery: can it be accomplished and if so what are the benefits?

Dan Mombourquette, Candidate, Master of Applied Science Program[a]

[a]Faculty of Science, Saint Mary's University, 923 Robie Street, Halifax, Nova Scotia, B3H 5C3
email: dmombour81@hotmail.com

Dan Mombourquette is a local Haligonian. He is a 2nd year MSc. student studying at Saint Mary's University under the supervision of Dr. Anthony Charles (SMU) and Dr. Robert Stephenson (DFO/UNB/CFRN). He is also a student member of the Canadian Fisheries Research Network (CFRN) and an associate with Nexus Coastal Resource Management. Dan Mombourquette's thesis is title: *A socioeconomic analysis of the distribution of benefits within Atlantic Canadian fisheries*. Dan Mombourquette is academically and professionally interested in developing innovative methods to address issues surrounding fisheries sustainability. In his private life, Dan loves the outdoors, playing music and spending time with friends and family.

Abstract

This report details that creating a false shortage of a fishery product could potentially have several benefits. A false shortage restricts a product's abundance (supply) in the market place when product is not in limited supply. Based on the price-quantity theory of microeconomics, if supply of product in the marketplace is limited then demand will consequently increase. As such, a false shortage could have the unique benefit of increasing a product's price (per unit). Another indirect benefit that could arise from creating a false shortage might be reduced harvesting pressure on the stock as catch effort decreases. Creating a false shortage in the fishery can also explained through the theory of fisheries bioeconomics. This theory states that as effort is reduced to a specific point, costs will be reduced, thus maximizing profits (i.e., creating the maximum economic yield). To further illustrate this concept, market and catch trends within a fishery will be explained using the American eel (*Anguilla rostrata*) fishery as an example. Within this example, market fluctuations from an "actual" supply shortage will be detailed. This example illustrates the possible outcomes of creating a false-shortage. Studies on the Spanish hake (*merluza* sp.) and Canadian silver hake (*Merluccius bilinearis*) fisheries are used to articulate the point that when quantity (supply) is limited in healthy populations, market prices and survivorship can increase. Following this comparative analysis, a cost/benefit analysis of predicted outcomes of creating such a false shortage is presented. Lastly, recommendations on how to promote such a management strategy are considered.

4.1 Introduction

To understand what creating a false shortage in a fishery might entail, it is first important to understand two basic principles of microeconomic theory: the price-quantity model and equilibrium. The price-quantity model (also known as the supply-demand curve) details the theoretical relationship between the price of a product and the quantity of that product on the marketplace (Figure 1). In a perfect market, the supply (quantity) of a product in the marketplace is theorized to be negatively correlated to the demand (consumer need) of that product. Therefore, as supply increases, the demand (and subsequently the price the consumer is willing to pay) for the product will decrease. It is also theorized within this model that the supply-demand relationship will reach equilibrium when producers limit the supply in order to meet the demand in order to optimize the price that can be received for the product. In other words, the supply will eventually equal the demand for that product (Lawson, 1984; Jain, 2007).

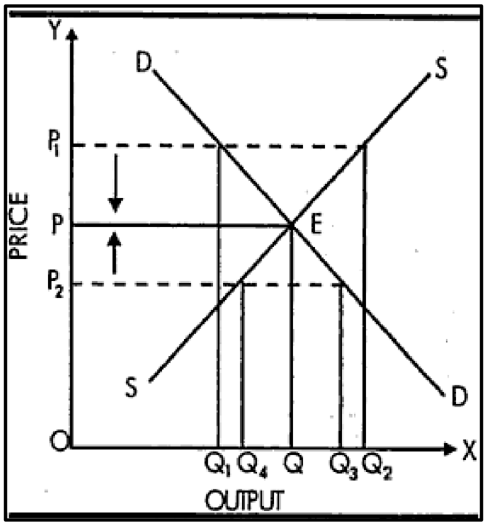


Figure 1. Price-quantity model (Jain, 2007).

Creating a false shortage in a fishery would be based on the premise of limiting the supply of a fish product in the marketplace, away from the equilibrium. If harvesters were bold enough to limit their supply of fish products on the marketplace, based on the microeconomic theory above, the demand could potentially increase and yield an increased price paid (per unit) to the harvesters known as ex-vessel price.

This theory is reinforced in fisheries bioeconomics. Figure 2 details the Gordon-Shaefer static model. As fishing effort increases over a prolonged period of time, the catch of a species will increase up until an optimum known as the maximum sustainable yield (MSY) - as the harvest yield is constrained by the species reproductive rate (*r*). If effort continues past the MSY, the *r* of the species will be compromised and the population will begin to decline. This figure also depicts the Total Revenue Curve (TR; solid line) and the Total Costs (TC; dashed line) of fishing operations. As effort increases, so will the Total Revenue until the MSY is reached. After this point, TR will continue to increase but at a diminished rate, as increased costs reduce the profit margin (area between TR line and TC line) gained by increased effort. These costs and revenues reach equilibrium where costs equal the revenue gained by the effort. This is known as bioeconomic equilibrium (BE), and after this point fishing becomes unprofitable. Interestingly, the Maximum Economic Yield (MEY) is the point on the TR curve where the distance between TR and TC is the greatest, thereby yielding the greatest profit. After this point, costs increase and the profit margin is reduced (Shaefer, 1957; Lawson, 1984; Seijo et al, 1998; Mombourquette, 2013). This bioeconomic theory echoes the theory of creating a false shortage by specifying that if effort were reduced (which would reduce catch and, ultimately, the supply on the marketplace) to a specific level, this would increase economic returns. These two theories differ slightly as false shortage is related to the supply-demand curve and MEY is represented by the relationship between revenues and costs.

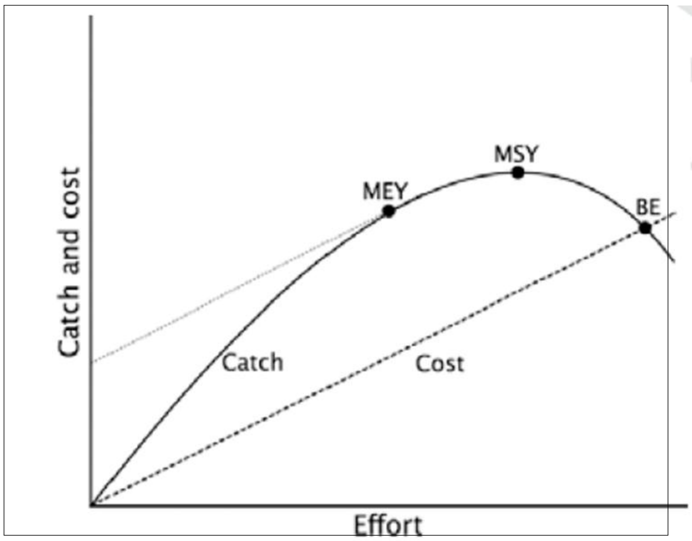


Figure 2 The Gordon-Shaefer fisheries bioeconomic static model (Gordon, 1954; Shaefer, 1957; Seijo et al, 1998).

Creating a false shortage could not only potentially increase the ex-vessel price but it could potentially create a number of positive outcomes for conservation. For example, fishing below the MSY would reduce the species mortality rate and thus would allow the population to increase over time, until it is constrained by the environment's carrying capacity (Schaefer, 1957). Another anticipated positive outcome could include the reduction of fishing gear in the water as fishing effort is reduced. Consequently, this would limit negative impacts on marine ecosystems.

4.2 Methodology

To test whether creating a false shortage in a fishery is feasible, several existing fishery market trends are examined through a literature review and analysed through the theory of a false shortage. The first example is that of the American eel fishery, which is currently experiencing and actual shortage driven by global market trends of this species (Gulf of Maine Council on the Marine Environment, 2007). Under the assumption of the price-quantity model, the value of this species should increase over time due to the shortage of its supply on the market. Following, the price fluctuations and catch rates of Spanish hake and the 2010 catch rate of Canadian silver hake are deliberated in order to articulate that when supply is limited of fish harvested from relatively healthy populations, market prices and fish stocks can increase over time thus increasing the economic and ecological sustainability of these resources (Garcia, 2006; DFO, 2010).

4.3 Results

4.3.1 American eel

Figure 3 details the US market and commercial harvest trends for American eel (*Anguilla rostrata*) from 1950 to 2003. The overall price-quantity trends between 1980 and 2000 mirror, almost perfectly, the price-quantity model of microeconomics. As landings of American eel declined, the ex-vessel price dramatically increased due to the extremely high demand for eels. This scenario supports the microeconomic theory of the price-quantity model (Gulf of Maine Council on the Marine Environment, 2007; Jain, 2007). Through the 2000s, however, a negative correlation between price and quantity of American eel is seen, which is due to a biological shortage of the supply.

Between 1998 and 2000 the ex-vessel price of American eel dramatically decreased even though the catch rates were still in decline. This phenomenon could indicate that the demand for this product reached a maximum. Demand is the quantities that consumers are willing and able to purchase at alternative prices during a given period of time (Jain, 2007). If this price becomes too high, consumers will switch to another product which is less expensive. This trend illustrates that world markets are not as perfect as economic theories would predict them to be. There are phenomena such as maximum demand and product switching which break away from the constraints of economic models (Jain, 2007).

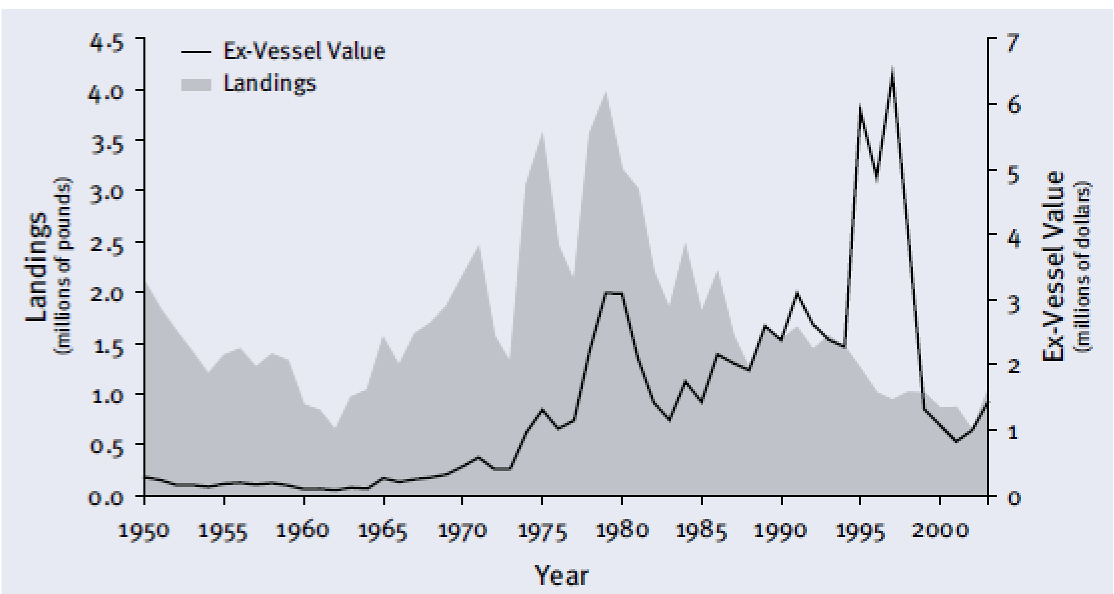


Figure 3 American market trends of American eel (Gulf of Maine Council on the Marine Environment, 2007).

4.3.2 Spanish hake

Figure 4 details price-quantity trends for Spanish hake (*merluza* sp.) between 2000 and 2005 and clearly aligns with the price-quantity relationship of microeconomics: as quantities decrease, ex-vessel prices increase and vice versa. It also demonstrates that an optimal quantity can yield a maximum price before the price continues to decline. This equilibrium point is approximately 18 tonnes and $10/unit (Figure 5). There also appears to be an optimal low quantity that fetches a maximum price, which is approximately 5 tonne and $16/unit (Garcia, 2006). As detailed by the catch data, this species' population appears to be healthy (there are no long-term trends which depict declines of the harvest). Since the fishery in this case study is not experiencing an actual biological shortage, harvesters would need to purposefully limit their catch rates (i.e. reduce landings through the use of trip limits and other output control mechanisms) to yield an increase in ex-vessel prices. In other words, harvesters would need to utilize a false shortage strategy, to optimize profit (please refer to bioeconomic theory presented on p. 4). Not only will decreasing supply increase the ex-vessel price paid to harvesters, reducing the amount of effort to catch fish will also increase profit but reducing total costs (Shaefer, 1957; Lawson, 1984; Seijo et al, 1998; Mombourquette, 2013).

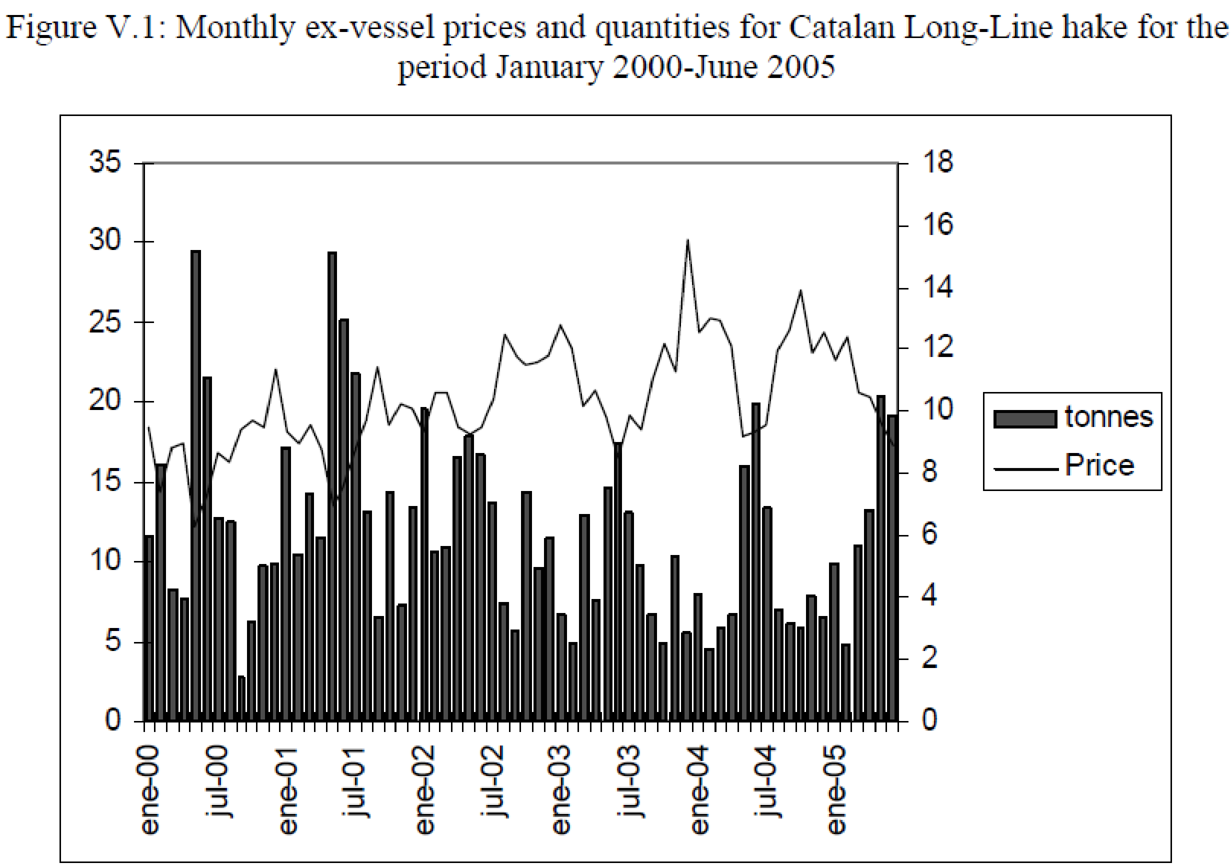


Figure 4. Price-quantity trends for Spanish (Catalan region) hake (Garcia, 2006).

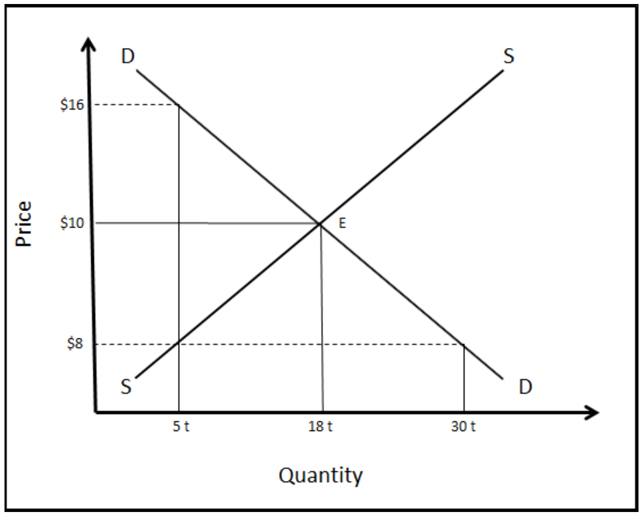


Figure 5. The price-quantity model for Spanish hake (developed by Daniel Mombourquette and adapted from Garcia, 2006).

4.3.3 Canadian silver hake

Table 1 details the total allowable catch (TAC) and actual catches of Canadian silver hake (*Merluccius bilinearis*) for 2010. As shown, several of the harvester groups (namely the individual transferable quota (ITQ) and enterprise allocation (EA) fleets, +100ft fleet and the aboriginal group) actually harvested a considerably lower amount than Fisheries and Oceans Canada (DFO) allotted. This occurred due to an industry led initiative to impose trip limits on each vessel where the objective was not to fill the vessel but to catch a prescribed amount. An industry expert stated the reasons for imposing these trip limits were a result of "reduced capacity to process this species, but they also provided prolonged employment for members of the community. Furthermore, trip limits can yield maximum/stable ex-vessel prices for this product." (C. Milley, personal communication, Nov. 4, 2012). An additional benefit is that 56 per cent of the remaining fishable biomass is allowed to escape the fishery and contribute to the increased growth of the silver hake population.

Table 1 Quota allocations (for all fleets within all areas of Atlantic Canada) for silver hake in 2010 (DFO, 2010).

2010 CANADIAN ATLANTIC QUOTA REPORT - HAKE - Catch to Date (M.T.)

AREA BY TYPE OF VESSEL - SEASON	INITIAL QUOTA	QUOTA AFTER TRANSFERS	MARITIMES	GULF	QC	NFLD	C&A	TOTAL	%	AMOUNT REMAINING
SILVER HAKE										
4VWX 2010-04-01 - 2011-03-31										
FRANCE	300	300	0	0	0	0	0	0	0%	300
ABORIGINAL FISHERY	709	577	165	0	0	0	0	165	29%	412
MOBILE < 65' BYCATCH	40	40	0	0	0	0	0	0	0%	40
MOBILE 65 - 100' COMPETITIVE	263	263	0	0	0	0	0	0	0%	262
VESSELS > 100' COMPETITIVE	176	6	0	0	0	0	0	0	0%	6
FIXED AND MOBILE GEAR - ITQ / EA FLEET	13,512	13,814	8,226	0	0	0	0	8,226	60%	5,588
TOTAL SILVER HAKE	15,000	15,000	8,391	0	0	0	0	8,391	56%	6,609

4.4 Discussion

The above examples provide evidence for the argument that creating a false shortage of supply of a fish product in the marketplace can yield several benefits. The American eel and Spanish hake examples illustrate that fishery products generally follow the price-quantity model of microeconomics which states that as quantity decreases, the market responds by increasing the value of that product (and vice versa). Within the Spanish hake example, it was further articulated that a reduced effort (caused by limiting the market supply) would also have the added benefit of reducing the overall costs of fishing, which would reduce economic costs and increase profits for the industry. This scenario coincides with the fisheries bioeconomic model of MEY and the Canadian silver hake example detailed that imposing trip limits, which is synonymous with creating a false shortage of supply, not only maximized and stabilized ex-vessel prices but also led to prolonged employment within communities that fish this species. Additionally, the remaining unfished biomass of Canadian silver hake would lead to an increase in the ecological sustainability of the resource over time.

As displayed in the American eel example, the market is not static and consumer demand can reach a maximum if prices become too high. This can result in a sharp decline of prices for products and, hence, there may be other economic forces that could counter the theory of creating a false shortage. As such, it is important to examine other possible economic (as well as social) impacts that may result from creating a false shortage of supply of a fishery product. The following section presents a cost/benefit analysis of some of these potential outcomes.

4.5 Cost/Benefit Analysis

Some may argue that reducing fishing effort (i.e. reducing the amount of time fishing) to reduce the supply in the marketplace would ultimately reduce employment, while others, have suggested that this may actually lead to prolonged employment (Weber, 1994; C. Milley, personal communication, Nov. 4, 2012). If harvesters were allowed to fish unbridled, this could result in overfishing that would, in the long-term, lead to total employment loss within the community. Therefore, if effort is reduced to create sustainable fishing practices, employment would be secured for generations to come (intergenerational equity) - creating sustainable livelihoods. Admittedly, there will be some initial employment loss, however it is better to have some employment loss in the short-term instead of total employment loss in the industry in the future (as witnessed during the Northern cod collapse) (Weber, 1994). Reducing the amount of fishing time for fishermen could also create opportunities for them to participate in other forms of employment, which has been noted as a means to increase employment diversity and ultimately increase the social resilience of a fishing community (Charles et al., 2002).

Others could argue that creating a false shortage could entice some harvesters to participate in cheating behaviours such as poaching (IUU fishing) and creating a black market for fish products. This is a perfectly logical scenario as these cheating behaviours currently occur in almost all fisheries (Weber, 1994; Agnew et al. 2009). This also attests to the fact that the market is not perfect or static. However, for a false shortage to be successful, all persons who participate in the fishery (e.g. harvesters, buyers, producers and other labourers) would have to agree to the terms of the false shortage strategy. If there are any fishery participants who cheat and place the fishery product onto the market illegally, or outside of the false shortage initiative, this could have the negative effect of flooding the market and thus reducing ex-vessel prices. Therefore, it would be important to include an effective monitoring and enforcement mechanism to ensure compliance to the false shortage strategy.

Lastly, it could be argued that reducing a fish products' supply on the market would reduce global food security because the amount of protein available would be reduced, which in turn could increase the price of that protein making it less accessible. However, it has been stated by the FAO (2012) and the Centers for Disease Control and Prevention (CDC; 2012) that fish protein consumption (per capita) in the developed world is far greater than that recommended for daily nutrition. Therefore, fish protein consumption (and consequently the supply of fish protein in the marketplace) should be reduced regardless of the market incentives they provide to the industry. An increased price for this product could be translated into the price of conservation for the species, as it has been argued that this strategy could lead to the sustainability of the resource (recall the Canadian silver hake example). Table 2 below displays all the predicted costs and benefits relating to these arguments of creating a false shortage initiative.

Table 2 The cost/benefit analysis of creating a false shortage of supply of a fishery product.

Predicted benefits/positive outcomes	**Predicted costs/negative outcomes**
• A lower quantity of product on the market place could lead to increases in the unit price • A reduced fishing effort (fisheries input) can maximize profits for harvesters (less overhead cost in fuel, gear/bait and wages) • A reduced catch (fisheries output) will benefit conservation; a greater population is allowed to escape the fishery and contribute to greater population growth • Labourers might benefit from increased time on land; increased time to participate in other forms of employment (leading to increased resilience; Charles et al, 2002) • Ultimately this strategy will lead to more prolonged employment; it is more important to have some employment loss now instead of total employment loss later (Weber, 1994; Milley, C., personal communication, Nov. 4, 2012) • As effort is reduced, so would the length of time gear would be used. This could reduce negative impacts gear has on marine ecosystems. • The developed world consumes (per capita) a far greater amount of protein than needed for daily nutrition (Weber, 1994; FAO, 2012, CDC, 2012). Thus, limiting the protein supply should not have a detrimental effect on food security	• A reduced fishing effort leads to less time fishing; therefore, reduced employment • All stakeholders within the fishery (harvester, buyers, processors etc.) have to participate; if rogue producers or poachers flood product onto the market, it could decrease the unit price • Could lead to increased poaching/black market sales • Demand (consumer purchasing) can switch to other protein source if there is not enough product on the market or if the price becomes too high • Could reduce global food-security by increasing food prices and reducing the amount of food available

4.6 Conclusion

Based on the table above and the arguments stated within the discussion, it appears that there are more anticipated benefits then there are costs of creating a false shortage within a fishery. Such a strategy, however, is vulnerable to human and market forces and therefore, it is pertinent that the following recommendations are followed:

1. The optimum price-quantity for the fishery product should be discovered through market research. It is important to understand this balance in order to avoid the scenario of consumers switching to other protein sources.

2. All fishery participants (e.g. harvesters, buyers, processers and other labourers) must agree to the terms of the false shortage strategy; they must not catch or sell the fishery product outside this initiative.

3. This initiative should be developed by the industry and within the community where it is applied (i.e., it must be a co-management or community-based management initiative).

4. A management body should be created to control monitoring and enforcement programs aimed at reducing cheating behaviours, promoting compliance and stewardship.

If these recommendations are followed, a false shortage initiative can potentially be applied to any fisheries to promote economic, ecological and social sustainability.

4.7 References

Agnew, D.J., Pearce, J., Pramod, G. , Peatman, T., Watson, R., Beddington, J. R and Pitcher, T. J. (2009) Estimating the Worldwide Extent of Illegal Fishing. *PLoS ONE 4(2),* 1-8.

Caddy, J.F. (1999). Fisheries management in the twenty-first century: Will new paradigms apply? *Reviews in Fish Biology and Fisheries, 9,* 1-43.

Centers for Disease Control and Prevention (CDC). (2012). *Nutrition for everyone.* Retrieved from http://www.cdc.gov/nutrition/everyone/basics/protein.html

Charles, A.T., Boyd, H., Lavers, A. and Benjamin, C. (2002). *The Nova Scotia GPI Fisheries and Marine Environment Accounts: A Preliminary Set of Ecological, Socioeconomic and Institutional Indicators for Nova Scotia's Fisheries and Marine Environment*. Nova Scotia, Canada: GPI Atlantic.

Christensen, V. (2010). MEY = MSY. *Fish and Fisheries, 11(1),* 105-110.

Department of Fisheries and Oceans Canada. (2010). 2010 Canadian Atlantic quota report (hake): Catch to date in metric tons. Retrieved from http://www.dfo-mpo.gc.ca/stats/commercial/qr-rc/2010/hak-eng.htm

FAO. (2012). The state of world fisheries and aquaculture. Rome, Italy: Food and Agriculture Organization of the United Nations.

Garcia, J.G. (2006). *The Spanish hake market: Price, product and market relationships.* Barcelona, Spain: University of Barcelona.

Gordon, H. S. (1954). The economic theory of a common-property resource: The fishery. *Journal of Political Economy, 62 (2),* 124-142.

Gulf of Maine Council on the Marine Environment. (2007). *American Eels: Restoring a Vanishing Resource in the Gulf of Maine*. Retrieved from www.gulfofmaine.org.

Jain, T.R. (2007). *Micro economics and basic mathematics*. New Delhi, India: V.K. Publications.

Lawson, R. (1984). *Economics of fisheries development.* London, UK: Frances Pinter Limited.

Miyake, M.P., Guillotreau, P., Sun, C-H. and Ishimura, G. (2010). *Recent developments in the tuna industry: Stocks, fisheries, management, processing, trade and markets*. FAO Fisheries and Aquaculture Technical Paper 543. Rome, Italy: Food and Agriculture Organization of the United Nations.

Mombourquette, D. (2013). *Literature Review: Fisheries indicators frameworks and corresponding materials.* APSC 6600: Graduate Seminar.

Roheim, C.A. (2008). *Seafood supply chain management: Methods to prevent illegally-caught product entry into the marketplace*. Washington, D.C., USA: IUCN World Conservation Union.

Schaefer, M. B. (1957). Some considerations of population dynamics and economics in relation to the management of the commercial marine fisheries. *Journal of the Fisheries Research Board of Canada, 14(5),* 669-681.

Seijo, J.C., Defeo, O. and Salas, S. (1998) *Fisheries bioeconomics: Theory, modelling and management.* FAO Fisheries Technical Paper 368. Rome, Italy: Food and Agriculture Organization of the United Nations (FAO).

Weber, P. (1994). *Net Loss: Fish, jobs, and the marine environment.* (C. Douglis, Ed.) Washington, D.C: Wordwatch Institute