KNOWLEDGE CO-CONSTRUCTION THROUGH KNOWLEDGE ACTIONS: A CASE STUDY OF THE SOUTHWESTERN NEW BRUNSWICK BAY OF FUNDY JOINT FISHERMEN SCIENTISTS OVIGEROUS FEMALE LOBSTER (*HOMARUS AMERICANUS*) ABUNDANCE PROJECT

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ABSTRACT

Knowledge co-construction has gained popularity as a means to understand and identify mitigating measures for management of risk in marine environments. While there is general agreement on the value of multi-stakeholder knowledge inclusion as seen through its adoption in numerous joint stakeholder collaborations, there is still much to learn about how knowledge co-construction takes place and what factors contribute to its success. The early boundary work of Star and Griesemer (1989) laid the foundation for examining the relations between stakeholders and the exchange of knowledge sets.

The subsequent literature however, has yet to speak to what is meant by the knowledge that is being jointly produced. This dissertation proposes an action oriented definition of knowledge that includes: theorizing relationships, agreeing on key concepts, specifying and interpreting required data, identifying principles and making evaluations. An argument will be made for the examination of knowledge actions in tandem with interdisciplinary knowledge exchange literature to glean a greater understanding of how knowledge co-construction occurs. Examples in support of this argument will be drawn from a case study examining the development and implementation of a scientific protocol for the Ovigerous Female Lobster Abundance Project, a joint fishermen-scientist project examining the impact of the Atlantic salmon (Salmo salar) aquaculture industry on the in-shore American lobster (Homarus americanus) fishery of Southwest New Brunswick. It is the conclusion of this dissertation that an increased understanding of the actions of knowledge in relation to the essential boundary objects used for joint stakeholder projects will both facilitate knowledge co-construction and inform risk assessment.
DEDICATION

For Elias
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iv
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# Table of Contents

ABSTRACT .......................................................................................................................... ii
DEDICATION ....................................................................................................................... iii
ACKNOWLEDGEMENTS ................................................................................................. iv
Table of Contents ........................................................................................................... vi
List of Figures .................................................................................................................... x
List of Symbols, Nomenclature or Abbreviations .......................................................... xi

1. Introduction .................................................................................................................. 1
   1.1 Introduction .............................................................................................................. 1
   1.2 Lobster Aquaculture Interactions in Southwestern New Brunswick ....................... 2
   1.3 Theoretical Exploration ......................................................................................... 3
   1.4 Methodological Approach ...................................................................................... 4
   1.5 Data Results ........................................................................................................... 4
   1.6 Analysis of Dominant Themes .............................................................................. 5
   1.7 Study Conclusion .................................................................................................. 6

2. Case Study .................................................................................................................... 7
   2.1 Sharing the Waters of Southwestern New Brunswick .............................................. 7
      2.1.1 Lobster Fishery in Southwestern New Brunswick ............................................ 8
      2.1.2 Salmonid Finfish Aquaculture Industry in Southwestern New Brunswick ....... 10
      2.1.3 Access Conflicts ............................................................................................ 13
      2.1.4 Risk Perceptions – The Link Between Risk Assessment & Increasing Conflict .... 13
   2.2 The Incident ........................................................................................................... 14
   2.3 Listening to the Fishermen of LFA 36 ................................................................. 17
      2.3.1 Risk Assessment Project .............................................................................. 18
      2.3.2 The Berried Female Abundance Project .................................................... 19
      2.3.3 Project Protocol Study – Studying Co-Construction of Knowledge ............. 20

3. Theory .......................................................................................................................... 23
   3.1. Introduction .......................................................................................................... 23
   3.2 Risk and Fisheries Management .......................................................................... 23
   3.3 The Role of Knowledge in Risk Management ..................................................... 26
   3.4 Inclusion of Alternative Knowledges ................................................................... 29
<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.5 Knowledge Sets: Science and LEK</td>
<td>33</td>
</tr>
<tr>
<td>3.6 Bringing Knowledge Together - Boundary Objects &amp; Trading Zones</td>
<td>38</td>
</tr>
<tr>
<td>3.6.1 Boundary Objects</td>
<td>38</td>
</tr>
<tr>
<td>3.6.2 Dynamic between ill and well-structured</td>
<td>43</td>
</tr>
<tr>
<td>3.6.3 Trading Zone</td>
<td>43</td>
</tr>
<tr>
<td>3.7 Conclusion</td>
<td>46</td>
</tr>
<tr>
<td>4. Method</td>
<td>48</td>
</tr>
<tr>
<td>4.1 Introduction</td>
<td>48</td>
</tr>
<tr>
<td>4.2 Research Method</td>
<td>49</td>
</tr>
<tr>
<td>4.2.1 Research Questions</td>
<td>49</td>
</tr>
<tr>
<td>4.2.2 Qualitative Research</td>
<td>50</td>
</tr>
<tr>
<td>4.2.3 Grounded Theory</td>
<td>50</td>
</tr>
<tr>
<td>4.2.4 Actor Network Theory (ANT)</td>
<td>51</td>
</tr>
<tr>
<td>4.3 Study Parameters</td>
<td>53</td>
</tr>
<tr>
<td>4.4 Term Operationalization</td>
<td>54</td>
</tr>
<tr>
<td>4.4.1 Study Participants</td>
<td>55</td>
</tr>
<tr>
<td>4.4.2 Lobster Fishing</td>
<td>56</td>
</tr>
<tr>
<td>4.4.3 Open Pen Finfish Aquaculture</td>
<td>62</td>
</tr>
<tr>
<td>4.5 Data Collection</td>
<td>63</td>
</tr>
<tr>
<td>4.5.1 Population Universe</td>
<td>65</td>
</tr>
<tr>
<td>4.5.2 Meetings</td>
<td>66</td>
</tr>
<tr>
<td>4.5.3 Field Observations</td>
<td>67</td>
</tr>
<tr>
<td>4.5.4 Other Documents</td>
<td>69</td>
</tr>
<tr>
<td>4.6 Data Analysis</td>
<td>71</td>
</tr>
<tr>
<td>4.7 Conclusion</td>
<td>72</td>
</tr>
<tr>
<td>5. Results</td>
<td>75</td>
</tr>
<tr>
<td>5.1 Introduction</td>
<td>75</td>
</tr>
<tr>
<td>5.2 Defining a Research Question</td>
<td>76</td>
</tr>
<tr>
<td>5.3 Building a Protocol</td>
<td>79</td>
</tr>
<tr>
<td>5.3.1 Paired sites vs. transects methodology</td>
<td>79</td>
</tr>
<tr>
<td>5.3.2 Protocol Boundaries – Aquaculture Bay Management Areas</td>
<td>81</td>
</tr>
<tr>
<td>5.3.3 Site Selection for Trap Survey Locations</td>
<td>82</td>
</tr>
</tbody>
</table>
6. Analysis

6.1 Introduction

6.2 Who is constructing knowledge

6.3 What is being co-constructed - knowledge

6.4 How is knowledge co-constructed

5.6 Conclusion

5.5 Reviewing the Protocol

5.4 Implementing the Protocol

5.3 Tides

5.2 Mixed terminology

5.1 Selection of sites

5.4.1 Start Dates

5.4.2 Deployment & Retrieval

5.4.3 Data Collection

5.4.4 Lobster Tables

5.5.4 Forgotten and Overlooked

5.5.3 Aquaculture Site Activity

5.5.2 Selection of sites

5.5.1 Mixed terminology

5.4.6 Tides

5.4.5 Data Collection

5.4.4 Lobster Tables

5.4.3 Deployment & Retrieval

5.4.2 Start Dates

5.4.1 Selection of sites
List of Figures

Figure 2:1 Map of Southwestern New Brunswick Coastal Waters (Wiber et al. 2012)..... 8

Figure 2:2 Map Fisheries and Oceans Assigned LFAs in Bay of Fundy Regions (Fisheries and Oceans 1998)........................................................................................................................................................................ 10

Figure 2:3 Map Aquaculture Bay Management Areas SWNB (Curtis Maillet et al. 2017) .................................................................................................................................................................................................................. 12

Figure 2:4 Project Protocol Study Structure ................................................................................................................................. 20

Figure 2:5 Knowledge Exchange Between Abundance Project Participants .......... 21

Figure 3:1 Trading Zones Basic Model (based on Collins et al. 2007:659) ............... 45

Figure 4:1 Author’s depiction of a 10 trap trawl line (Field Notes August 7, 2014)....... 60

Figure 4:2 Protocol Study Timeline......................................................................................................................................................... 64

Figure 4:3 Participants in the Protocol Study ........................................................................................................................................ 66

Figure 5:1 Trap Deployment and Retrieval Method.......................................................................................................................... 93

Figure 6:1 Actions of Knowledge......................................................................................................................................................... 123

Figure 6:2 Boundary Objects within Trading Zones as points of knowledge exchange 136

Figure 6:3 Actions of Knowledge as Boundary Objects ................................. 139

Figure 6:4 Protocol Study Examples of Actions of Knowledge as Boundary Objects .. 140
## List of Symbols, Nomenclature or Abbreviations

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Full Form</th>
</tr>
</thead>
<tbody>
<tr>
<td>ABMA</td>
<td>Aquaculture Bay Management Area</td>
</tr>
<tr>
<td>ACFFA</td>
<td>Atlantic Canada Fish Farmers Association</td>
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<tr>
<td>ANT</td>
<td>Actor Network Theory</td>
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<tr>
<td>DFO</td>
<td>Fisheries and Oceans Canada</td>
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<td>FFAW</td>
<td>Fish, Food &amp; Allied Workers</td>
</tr>
<tr>
<td>FNFA</td>
<td>Fundy North Fishermen’s Association</td>
</tr>
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<td>ISA</td>
<td>Infectious Salmon Anemia</td>
</tr>
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<td>LFA</td>
<td>Lobster Fishing Area</td>
</tr>
<tr>
<td>SKS</td>
<td>Sociology of Scientific Knowledge</td>
</tr>
<tr>
<td>STS</td>
<td>Science and Technology Studies</td>
</tr>
<tr>
<td>SWNB</td>
<td>South West New Brunswick</td>
</tr>
</tbody>
</table>
1. Introduction

1.1 Introduction

The coastal waters and inshore industries of eastern Canada have long played an important role in the livelihoods of Atlantic Canadians. Increasingly, however, there has been growth in the types of human-environment interactions as new opportunities for resource access, use and harvesting are identified. In turn, these encounters become the catalyst for an increase in conflicts between users such as the capture fisheries, aquaculture, tourism, energy industry, and other stakeholders located in regions such as the southwestern New Brunswick Bay of Fundy. The decision-making processes required for the management of this complex ecological system raise important considerations over what constitutes acceptable levels of risk and how the oceans should be governed. Risks, “the statistical probability of an outcome, combined with severity of the effect” (Boholm 2010), are perceived differently by different stakeholder groups. Simply put, perceptions of harm are varied; what one group may perceive as being acceptable another may not. Therefore, conflicts arise between social groups with respect to the decisions needed for policy, regulation and management of resources and their access. Research work that takes into consideration these differing perceptions of risks and uncertainties could provide informed knowledge on which to base assessments of perceived risks and identify potential mitigation measures.

This dissertation is an examination of how resource stakeholders, or social worlds, can come together to co-construct the knowledge that is necessary to inform decision-making processes for mitigating risk.
1.2 Lobster Aquaculture Interactions in Southwestern New Brunswick

This study begins with an outline of the recent conflicts experienced in the southwestern New Brunswick (SWNB) portion of the Bay of Fundy. This coastal area, designated by the federal department of Fisheries and Oceans Canada (DFO) as Lobster Fishing Area 36 (LFA 36), is home to an historic inshore Atlantic lobster (*Homarus americanus*) fishery now competing for ocean access with, among other industries, an expanding Atlantic Salmon (*Salmo salar*) open net pen (i.e., cages) aquaculture industry. While there has been a decrease in the total number of licensed aquaculture sites in use, the overall footprint is increasing because of the growing size of the remaining sites. The near shore characteristics that are understood to be ideal for lobster spawning grounds, nurseries and growing habitats are the same ocean waters most desired for the husbandry practices of the finfish aquaculture industry.

As will be outlined, lobster fishermen of the LFA 36 have been willing to share their knowledge of changing behaviour patterns of lobsters since the introduction of the aquaculture industry and in particular their observations around the application of chemical treatments for the control of sea lice (*Caligus elongates*). While the fishermen have raised concern about the potential harm caused to lobsters during their life cycles in the presence of aquaculture production, the aquaculture industry has in turn promoted conflicting information and research dismissing these concerns (Strain and Hargrave 2005). Meanwhile, scientists studying animal biology and ecosystem development have called attention to the number of unknowns including the spatial and temporal distribution of lobster around aquaculture sites and the vulnerabilities during different
stages of the lobster life cycle (e.g. McMahan et al 2016, Quinn et al. 2013, Grabowski et al. 2010).

In 2014, a group of fishermen and scientists launched the *Ovigerous Female Lobster Abundance Project* (Abundance Project) in order to address some of the diversity between these *knowledge sets*, meaning the subject-related knowledge iteratively developed and collectively acknowledge by the members of the individual stakeholder group. This dissertation will focus on the efforts of these fishermen and scientists to combine their unique knowledge sets and expertise to jointly design and implement the scientific protocol necessary for the Abundance Project. Moreover, knowledge itself will be examined as an actor, in order to reveal how the way knowledge is defined contributes to the efforts of diverse social worlds seeking to co-construct knowledge.

### 1.3 Theoretical Exploration

Drawing on an interdisciplinary body of scholarly literature, chapter three will speak to the central argument for both giving consideration to risk in resource management, and the role knowledge can contribute towards risk management. The literature will also be used to define and compare scientific and local knowledge sets as well as their contributions to knowledge co-construction. Finally, literature that addresses how knowledge sets are brought together for knowledge co-construction will be explored. In particular, emphasis will be given to the literature that proposes the use of boundary objects (e.g. Star and Griesemer 1989) and trading zones (Collins, Evans & Gorman 2010), as facilitators for knowledge co-construction.
1.4 Methodological Approach

Chapter 4 will explain how this qualitative research study applied both grounded theory and actor network theory (ANT) approaches to examine the joining of different social worlds to co-construct knowledge. As a participant observer, I was privileged to use the multi-stakeholder Abundance Project as a case study. The study population for my research included the stakeholders of the Project including fishermen, representatives of fishermen’s organizations, both academic and government natural and social scientists, research technicians, students and government employees.

Data for the protocol study was collected from 2 years of the Abundance Project’s meetings transcripts and notes, semi-structured interviews with representatives of the stakeholder groups, field observations and other project related documentation such as email correspondence, maps, marine charts, scientific research licenses, reports, and more. A comprehensive review of the data was conducted including the application of line-by-line, focused and axial coding of the data to identify topics of knowledge exchange for analysis and application of theoretical arguments.

1.5 Data Results

Chapter 5 will present in some detail the data as identified during the comprehensive review. Three data areas were of particular interest to my study: the building of the protocol, the implementation of the protocol, and the discoveries made about the Abundance Project’s protocol design and its logistics once the project was underway. These three topic areas will be further divided into several subtopics that specifically demonstrate the processes of information exchange between stakeholder
participants from different backgrounds and experiences, collectively working to
develop a research protocol.

1.6 Analysis of Dominant Themes

Public policy development and resource decision-making processes are
increasingly mandating the inclusion of stakeholder knowledge through legislated
procedures (e.g. Fisheries Act R.S.C. 1985, c.F-14; Canadian Environmental
Assessment Act, 1992, R.S.C. c.37; Oceans Act S.C. 1996, c.31) and consultation
processes (see http://www.consultingcanadians.gc.ca for current list of processes with
Canadian federal government departments). Within the Canadian fisheries, the value of
this stakeholder inclusion is demonstrated through the unique experiential and local
knowledge they contribute concerning resources and resource habitats. When this local
knowledge is used in conjunction with scientific expertise, the research work becomes
more robust, helping to produce policy outcomes that are both meaningful and feasible
(e.g. Olsson and Folke 2001). Despite the recognized benefit of increased stakeholder
knowledge inclusion in research work, the results of such joint fishermen scientist
projects are not always successful (Siddiki and Goel 2015).

Turning to the literature that examines knowledge co-production for an
explanation of this disconnect is at once both meaningful and limited. While the
literature speaks to both who should be included and even what successful knowledge
co-construction looks like, I discovered a lacuna in the literature as to how knowledge
col-construction actually takes place. In the sixth chapter I reflect back on what
happened during protocol development using an action based definition of knowledge
which I developed for this project and I was able to use during the protocol study to address this gap. Turning to the literature of boundary objects, it becomes clear an action-oriented definition of knowledge expands on the boundary object literature and shows the vital role of boundary objects in facilitating knowledge co-construction. My proposed definition of knowledge itself, a definition that speaks to knowledge not as a ‘thing’ but as a series of actions, provides insight into knowledge co-production and can actually facilitate its occurrence between social worlds.

1.7 Study Conclusion

As an interdisciplinary work, this study examines a multi-stakeholder scientific research project, following the scientific protocol from its inception through the first two years of its progress. The development and implementation of the project’s scientific protocol are examined to illustrate how meaningful scientific knowledge can be co-constructed with multiple-stakeholders jointly contributing their unique knowledge sets and expertise. Drawing on the literature and research methodologies of anthropology, sociology, environmental management, and science and technology studies, this work will not only demonstrate the importance of the inclusion of diverse expertise, experiential and scientific, for meaningful knowledge co-construction but will also argue as to how this co-construction might be facilitated. Focusing on the actions of knowledge, a new approach is proposed for understanding and facilitating the knowledge co-production necessary for informed resource risk management.
2. Case Study

2.1 Sharing the Waters of Southwestern New Brunswick

The coastal waters of the Bay of Fundy, located off the shores of southwestern New Brunswick (SWNB) Canada, are home to both breathtaking views, ecological wonders and numerous marine species (see Figure 2.1). It is also a region faced with many competing resource access and risk management concerns. Commercial fisheries (e.g. lobster, herring, scallop, sea urchin), aquaculture, tourism (e.g. whale watching, kayaking tours, scuba diving), shipping and ferry vessels, oil and gas industries, and tidal energy research are all located in this small coastal region. The Fundy North Fishermen’s Association, the New Brunswick Conservation Council, the Fundy Baykeeper and the NB Aboriginal Peoples Council are just four of the stakeholders and not-for profit groups working towards sustainable resource use and management. While these resource users and groups often find themselves at odds with both access and resource governance strategies (e.g. conflicts of interest between North Atlantic right whale and shipping lanes), two industries of particular concern are the inshore Atlantic lobster (*Homarus americanus*) fishery and the Atlantic Salmon (*Salmo salar*) open net pen aquaculture industry.
2.1.1 Lobster Fishery in Southwestern New Brunswick

The lobster fishery, a traditional commercial fishery, is but one of a variety of inshore fisheries that has played a major role in the livelihoods of SWNB communities since European settlement in the region during the 1700s (Wiber, Young and Wilson 2012). The New Brunswick Department of Agriculture, Aquaculture and Fisheries 2015 Commercial Fisheries Sector Review (Agriculture, Aquaculture and Fisheries 2015b) reports that 2403 fishing vessels were located in New Brunswick waters in that year. Collectively, the harvest totaled 85,435 tonnes of seafood for a value of $351 million.
Of the commercial landings\(^1\), 85 percent is contributed from lobster and snow crab. Oceans and Fisheries Canada (DFO) claims lobster as Canada’s most valuable seafood export with a reported commercial landing of 9,229 metric tonnes of live weight lobsters from the New Brunswick maritime region in 2014 (Fisheries and Oceans Canada 2017). New Brunswick is reportedly the second largest exporter of fish and seafood products in the country with 86 percent of the total export value of $1.4 billion in 2015 destined for the United States. Employment from the NB fisheries sector generated about 1,900 harvesting and 4,500 full time equivalent jobs in processing (Agriculture, Aquaculture and Fisheries 2015).

In Canada, the federal department of Fisheries and Oceans Canada (DFO) regulates inshore commercial fishing. The DFO allocates fishing rights that are spatially restricted to a single Lobster Fishing Area (LFA). LFA 36 is located in the coastal waters off the shores of Southwestern New Brunswick, the area in question for the study. LFA 36 runs from St. Martin’s, New Brunswick (just north of the port city of Saint John) to the US border, and includes Deer and Campobello Islands. While the number of active fishermen varies per season, by way of example there are 177 lobster fishing licences in LFA 36, in 2013 all of these were active (M. Recchia, personal communication, August 11, 2014). In addition to a limited entry through licensing, each license holder is limited to a maximum number of traps (or lobster pots) they are allowed to set and haul. For LFA 36, the maximum is set at 300 (Fisheries and Oceans

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\(^1\) Landings are defined by Fisheries and Oceans Canada “as the part of the catch that is put ashore” (http://www.dfo-mpo.gc.ca/stats/commercial/land-debarq-eng.htm).
Canada 2013). Each trap is tagged and numbered so that all traps can be identified to their respective license holder.

Figure 2: Map Fisheries and Oceans Assigned LFAs in Bay of Fundy Regions (Fisheries and Oceans 1998)

2.1.2 Salmonid Finfish Aquaculture Industry in Southwestern New Brunswick

In the 1970s, because of their natural ecosystem characteristics, the coastal waters off Southwestern New Brunswick provided early Atlantic salmon (*Salmo salar*) aquaculture enthusiasts with promising prospects for the development of a finfish aquaculture industry (Walter 2007).

Despite initial reservations on the part of federal and provincial governments, limited physical resources and the lack of expertise from both scientific and local knowledge, by the mid to late 1980s, aquaculture development in the southwestern New Brunswick region had gained the respect of the international aquaculture industry (Anderson 2007). Finfish aquaculture in the region started out as a small experimental industry for supplementing or providing an alternative income for locals. After a few
rough starts, the industry grew exponentially and began attracting support from both provincial and federal governments, particularly with its promise of local economic prosperity (Agriculture, Aquaculture and Fisheries 2010; Gardner and MacAskill 2010). This support for the industry is reflected in policy and legislation as well as ever-increasing financial support. The first aquaculture loan granted by the provincial New Brunswick Development Loan Board was issued in 1981 for the amount of $660,000 to Marine Products Ltd., one of the first companies in the area. Today aquaculture grants range in the millions of dollars supporting industry growth and development in research and technology, employment development and business expansion opportunities (Fish Site News 2016).

Unlike the commercial fisheries, the Aquaculture industry is regulated by both provincial and federal legislation. Site licenses are issued under the province of New Brunswick *Aquaculture Act*, RSNB 2011, c 112, a statute under the provincial ministry of Agriculture, Aquaculture and Fisheries. Aquaculture activities however, are subject to the federal *Aquaculture Activities Regulations*, SOR/2015-177 which falls under the *Fisheries Act*, RSC, 1985, c F-14 administered by the Ministry of Fisheries and Oceans Canada (DF0).

With a total area of 1725 hectares leased to salmon sites, the farm gate estimate for 2015 for salmon was 155.1 million dollars (Agriculture, Aquaculture and Fisheries, 2015 *Aquaculture Sector Review*, accessed May 4, 2017.) Site licenses are granted within, and the cycle of production is regulated through, Aquaculture Bay Management Areas (ABMAs). Three ABMAs subdivide the waters of LFA 36; including ABMA 1, ABMA 2a and ABMA 3a (see Figure 2.3). The number of aquaculture sites has
fluctuated over the years. In 2015, 91 salmon aquaculture sites were licensed in total for the province of NB (Agriculture, Aquaculture and Fisheries, *2015 Aquaculture Sector Review*, accessed May 4, 2017), a slight decrease from 2007, when 94 aquaculture sites existed in southwestern New Brunswick, 66 of which were located within ABMA 1, 2a and 3a (Chang et al. 2007). The province identifies the town of St. George (adjacent to LFA 36) as “the industry hub” for the province (Agriculture, Aquaculture and Fisheries 2017).

![Map Aquaculture Bay Management Areas SWNB (Curtis Maillet et al. 2017)](image)

**Figure 2:3 Map Aquaculture Bay Management Areas SWNB (Curtis Maillet et al. 2017)**

In 2015, salmon composed 96.1% of the total volume of aquaculture production in NB and 95.4% of the total 162.5 million dollar aquaculture industry with almost all salmon exports from NB being sold to the United States. During the same year, the aquaculture industry in New Brunswick provided 980 full-time equivalent primary industry positions and 730 in processing (Agriculture, Aquaculture and Fisheries 2015a).
2.1.3 Access Conflicts

Given employment and contributions to the prosperity of the rural communities of southwestern New Brunswick, both the lobster fishery and salmon aquaculture have much to offer to the region. With both industries competing for the same ocean space however, challenges have existed since the aquaculture open pens were first placed in the Bay.

Both the manner of introduction and the rapid growth of aquaculture in SWNB have had impacts on coastal resources and their users. These impacts range from the subtle, such as the gradual displacement of fishermen’s access to traditional fishing grounds (forcing fishermen to go further offshore at increased expense and risk), to the blatant, as when the ‘largest vertically integrated independent salmon farming company in North America’ (Cooke Aquaculture 2017) was fined for ‘depositing a substance that is harmful to fish into fish-bearing water’, under section 36(3) of the Canadian Fisheries Act, RSC, 1985, c F-14 (CBC News 2013). These impacts and their uncertain outcomes have resulted in risk identification efforts among fishermen and other resource users and coastal community members. Risk mitigation calls for sound scientific research to support informed management decisions and policy outcomes that will allow for competing industries to co-exist in a manner that will ensure both the health of multiple industries and the environment.

2.1.4 Risk Perceptions – The Link Between Risk Assessment & Increasing Conflict

Throughout Canada, the introduction of open net salmon aquaculture into marine near shore spaces has generated conflict (Young and Matthews 2010; Loucks et al.
With different interests at stake, different stakeholders have different perceptions of the risks associated with this introduction. Fishermen have presented concerns about the potential harm caused to lobsters throughout their life cycle when located near aquaculture cages. Left over feed waste and detritus, medical treatment effluent and various husbandry practices have all been identified as risks. Fish farmers, on the other hand, have held steadfast that the effects are minimal, citing industry research work showing, for example, rapid dispersal of pharmaceuticals to non-toxic levels (Strain and Hargrave 2005). Still other scientists studying animal biology and ecosystem development have called attention to the number of unknowns including the spatial and temporal distribution of lobster around aquaculture sites and the vulnerabilities during different stages of the lobster life cycle (Loucks et al. 2014). Research work that takes into consideration these differing perceptions of risks and uncertainties could provide informed knowledge on which to base assessments of perceived risks and identify potential mitigation measures.

2.2 The Incident

The largest incident to draw attention to the potential threat a growing aquaculture industry presents to the SWNB commercial lobster fishery occurred in November 2009. Fishermen and community members had long raised their concern about the aquaculture practice of adding pesticides directly to the water, where it has the potential to affect the environment and non-targeted species (Page and Burridge 2014; Burridge et al. 2010). Their concerns however, were ignored until early in the 2009 November fishing season, when hundreds of dead and dying lobsters were hauled up in
traps. Extensive media attention from CBC, the national news carrier, included speaking to a variety of stakeholders and quoting community members. For example, David Thompson, an environmentalist, summarized local suspicions about how pesticides toxic to lobster entered the water; “Public feeling is that it probably originated at salmon farm sites, with people attempting to control a very serious problem they had with sea lice” (CBC News 2010a).

Subsequent investigations by the federal ministry Environment Canada revealed that:

The test results registered the presence of [C]ypermethrin in significant concentration levels in salmon samples collected from a number of aquaculture sites owned and operated by Kelly Cove Salmon…(CBC News 2013).

The use of the synthetic insecticide Cypermethrin is illegal in Canada. Its use, however, is permitted elsewhere (CBC News 2010b) and it was reportedly purchased by Canadian operators from outlets in the adjacent US state of Maine (SouthcoastTODAY.ca 2014). Environment Canada conducted four investigations in the region and detectable levels of Cypermethrin were found at two additional aquaculture sites in southwest New Brunswick beyond the original identified area (CBC News 2010)

Salmon louse, Lepeophtheirus salmonis, a parasite that attaches itself to and feeds on salmon, has historically been a significant threat to the aquaculture industry. A member of the copepod family, sea louse occur naturally in the wild causing minimal harm; however, they can be extremely destructive in the dense environment of open pen aquaculture. A recent media report noted that:

Lepeophtheirus salmonis, or the common salmon louse, now infests nearly half of Scotland’s salmon farms. Last year lice killed thousands of tonnes of
farmed fish, caused skin lesions and secondary infections in millions more, and cost the Scottish industry alone around £300m in trying to control them (The Guardian 2017).

Although Cypermethrin is used in some countries to treat sea lice it is also known to be harmful to numerous species and thus is prohibited for use in Canada. During the 2009/2010 Environment Canada investigation, CBC reported Maria Recchia, Executive Director of the Fundy North Fishermen’s Association as saying: “We know it's toxic to all crustaceans and that's a problem not only for our fisheries but for the environment” (CBC News 2010b).

Although initially denying all culpability (CBC News 2010a), the aquaculture company at fault eventually did plead guilty to two of the charges made against them (Queen v Kelly Cove Salmon Ltd. (26 April 2013), St. Stephen 03043904 (NBPC). The time from incident to the guilty plea took over three years, but the penalties imposed were some of the largest ever given in New Brunswick for violations under the federal Fisheries Act, RSC, 1985, c F-14.

A New Brunswick aquaculture company has been ordered to pay $500,000 after pleading guilty to two charges in connection with the deaths of hundreds of lobsters in the Bay of Fundy from an illegal pesticide about three years ago.....And "it's in the top three fines in Canada," said Robert Robichaud, regional operations manager for the environmental enforcement division in New Brunswick. "We feel that it will definitely send strong message, not only to the aquaculture sector, but to other marine users, that the illegal use of pesticides is simply not tolerable" (CBC News 2013).

The 2009 incident and its subsequent investigations, charges, denials and eventual guilty plea provide an excellent example of conflicting stakeholders’ interests with respect to SWNB ocean access and management. Competing industries operating within their own needs and demands hampers the potential for trust between shared
resource users and highlights how complex joint risk assessment and resource management efforts can be.

2.3 Listening to the Fishermen of LFA 36

In 2011, the participatory action research report *Fishermen’s On-the-Water Observations Aquaculture-Traditional Fishery Interactions Southwest New Brunswick 2011* was released, followed by the related 2012 publication by Wiber, Young and Wilson. This research was conducted by members of the Coastal Community Research Alliance (CURA), and was in response to the 2009 Cypermethrin incident as well as other observations made by fishermen involving the lobster, herring, scallop, and sea urchin fisheries and significant environmental changes around aquaculture sites in Southwestern New Brunswick.

This body of work was important because it drew attention to the significant need for comprehensive research work examining the interactions and potential risks between the aquaculture industry and fisheries in the area. In particular, it emphasized the necessity for an integrated resource management approach that includes the knowledge sets of not only the industry and scientific experts but also the experiential expertise held by fishermen.

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2 Funded by the Social Sciences and Humanities Research Council of Canada (SSHRC), the Coastal Community University Research Alliance (CURA) was a six-year project (2006-2012) that built knowledge and capacity, across the Maritimes for increased community involvement in coastal resource management. Partners in the Coastal CURA included First Nations communities, fishery-related organizations and academics. See [www.coatalcura.ca](http://www.coatalcura.ca) for more information.
2.3.1 Risk Assessment Project

In 2014, responding to the need for stakeholder inclusive research, a multi-year joint fishermen scientist project was established and funded through the Social Sciences and Humanities Research Council of Canada (SSHRC) Insight Grant led by principle investigator Dr. Melanie Wiber, of the Department of Anthropology, the University of New Brunswick. The project, *An Ethnographic Study of Risk Assessment in Coastal Management: Resource Sustainability and Community Resilience* (hereafter Risk Assessment Project) is divided into four interrelated projects considering both fishermen and scientist assessments of risk in areas of immediate concern for the waters of Southwestern New Brunswick, including: 1) knowledge co-construction towards potential risks from the co-location of salmon aquaculture in traditional lobster fishing grounds; 2) risks arising from tidal power development; 3) the role spatial mapping might contribute to marine debris mitigation, and 4) an ethnography of marine science perceptions of risk. It is the first sub-project that is of particular interest to my dissertation work. Specifically, the aquaculture project goals were two fold: to examine the co-production of knowledge (Murray et al. 2008) processes during interactions between fishermen and scientists as they jointly developed and conducted a natural science project examining the potential impact of aquaculture on the health of lobster

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3 Changes to benthic community habitat, species distribution, elevated sulphite levels, and impacts of pesticides and effluents represent risks to species diversity including commercial species. A decrease in the abundance of commercial fishing grounds results in economic loss to fishermen.
stocks in SWNB, and to apply this examination towards developing an understanding of the potential contribution of knowledge co-construction in risk assessment.

2.3.2 The Berried Female Abundance Project

In 2014, similar to the Risk Assessment Project, the Fundy North Fishermen’s Association (FNFA) also began an industry led research initiative in response to the call for joint stakeholder research from Wiber, Young and Wilson (2012). The FNFA, a fishermen’s association representing members of the small-scale commercial fisheries of LFA 36 and Saint John and Magaguadavic River systems, secured funding from the Atlantic Lobster Sustainability Foundation (Fundy North Fishermen’s Association 2014) to begin a scientific research study on egg bearing females (also known as berried females, ovigerous females) lobster abundance in relation to their proximity to salmon farming activity in the SWNB region of the Bay of Fundy.

This Berried Female Abundance Project (hereafter the Abundance Project), initiated by the FNFA’s Executive Director Maria Recchia, became the central piece for the aquaculture component of the Risk Assessment Project. Together, principle investigator Dr. Melanie Wiber and co-investigators Maria Recchia and Dr. Remy Rochette, Department of Biology, of the University of New Brunswick became the three study leads. The Abundance Project research team, composed of local fishermen, subject area scientists and students, worked together through the exchange of knowledge and set out to co-develop and implement a research protocol. Due to reasons that will be examined later, the Aquaculture Industry was not involved in the berried female abundance project.
2.3.3 Project Protocol Study – Studying Co-Construction of Knowledge

Similar to earlier work on joint stakeholder participation in research projects examining fisheries resources, the focus of the Abundance Project is on the stakeholders’ needs and interests in relation to aquaculture site locations for the lobster fishery (Carlberg 2005; Young & Matthews 2010). This dissertation will focus on the knowledge that individual stakeholders brought to the project’s protocol development and design; moreover, the knowledge itself will be examined as an actor, similar to the other stakeholders, in the research project equation. Therefore, the scientific results and analytical conclusions of the Berried Female Abundance Project will not be presented in this work. Instead this is a study of the Abundance Project protocol itself and specifically the exchange of knowledge sets between fishers and scientists (Figure 2.4).

Figure 2:4 Project Protocol Study Structure
Figure 2.5 below represents the potential stakeholders who theoretically might have contributed to the Berried Female Abundance Project and highlights those who did come together to exchange knowledge for the project.

![Figure 2.5 Knowledge Exchange Between Abundance Project Participants](image)

As I will outline in the next chapter, this Protocol Study is prefaced on the extensive body of research from a variety of disciplines, which argues for the inclusion of multiple knowledge sets using diverse approaches to enhance information and knowledge building (Lyons et al. 2014; Johnson & McCay 2012, Ommer et al. 2012; Ballard & Belsky 2010; Johnson & van Densen 2007; Jasanoff 2003; Irwin & Wynne 1996; Wynne 1992; Kloppenburg 1991). The outcome from such inclusion is said to be more robust research allowing for informed risk management and resource management decision-making. My hypothesis proposes that to conduct this much-needed co-construction of knowledge we must first understand what is meant by knowledge when
we speak to knowledge co-construction. Therefore, using a case study example of knowledge co-construction, my work will present an action oriented definition of knowledge, in turn this definition can serve as a toolkit to facilitate a better understanding of knowledge co-construction for decision making.
3. Theory

3.1. Introduction

This chapter will present a brief review of key theoretical works that give structure to the central focus of this dissertation, that is, an examination of knowledge co-construction when different social worlds or holders of different knowledge sets are brought together to address a research problem. The chapter will begin with work that speaks to the role of risk in fisheries resource management, both as it has been more traditionally understood as well as some alternative understandings of risk. Second, arguments examining the role of knowledge in risk management are presented followed by works that speak to the need for the inclusion of multiple knowledge sets for the co-construction of new knowledge, inclusive of Collins and Evans (2002) definition of ‘expertise’. Literature describing and comparing the two-principle knowledge sets of this research study, natural science and local ecological knowledge, will then be presented, exploring both their differences and similarities. Finally, the chapter will conclude with an overview of the seminal boundary object work of Star and Griesemer (1989) and a review of trading zones (e.g. Collins, Evans & Gorman 2010), both of which provide insight on how differing existing knowledge sets can be brought together for the co-construction of new knowledge. The chapter will conclude by pointing out the lacunae that exists in this literature with respect to defining knowledge.

3.2 Risk and Fisheries Management

The overwhelming and “spectacular resource crises” (Stephenson & Lane 1998:1) of the Canadian fisheries in the 1990s forced fisheries managers to re-examine
their approach to decision making in fisheries management. Specifically, managers were forced to move beyond population management for maximum sustainable yield in order to address the reality of the multiple factors influencing fisheries resources such as socio-economics, operational logistics and environmental and conservation considerations.

One approach to addressing the multiplicity of factors is through the adoption of a ‘decision analysis’ or ‘risk analysis’ approach as proposed by Stephenson and Lane (1998:1). Risk, defined by the authors as “occurrences beyond our control that may have undesirable consequences” (Stephenson & Lane 1998:1) speaks to the uncertainty of potential outcomes, desirable and undesirable, whose occurrence must be taken into consideration when weighing out and examining decision options. A decision analysis approach as proposed by Stephenson and Lane (1998) is a three-step process that: 1) establishes bureaucratic objectives and values, 2) undertakes scientific assessment of the level of risk to these objectives, and 3) formulates potential managerial responses.

Beck (1992, 1998, 2006) however, has been highly critical of such approaches, arguing that:

Risk …is a socially constructed phenomenon, in which some people have a greater capacity to define risk than others…Risk definition, essentially, is a power game (Beck 2006:332-333).

For Beck (1992:21), risk is the outcome of ‘modernization itself’ and therefore exceeds the capacity of the very institutions (science, state, business) that should manage it (Beck 2006).

Beck speaks to the fundamental shift that began to take place within industrial society during the mid-twentieth century (Beck 1992). Society, Beck (1992) argues,
slowly became aware of the risks associated with an increasing focus on technological production of material goods and services. Many of the risks identified were the results of human decision-making and held impacts that would reach beyond national boundaries, particularly threatening wider social ecological systems. ‘Risk society’ results in what few would ever want: "the self-endangering, devastating industrial destruction of nature" (Fisher 2000:49). The nature and scale of risks have also been shifting; risks no longer have foreseeable boundaries. Not so long ago ‘preparations’ could be made for identified risks, for example such as a coal mining disaster and the lives, the community, and industry that would be impacted in the event of such a disaster. Today, there are no means to foresee the range of potential outcomes. One example is the 2011 earthquake off the coast of Japan, which resulted in a tsunami impacting the Fukushima Daiichi Nuclear Power Plant, leading to chain of nuclear accidents which caused death, injury, displacement and health threats for hundreds of thousands of people (see Jasanoff 2003). Such risks as those posed by nuclear power are often exported to those who are most vulnerable and who will bear the cost of negative outcomes (Beck 1992). Administrative responses once deemed appropriate in addressing risk can no longer respond to “modern catastrophes”. Additionally, determining accountability, causality and/or liability of risks falls increasingly to the victims who have few resources at their disposal compared to those who are actually responsible for the disastrous outcomes (Beck 1992).

Similarly, Boholm (2003) challenges a risk analysis approach on the basis of a lack of a shared understanding of risk. Risk as defined by Boholm (2003) can be understood “as the statistical probability of an outcome, combined with severity of the
effect…” (Boholm 2003:160). She further divides risk into two types: 1) “objective risk” based on scientific values and concerns or “the phenomena and causality in the natural world that can have harmful effects”, and 2) “subjective risk” based on local values and concerns or people’s ability to “understand and judge risk in terms of emic, locally, defined, values and concerns” (Boholm 2003:161). This distinction between types of risk comes from two fundamentally different perceptions of risk. In turn, these differing perceptions mean there is conflict over what is acceptable with respect to the resulting policies, regulations and mitigation measures necessary for risk management. Perceptions of risk are different because the perceptions of potential harm are dissimilar between stakeholders. For example, the introduction of open net salmon aquaculture into the coastal zones of SWNB has generated just such conflict (Grant et al. 2016; Loucks et al. 2014; Young & Matthews 2011). With its many near-shore stakeholders (fishing, aquaculture, petrochemical, shipping, tourism, etc.) invested in marine access, what one group sees as potentially harmful, another may not.

### 3.3 The Role of Knowledge in Risk Management

With the unprecedented increase in scale and temporality of risks, our need to understand risks has been equally compounded. Knowledge is needed to understand and manage risk and much of the information provided has routinely come from scientific and technological expertise. From nuclear fallout to plastics in the ocean, society has turned to science and technology for solutions (Beck 2006). We have grown increasingly dependent on the very same knowledge institutions that have significantly contributed to the risks in the first place.
Western scientific and technological knowledge has long been presented as the information source, the unquestioned “expertise” that has been left unchallenged. In addition, scientific expertise is often locked in disciplinary silos, with resulting difficulties in cross communication (Star 1993, 2002, 2010; Star & Griesemer 1989). The result is that scientific expertise is held in isolation leading to simplified and misleading models of natural phenomena that in turn obfuscate risk.

Efforts to identify the distinct uniqueness of scientific knowledge, i.e. the ‘problem of demarcation’ (Gieryn 1983) have a long history. From Comte’s positivist science in the mid-1800s, to Popper’s criteria for falsification in the 1960s, to Merton’s 1970s identification of scientific norms such as rationality, neutrality, universalism, and organized skepticism, scientific knowledge has been described by Weber (1918) and other scholars (e.g. Kuhn 1962; Traweek 1992) as not only a type of knowledge but also as a set of cultural values. These perceived values assigned to science are fundamental to the special status that has been given to its knowledge set (Yearley 2008). These values have provided dominant social institutions with a methodology for both obtaining scientific knowledge and simultaneously excluding knowledge that may be held outside of the scientific community. Systematic exclusion of other knowledge sets has been done by placing requirements on knowledge holders to assume particular social, relational and behavioral values, by dismissing knowledge held by specialists outside of science, by dismissing the concerns expressed about scientific knowledge as irrational and finally, by reinforcing a need for the public to be protected from its own ignorance (Wynne 1996).
Within the ‘risk society’ however, this approach of using a sole knowledge source to inform risk is no longer acceptable. Problem solving can no longer remain apathetic, ignoring the societal and political environments in which potential threats occur. The reality is that problems are framed with factual uncertainty, are value laden, carry high risks and have short turn-around times for decision-making (Funtowicz & Ravetz 1993). Funtowicz and Ravetz (1993) propose a new science that could work within this uncertainty; post-normal science, as an alternative method of developing scientific knowledge, addresses the problems of uncertainty, quality and values. Building on Kuhn’s ‘normal science’, a post-normal science measures the quality of the scientific information and includes a quality assurance approach that takes into consideration the knowledge sets from extended peer communities of all stakeholders (Dixon 2016). Funtowicz and Ravetz (1993) argue that post-normal science requires better communication across scientific disciplinary silos, as well as across the science/experience-based knowledge divide.

In support of this approach both Fischer (2005) and Jasanoff (2003) also argue that better risk management can be achieved by opening up the “cultural rationality” of risk (Fischer 2005:55) and examining the qualitative circumstances under which risk is identified.

The inclusion of alternative knowledge sets such as experience-based expertise or experiential knowledge of laypersons and stakeholders can be used as an alternative to relying solely on science and technology to address risk (which only serves to proliferate their status and authority) (Carolan 2006, Brattland 2013, Linke and Jentoft 2014). The literature argues for the opportunity to increase the democracy of science
and technology by including alternative ways of knowing that will enable a participatory, political conscious form of science, allowing society to be self-critical, or reflexive, of science and technology practices: a “reflexive modernity” (Beck et al. 2003).

Democratization of science will occur through processes that allow for stakeholder inclusion (Fischer 2000; Wynne 2005) and the establishing of institutions that are inclusive of a wider diversity of knowledge (Jasanoff 2003). A political understanding of risk, enriched by experience-based knowledge can result in the co-production of knowledge, providing knowledge that offers a more rounded understanding of the situation at hand (Fisher 2005, Wynne 1996), facilitating better decision making and resource management.

3.4 Inclusion of Alternative Knowledges

The idea of knowledge co-construction has subsequently taken hold in numerous disciplines, including; anthropology (Ommer et al. 2012), sociology (Kloppenburg 1991), environmental management (Ballard & Belsky 2010; Raymond et al. 2010), and science and technology studies (Johnson & McCay 2012; Jasanoff 2003; Irwin & Wynne 1996; Wynne 1992). Often these efforts are through forms of citizen science (Irwin 2002), participatory research (Fortmann 2008) or co-management efforts (Lyons et al. 2014). Literature surrounding citizen engagement indicates that while both scientific and experiential ecological knowledge are valuable, that value increases when they are used in tandem (Wynne 1989). Therefore, resource managers and users are adapting and seeking new methods to facilitate multiple stakeholder engagement and
knowledge sharing in management processes and decision-making. As stakeholder engagement and public participation increasingly gains acceptance, there is increasing demand for stakeholders to contribute their experiential knowledge jointly with the knowledge of academic and research scientists to feed into public policy and resource governance.

In marine management, such knowledge inclusivity has been intrinsic to more participatory governance structures, including co-management (Pinkerton 1989) and integrated coastal management (Cicin-Sain & Neckt 1998; Berkes et al. 2000; Wiber et al. 2009; Bigney et al. 2012). The opportunities however, for alternative knowledge inclusion on their own are still not sufficient. Problems continue to exist both at the level of alternative knowledge inclusion and its translation into policy (Finlayson 1994; Irwin 2002; Hind 2015; Verweij, van Densen & Mol 2010; Stephenson et al. 2016). Stakeholder knowledge appears devalued, overlooked or ignored in comparison to the knowledge provided by the scientific community (Leach, Scoones & Wynne 2005). A lack of equality in knowledge inclusion may be indicative of a larger systemic problem for knowledge co-construction.

Examining the co-production of knowledge in relation to sustainable agriculture and science, Carolan (2006) summarizes Collins and Evans (2002) formative work on specialist expertise into a tripartite model for studying the sharing of expertise or knowledge between multiple knowledge holders who have been brought together for problem solving.
Level one – At the ubiquitous tacit level, there is no actual knowledge exchanged between participants; only a limited amount of communication is conducted through observation and general conversation.

Level two – Interactional expertise involves enough exchange of expertise between actors to enable a basic understanding of the topic in question and to help inform collective decisions. Subject knowledge at this level may be broad and general or more local and practical and “interactions occur to the extent that all participants leave the process cognitively altered” (Carolan 2006:423).

Level three – Contributory expertise involves enough exchange of expertise that participants have the capacity to contribute to the field of knowledge. Individual contributions at this level can be either at a general and abstract level or on a more local and practical knowledge level.

Knowledge exchanged at the first level, ubiquitous tacit knowledge, can provide a basic level of generalized subject information such as you might find in a Wikipedia search. Conversely the third level of contributory expertise speaks to the exchange of knowledge that occurs between practicing experts in the same area of knowledge work (e.g. scientist to scientist or fisher to fisher). Interactional expertise however, exists somewhere between these two levels. Here, participants hold more than a simple generalized understanding of a subject but are certainly not practicing professionals in a particular field. They have vested enough effort to gain a type of expertise that means an increased use of a subject matter’s technical language (Galison 2010) and enough knowledge exchanged on the subject that individuals can speak meaningfully on the topic with some level of comprehension (Collins & Evans 2002).
At an interactional level of expertise, participants in a collective problem solving process can co-construct new ways of knowing or knowledge because they are able to engage in meaningful exchange of their expertise (Galison 2010). In resource co-management regimes, success lies in the group’s ability to generate and use knowledge (Berkes 2009). I would argue that it is interactional expertise that provides for the ability of researchers, scientists, resource users and community stakeholders to work together for the co-construction of locally relevant knowledge that neither party can produce alone (Berkes 2009; Davidson-Hunt & O’Flaherty 2007).

When examining resource management in Canada’s East Coast fisheries for an interactional level of exchange of expertise, it is clear that while many legislative inclusive opportunities allow for stakeholders (e.g. fishers, coastal communities, fisheries scientists) to contribute their expertise, there is minimal evidence of cognitive exchange facilitating the co-construction of new knowledge to assist in the navigating of the necessary decision making and policy making for resource governance.

In SWNB, opportunities for knowledge or exchange of expertise are most often between the scientific knowledge held by natural and social scientists working in the region and the knowledge set or expertise held by fishers or fishermen of SWNB within local ecological knowledge (LEK). While LEK relates to the resources, living organisms and systems, and their direct interaction with each other and their physical environment (Olsson, Folke & Berkes 2004) (i.e. the information, data, and experiences of the fishers of SWNB), the resulting resource management decisions often appear to be dominated by scientific knowledge. Scientific knowledge is seen as the primary and often sole information source for both fisheries policy and decision making, holding a
position of privilege over other knowledge sets (E.g. the “best science available” from DFO⁴). In the exchange process that is needed for knowledge co-construction (i.e. the collaborative process of joining diverse knowledge sets with others to build new knowledge) however, it is not relevant where the information or knowledge originates, from fishers or scientists (Agrawal 1995), only that the knowledge has been contributed, contextualized and combined with local observations so that the knowledge can facilitate management practices that are constantly reevaluated and reshaped for amelioration (Olsson et al. 2004).

3.5 Knowledge Sets: Science and LEK

In an effort to address the disconnect between the identified need for the co-construction of knowledge for informed resource policies and decisions and its failure to materialize, many authors have explored local and scientific knowledge in greater detail. In particular, they have taken to describing knowledge sets through comparison analysis, by comparing and contrasting what science and local knowledge are and are not.

Corburn (2003) defines local knowledge as being distinctively unbound by professional techniques and reliant instead on “common sense, causal empiricism, or thoughtful speculation and analysis” (Lindblom & Cohen 1979:12), as well as being “practical, collective and strongly rooted in a particular place” (as attributed to Geertz

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1983\textsuperscript{5}). Indirectly, using the Mertonian norms often assigned to scientific knowledge, Corburn (2003) listed distinctions between it and local knowledge. In comparison to the claim that scientific knowledge is shared extensively among its knowledge community (the so-called “universality” of science), the author stated that local knowledge will be specific to the geographic region and the knowledge will be unique to its members. The distinct processes and methods used for evidence gathering of scientific knowledge are said to stand in contrast to the accumulation of local knowledge gained from life experiences through culture, social institutions, and hands-on experiences. Local knowledge is defined as both accessible and tacit. Comparatively, scientific knowledge is built on the analysis of cause and effect, and methodical experimentation. Corburn (2003) attributes local knowledge to direct personal and observed experiences of community members and its validation is through public scrutiny from the community, while in comparison, scientific knowledge is validated by a jury of its knowledge peers. Local knowledge provides clarity to problem solving because unlike scientific knowledge, it does not aggregate observations into lump sums, removing the heterogeneity of individual experiences. It moves beyond cause and effect, and people can relate to the experiences and the knowledge (Corburn 2003).

\textsuperscript{5} This definition is repeatedly cited and attributed to Geertz, Clifford. 1983. Local Knowledge: Further Essays in Interpretive Anthropology. USA: Basic Books, Inc. page 73, yet I can find no such definition on this page or in this particular work. As this definition is used consistently throughout scholarly literature on the subject its absence here would be conspicuous.
The 2000-2006 project, Linking Science and Local Knowledge⁶, which specifically addresses fisheries local and scientific knowledge, provides an additional example of a local vs. scientific knowledge set comparison (Ng’ang’ et al. 2005). Local knowledge is described as being holistic in its approach to information gathering, paying little attention to a system’s constituent parts. In comparison, science is said to adopt a reductionist approach when examining nature, dividing knowledge into small manageable parts so these parts might be studied individually. Ng’ang’ et al. (2005) also suggest LEK has the ability to work around gaps in knowledge because of the extent of data collected over a long period of time. Having passed through many generations, LEK can be revised and updated along the way, with a multi-dimensional approach to understanding. In contrast, scientific knowledge is described as continuously collecting data, condensing it into compact parts through and for ongoing step-by-step study.

Agrawal (1995) drew attention not only the perceived difference between scientific and local knowledge, but, perhaps more importantly, to the similarities. Agrawal spoke to three points that commonly separate indigenous and or local knowledge and science. First, an assumption is made that indigenous knowledge subject coverage focuses solely on the activities and matters of concern to the holder’s local livelihood. So great is this livelihood focus, that there is supposedly no capacity to participate in abstract thought and the development of ideologies and philosophical thinking. In comparison, science is thought to lack the capacity to take into account the

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⁶ A joint SSHRC and DFO funded Ocean Management Research Network (OMRN).
day-to-day activities of life and functions, since it operates at a higher detached level, a trait perceived as more desirable in rational problem solving. Indigenous knowledge however, has clearly contributed to both abstract and innovative thought as well as ideological development, while science and its related technologies are present in almost every day-to-day western activity (Agrawal 1995). Secondly, the two knowledges are said to use distinct methodologies and ways of knowing. While science has long been identified with the systematic, objective and analytical approaches, indigenous or local knowledge is described as being a way of “common sense” knowing. As noted by Agrawal (and previously in this chapter), however, the philosophy of science literature has long struggled to establish a clear divide between the methods of science and non-science. Finally, there is a misplaced belief that there is a contextual distinction between local and scientific; that is, that local knowledge developed within an identifiable context or ‘setting’ coming from the people who are living, experiencing and interpreting the knowledge. Science, on the other hand, is said to remain neutral or uninfluenced by the social, political and cultural context in which it is generated. In reality, knowledge is never immune to social, political and human influences. In fact, the more effort made to identify the differences between the two knowledge sets, the more it appears they have in common; unique characteristics thought to be distinct for each can be challenged in reality or shared by both (Gieryn 1983).

These three representative examples are only a few of the vast body of work covering both the qualities and characteristics of local ecological knowledge and scientific knowledge, but they indirectly highlight what is not addressed, the matter of these knowledge sets coming together for knowledge co-construction. While we may
find insight from a study of the similarities and differences of LEK and scientific knowledge, little is offered in terms of what is necessary for co-construction of knowledge.

A second identifiable gap lies in the dichotomous nature of the literature. That is to say much of the literature speaks to only two knowledge sets, perhaps leading to misconceptions that specific knowledge types are limited to specific knowledge content. For example, a fisher’s knowledge goes far beyond the details and skills needed to catch a particular species of fish. Local ecological knowledge requires an understanding of the interactivity between the complex social and ecological systems at play. For example, LEK draws on temporal and scalar information, regional history, technological information, species knowledge, and market, as well as governance and regulatory understanding (for example, see Wiber et al. 2012). To remain relevant, knowledge content must adapt and adopt new and relevant information; this knowledge elasticity is not exclusive to fishers but can be applied to all resource stakeholders (e.g. fisheries processors, non-government organizations, etc.) (Ommer et al. 2012). Fisheries sciences will also be composed of a complexity of subject disciplines inclusive of such diverse fields as population ecology, chemistry and geophysics. Recognition of the complexity of information, data and knowledge that make up knowledge sets illuminates the range and difficulty faced when social worlds are brought together in an effort to create new knowledge.
3.6 Bringing Knowledge Together - Boundary Objects & Trading Zones

To explore the processes and development of co-construction of knowledge between stakeholders’ groups, it is helpful to turn to a body of work found in the social studies of sciences examining knowledge exchange. Work in this area examines the exchange of expertise between social worlds, in particular the exchange of knowledge between experts holding diverse knowledge sets such as the knowledge from a variety of scientific disciplines on one topic area or the exchange of knowledge between different stakeholder groups holding different knowledge sets. The work of Star (2010, 1989), Star and Griesemer (1989) and Bowker and Star (1999) on the use of ‘boundary objects’ provides insight into how exchanges take place between social worlds while the work of Galison (2010) and Collins, Evans and Gorman (2007) addresses the concept of ‘trading zones’, which speak to the power struggles between knowledge holders during knowledge exchange.

3.6.1 Boundary Objects

Star and Griesemer (1989) identified that for scientific work or the co-construction of knowledge to occur between social worlds, there is a need for those worlds to be able to contribute their heterogeneous knowledge sets at the same time that they maintain cooperation between the worlds. It is argued that together, sharing and cooperation can ensure that information is able to hold “integrity across time, space and local contingencies” (Star & Griesemer 1989:387). Central to their arguments for the success of intersectional work is the emergence of boundary objects. Star and Greisemer (1989:393) define boundary objects as:
… objects which are both plastic enough to adapt to local needs and the constraints of several parties employing them, yet robust enough to maintain a common identity across sites. They are weakly structured in common use, and become strongly structured in individual-site use. These objects may be abstract or concrete. They have different meaning in different social worlds but their structure is common enough to more than one world to make them recognizable, a means of translation. The creation and management of boundary objects is a key process in developing and maintaining coherence across intersecting social worlds.

Boundary objects serve as points of common focus that exist in the space of understanding between groups with different viewpoints (Star 1993:103). By focusing on boundary objects as the common point of interest, actors who have come together to co-construct knowledge are able to collectively communicate and share knowledge around the boundary object while at the same time retaining their own individual perspectives and interpretations about the wider topic. In her later work Star defined a boundary object as:

…a sort of arrangement that allow different groups to work together without consensus…the forms this may take are not arbitrary… They are essentially organic infrastructures that have arisen due to “information needs” … “information and work requirements” (Star 2010:602).

In an environment without consensus, knowledge can only be successfully co-constructed where the development of boundary objects plays a key role between multiple knowledge sets: “[T]he creation and management of boundary objects is a key process in developing and maintaining coherence across intersecting communities” (Bowker & Star 1999:297). Boundary objects provide the crossroads for existing knowledge to be exchanged and for the co-production of additional knowledge. This argument is similar to that of Callon (1986) who uses an ‘interessement’ model focusing on the task of translation in forming networks. In contrast to ‘interessement’, which
serves more as a funnel pushing knowledge in the direction of ‘non-scientist to scientist’, boundary objects allow translation in multiple directions (Star 1993:101). All participants are able to cooperate in both the sharing of knowledge and its interpretation with limited risk of having to defend their individual views and interpretations.

In their 1989 work, Star and Griesemer elaborate on four non-exclusive types of boundary objects, the first of which are the repository boundary objects. These are venues such as libraries and museums that are able to give order to a wide assortment of unorganized materials. When individuals go to a public library with its vast collection of items and subject coverage, they are able to follow the order assigned to items and select, find and use the materials that are unique to their own interests.

Described as an ideal type, the second type of boundary object would include representations of places or things. Representations are materials that are not exact descriptions but offer enough depiction that social worlds are able to apply their own interpretations and meanings without hindering the interpretations of others. The example often given for representation boundary objects is that of maps or an atlas. These representations can be nebulous enough that they are not exact replications of any one understanding but they are accurate enough that people from various backgrounds consulting them are able to understand them. I think of the cartoon style ‘You Are Here’ tourists’ maps often handed out in hotel lobbies where iconic points of interest are disproportionately larger than the rest of the map scale or points of commercial interest.

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7 Although clearly stated to be non-exhaustive the four examples provided by the authors have come to dominate the lens through which boundary object arguments are made (Star 2010). I would argue our lack of extrapolation has been to our detriment.
are given far more space than those who have not paid for advertising. These guides are by no means accurate representations of the area yet diverse actors such as the vacationer, the visiting businessperson or the newcomer to the region is able to navigate their way to the beach, government offices, the museum or the mall.

The third type or *coincident* boundary objects are described by Star & Greisemer (1989:410) as “common objects which have the same boundaries but different internal contents”. The example given here is that of multi-purpose maps that depict one regional boundary but provide different information depending on the user. For example, although my local park has a set external boundary or perimeter, depending on your reason for accessing the park, where you look within the map or the legend will be different. As a dog walker, I do not look for the cross-country ski trails or only to the extent that I need to avoid them, but I do consult the trails for where and how (on lead/off lead) I may walk my dog. All users of the park however, regardless of our chosen activity cannot take those activities beyond the boundary of the park without potential city bylaw repercussions.

A fourth type of boundary object, *standardized forms*, allow for communication between social worlds. Standardized forms when complete enable multiple participants from diverse backgrounds to contribute information collectively in a consistent and homogenous way. These ‘immutable mobiles’ as described by Bruno Latour (1986) record information and hold it consistently over time and space. An increasing growth in citizen science has seen the willingness on the part of citizen participants to collect and share knowledge and observations such as environmental, health and natural science data. Through the use of forms or online websites an individual’s information can be
collected and added to a large aggregate data set such as the National Audubon Society’s Christmas Bird Count in a uniform manner.

Each of these four boundary object examples; repositories, representations, coincident and standardized forms exemplify key elements of the authors’ definition. They emphasize how, when used by the wider group, boundary objects may be ‘weakly structured’ yet become ‘strongly structured’ when used as the specific individual level (Star & Griesemer 1989). Boundary objects being both “abstract or concrete” (Star & Griesemer 1989:393), hold different meanings in different social worlds, yet they are still recognizable to more than one world, enabling them to serve as “a means of translation” (Star & Greisemer 1989:393) between social worlds. The ability to create and manage boundary objects is key to “developing and maintaining coherence across intersecting social worlds” (Star & Greisemer 1989:393). As groups work together, the processes they engage in create boundary objects, which in turn enable cooperation to increase and thereby, facilitate the success of the work.

In her later work, Star (2010) extrapolates on the architecture of boundary objects by reviewing three attributes that are essential to their functioning. Star (2010) acknowledges that the most noted and utilized aspect of boundary objects, that of interpretive flexibility or the ability of multiple groups to assign different meanings to an object based on their own use and interpretation while not taking away from meaning held by others, is the most widely held understanding of boundary objects. Star however, also highlighted two less examined aspects of boundary objects: work processes and arrangements (material/organizational structure of boundary objects) and, the ability to move “back-and-forth between the ill-structured and well-structured
aspects of the arrangements” (scale/granularity of boundary objects) (Star 2010:602-603).

3.6.2 Dynamic between ill and well-structured

These two later aspects of boundary objects, work processes, the ‘organic infrastructures’ that come from information needs, and, the scale or the placement of boundary objects within a specific time and place, the temporality of boundary objects (Star 2010), contribute to a key trait that goes against the traditional understanding of how collective work takes place. Boundary objects work because they lack consensus. Star (2010) points out that when boundary objects are organic and ill-structured, holding ‘just enough’ understanding between social worlds, they are functional; however, when they are forced to be well-structured, they lose their malleability and no longer work in the same way. Well-structured objects hold meanings that are rigid and constrained; once objects are homogenous there is no room for inclusion of other meanings. Boundary objects are most inclusive when groups are able to tack back and forth between ill and well-structured meanings. Star (2010:614) describes the power struggle that emerges to find that balance:

We live in a world where the battles and dramas between the formal and the informal, the ill structured and the well structured, the standardized and the wild, are being continuously fought.

3.6.3 Trading Zone

The power struggles between social worlds that are exchanging knowledge can be further understood through the literature that examines the idea of ‘trading zones’. Peter Galison (1997) first presented the term ‘trading zone’ in his in-depth examination
of metaphysics and the diversity of scientific cultures that participate in the production of data. Galison used the metaphor of the ‘trading zone’ to explain the exchange of information that is possible between fields of study with no common or shared methods of measurement. This metaphor uses the concept of trade between cultures or social groups to demonstrate how two seemingly dissimilar groups can successfully interact.

Two groups can agree on rules of exchange even if they ascribe utterly different significance to the objects being exchanged; they may even disagree on the meaning of the exchange process itself. Nonetheless, the trading partners can hammer out a local coordination despite vast global differences (Galison 1997:783, emphasis in original).

Together with various perspectives on what is being traded, trading partners are able to arrive at a shared meaning allowing them to work together. Galison (1997) uses this example to suggest that different communities of knowledge holders are able to develop ‘in-between’ vocabularies that allow them to communicate (see also Collins, Evans & Gorman 2010). In particular, Galison (1997) presented the argument for levels of language development or ‘interlanguages’ between sciences that may be as simple as shared “jargon”, through to “pidgin” or even a “creole” or the development of a new mixed language.

Building on Galison’s metaphor, Collins, Evans and Gorman (2007) defined trading zones as “locations in which communities with a deep problem of communication manage to communicate” (Collins, Evans & Gorman 2007:658). Collins, Evans and Gorman offer a two-dimensional model of trading zones that focuses on the use of both power and shared culture within a trading zone. Along the Y-axis is the level of power employed between those exchanging knowledge that ranges between coercion to collaboration. Along the X-axis is the blending of culture (or information or
knowledge up-take) ranging from homogeneity to heterogeneity. Social groups, the authors argue, may fall within four potential trading zones.

![Trading Zones Basic Model](image)

**Figure 3:1 Trading Zones Basic Model (based on Collins et al. 2007:659)**

The first, an *enforced* trading zone involves both coercion and no cultural exchange of knowledge, the most severe example being that of slavery where in order to survive individuals are coerced into accepting the culture imposed on them. The second trading zone type, *subversive*, involves the imposing of the culture of one social world on to another, but there exists a common or homogenous understanding between social worlds. Such is the reality within the world of technology where the Microsoft Window operating system application has come to dominate over other alternatives (Jenkins 2010). Users of alternative operating systems such as Mac and Linux are left with little choice but to adapt and find compatibility solutions. Third, an *interlanguage* trading zone describes a situation where there exist both collaboration and a homogeneous level
of understanding between social worlds, allowing for the development of new cultural tools such as academic disciplines (e.g. biochemistry, the joining of biology and chemistry for a new language). Finally, a fractionated trading zone represents a situation of collaborative exchange between social worlds of heterogeneous knowledge. The authors further subdivide fractionated trading zones into boundary objects which use material items for exchange in place of language, and interactional expertise trading zones which uses cultural language in the absence of material items (Collins et al. 2007, Jenkins 2010).

The defining of the boundary object trading zones speaks to the arguments made by Star (2010) and Star and Greisemer (1989). The usefulness of boundary objects lies in their ability to hold diverse meanings or a place of heterogeneous understanding between social worlds while at the same time being a space, or zone, for collaborative work. They are a place or space of give and take, a place for the tacking back and forth of knowledge exchange.

3.7 Conclusion

The literature presented in this chapter has served to provide an overview of significant works that speak to: the risk in resource management, the role of knowledge in risk management, the defining and comparison of science and local knowledge types, and the role of boundary objects and trading zones for facilitating an understanding of knowledge co-construction. Despite the richness of this literature, a problem exists in that these authors do not normally define knowledge itself. With the intention of applying and building on the above arguments, the following chapter will present the
research design and methodology used for this dissertation work. The focus of the study being to examine the processes of knowledge co-construction when different social worlds are brought together to identify a research problem and develop a research protocol to address a commonly held fisheries resource management problem.
4. Method

4.1 Introduction

The motivation for my research originated with fishermen sharing their concerns about their past experiences participating in joint fishermen and scientists research projects. During my graduate work with coastal communities and during previous employment opportunities, I had repeatedly heard first hand from fishermen about their frustrations and discouragement when participating in knowledge co-construction projects. Unfortunately, the sentiments I heard were by no means unique and are reflective of the feelings shared by many fishermen and coastal communities (Wiber 2012, Johnson & McCay 2012). These shared experiences raised questions for me about the nature of joint research work and the processes involved in knowledge co-construction. In particular, what did these personal experiences mean with respect to the success or failure of joint research and knowledge co-construction, often promoted as a means to encourage community involvement and provide the opportunities needed for stakeholder voices to be heard and knowledge contributed?

Several questions center around the processes that are involved when differing social worlds join together to exchange their individual knowledge sets and how that shared knowledge will be received or perceived by others. What happens during the exchange of knowledge between social worlds and is knowledge translated? How do social worlds bring their knowledge together to co-construct still more knowledge? These, and similar related points of inquiry stood out as in need of further study and examination. Therefore, the purpose of my work was to explore the process of multiple
social worlds, in this case fishermen and scientists, coming together to jointly co-construction knowledge on a matter of shared concern. I was able to ask the above questions and explore the processes of knowledge co-construction when I was granted the opportunity to assume the role of participant observer in the development of a natural science research project. In this role, I was able to track knowledge co-construction by following the design and implementation of a scientific research project. The project was tracked from the formation of the research question, to the development and design of the scientific protocol and on through to its implementation and actual fieldwork. The Berried Female Lobster Abundance Project (hereafter Abundance Project) sought to identify the likelihood of any deleterious impact on American lobster (*Homarus americanus*) as a result of the growing Atlantic salmon (*Salmo salar*) aquaculture industry in SWNB.

### 4.2 Research Method

#### 4.2.1 Research Questions

The two principal research questions for my study were: “How do stakeholders bring their differing knowledge sets together to contribute to knowledge co-construction and what are the factors that facilitate or block the co-construction of knowledge between social worlds?” To address these questions, it was necessary to adopt a research design that would allow for the identification, tracking and documenting of the processes involved in the co-construction of knowledge, therefore a qualitative research methodology was identified as the appropriate approach (Creswell 2003:21).
4.2.2 Qualitative Research

Qualitative research design offered the necessary opportunity to study fishermen and scientists in a ‘real life’ setting using a combination of field observation, personal interviews and document analysis for data collection. Additionally, a qualitative approach afforded the opportunity to include participant viewpoints into the study and to review the findings with participants (Gray 2004). Data collection strategies could also be modified appropriately to accommodate reality and the flexibility needed to ensure that the fishermen and scientists were able to participate throughout the length of the study.

4.2.3 Grounded Theory

Grounded theory was adopted as a research approach because of its provision for the study of complex phenomena. A socially constructed event can be investigated without the restriction of using a lens of what we already know about a topic (Jones & Alony 2011); that is, it allows for ‘thinking outside the box’. This lack of restrictions was appropriate to my planned research process as it provided me the opportunity to make a wide variety of observations, draw on a lot of different kinds of data, and thus gain new understanding of knowledge co-construction. As defined by Strauss & Corbin (1990:23), grounded theory is a theory that is:

…discovered, developed and provisionally verified through systematic data collection and analysis of data pertaining to that phenomenon. Therefore, data collection, analysis and theory stand in reciprocal relationship with each other.

Using a grounded theory approach, the emphasis was placed on the collection and analysis of data allowing the theory to emerge “grounded” in the data (Charmaz 2014).
Before proceeding it should be acknowledged that while a grounded theory approach was adopted for my study so that the data themselves determined the study’s focus (i.e. ‘the data could speak for themselves’), significant theoretical works and research literature relative to the co-construction of knowledge were previously consulted to inform both the study and the research topic. Much of the work consulted is commonly associated within the sociology of scientific knowledge (SSK), sociology of science, science and technology studies (STS), and similar. Therefore, the vocabulary and terminology commonly used within these areas of study was adopted and incorporated into my own work. It should also be stated that while a conscious effort was made to avoid research bias, having consulted such a body of work, there is always the potential that any interpretation of data may have been influenced and or my observations tainted because of this background knowledge (Gray 2004).

4.2.4 Actor Network Theory (ANT)

In addition to a grounded theory approach, an effort was made to apply Actor Network Theory (ANT) (Callon 1987; Latour 2005; Law 2004). As described by Callon (1987), the actor network includes both animate and inanimate elements that are linked. It is different from other networking theories in that it speaks to non-human as well as human components. In addition, it has an unpredictable nature allowing for networking to occur as needed. “An actor network is simultaneously an actor whose activity is networking heterogeneous elements and a network that is able redefine and transform what it is made of” (Callon 1987:93).
ANT was chosen because of its unique potential to facilitate the attempt to follow the processes and actors, human and non-human, involved in the co-construction of knowledge. Throughout the study of the protocol, not only were the actions of representatives of human stakeholder groups examined, but also the important connecting roles played by the non-human participants of the study, such as: the knowledge itself, the research tools used, the Bay of Fundy ecosystem, and the objects of the research work including lobsters and aquaculture sites and their activities. These non-human participants in the study were not only ‘actants’ but often held agency and contributed to the outcomes of the study (Sayes 2014). As Callon (1987) argues, every actant plays a contributing factor towards the knowledge development outcomes, even before the research question has been asked. No actor works in isolation, human or nonhuman, and the ability to examine the interactions between all actors and their agency helped to fill the gaps of understanding around knowledge development.

In addition, the linkages between actors, the ‘networks’ or ‘assemblages’ that are formed, are ‘messy’, unpredictable processes of bundling and bringing actors together (Law 2004). In turn, it is this messiness that is the strength of the ANT approach as it enables the examiner to see beyond theoretical certainties and enables new linkages between actors to be recognized and assessed for durability (Latour 2005).

Similar to the grounded theory approach, applying ANT methodology facilitates the removal of traditional constraints often found in data and results analysis thus allowing for a unique examination of knowledge co-construction.
4.3 Study Parameters

Beginning in 2014, a three year study entitled: *An Ethnographic Study of Risk Assessment in Coastal Management: Resource Sustainability and Community Resilience* (hereafter Risk Assessment Study) was granted funding through the Social Sciences and Humanities Research Council of Canada (SSHRC). One of the Risk Assessment Study’s objectives was to examine the impact of the salmonid finfish aquaculture industry on the lobster ecology of Southwest New Brunswick (SWNB) and to identify opportunities for improving resource management practices for these interacting industries. To specifically address this research objective, *The Berried (Ovigerous) Female Lobster Abundance Project* (Abundance Project), a subproject of the larger Risk Assessment Study, was initiated.

The Abundance Project endeavored to measure the current state of lobster abundance, specifically fertile females\(^8\) currently found within the proximity of the Atlantic salmon (*salmo salar*) aquaculture sites in SWNB. As a joint stakeholder research project, the Abundance Project was, and continues to be, developed through the collaborative efforts of fishermen, academic scientists, government scientists and other stakeholders of the SWNB lobster fishery. As a participant observer following the Project’s protocol development and its implementation from the beginning I had the unique opportunity to study the processes and outcomes of knowledge co-construction first hand.

\(^8\) *For the general purposes of the Abundance Project, a fertile female lobster (aka ovigerous females) were understood to be a female in any stage of egg bearing.*
Elements of the Project that I studied included: the development of the research protocol, including the framing of the appropriate research question(s), identification of the study variables (controlled, dependent and independent), identification of research methodology to conduct the measuring, examination and observation of these variables, identification and development of the necessary tools to conduct the research work (e.g. maps, boats, data sheets, etc.), identification of the necessary skills, resources and recruitment of individuals to carry out the research work (boat operation, research sampling, etc.) and the means of communication between project participants.

For clarity, going forward my research study or the detailed examination of the Abundance Project’s protocol development and implementation will be referred to as the Protocol Study. The Protocol Study includes examination of the Project’s actors (human and non-human) and the decision-making processes and outcomes of the research protocol elements for the first two years of the Abundance Project, beginning in late summer 2014 and ending in October 2015\(^9\). Please note, the Protocol Study will not report on the research results or data findings and research conclusions of the Abundance Project.

### 4.4 Term Operationalization

The following sections will provide definitions and descriptions of the participants, species of study, gear and equipment, fishing practices and animal

\(^9\) *In May 2017 the Abundance Project entered its fourth year of research work, and conclusions drawn from the research are not yet finalized.*
husbandry relevant to the Abundance Project and the protocol being studied. Although many of these terms and concepts may be generally familiar, it is important to identify their meanings and uses in this specific case study and how they were understood through participant observation and/or through definitions provided by study participants.

4.4.1 Study Participants

With the exception of one woman, the fishermen\(^{10}\) participating in the Protocol Study were men active in the inshore capture fishery for American lobster (\textit{Homarus americanus}) off the coast of SWNB. The age of the participants ranged from late 20s into their 80s, representing generations of the region’s lobster fishermen. Many of these fishermen are children and or grandchildren of lobster fishermen. While some of the fishermen owned their own boat and held the position of active captain, others were former owners and captains and still others were crew members and or potential future captains. All current captains were Atlantic Lobster (\textit{Homarus americanus}) species license holders with some holding licenses as well for other commercial species. Many fishermen participating in the Protocol Study have worked for years on board vessels and have work experiences in other fishing related industries such as seafood processing plants or the aquaculture industry.

\(^{10}\) Although the more inclusive term ‘fisher’ is often used in relation to commercial fishing industries, the term ‘fishermen’ is used throughout this dissertation as it is the preferred term by which the participants self-identified.
The scientists as members of a community of practice can be divided into two principle types for the Protocol Study. First, there were the academic scientists involved in the Abundance Project that included both natural and social scientists professionally engaged as teaching and research academics in the fields of social (anthropology and sociology) and natural sciences (marine biology and ecology). The second group of scientists was made up of those who are currently in full-time government employment working in disciplines such as oceanography and marine biology research and are described throughout the study as government scientist.

4.4.2 Lobster Fishing

In the province of New Brunswick, the lobster fishery is described as an inshore capture fishery. This term is used in reference to the capturing of wild fish stocks while working from smaller vessels or boats, usually independently owned and operated and running daily from shore as opposed to larger commercial fleet vessels which have the capacity to both harvest in deeper waters and remain at sea for extended periods of time. Boats participating in the inshore capture fishery vary in length due to licenses and gear restrictions for each fish species; however, the average length of boats used during the Protocol Study were around 45 feet long. In addition, the captains and owners of each boat usually have one to two regular crew members on board during a harvest season. While many crewmembers hold a family tie to the captain for whom they work, there are also those who have no kin connections.

As described in Chapter 2, the geographic location for the Protocol Study is located off of the southwestern coast of the province of New Brunswick. For ease of
fisheries management, DFO (the federal department of Fisheries and Oceans Canada) has historically divided the Canadian coastal waters into species-specific fishing ‘zones’, or areas, that identify the boundaries within which an assigned license holder may harvest. While there are 43 districts assigned to lobster fishing off the coast of Atlantic Canada, approximately nine are accessible from the shores of New Brunswick (Fisheries and Oceans Canada 2015a). The Protocol Study examined research work being completed within the Lobster Fishing Area (LFA) 36 (see Figure 2.2). LFA 36 runs from the Canadian/United States border from the top of the state of Maine then up along the New Brunswick coastline ending at the village of St. Martin’s and extending out approximately half way across the Bay of Fundy.

In addition to the assignment of federal fishing zones, the province of New Brunswick, for ease of its Aquaculture Site Licensing responsibilities and aquaculture husbandry, has created three Aquaculture Bay Management Areas (ABMAs) that overlap with LFA 36 (Chang et al. 2007). The current division of the area into three ABMAs is the result of mitigation measures put into place to address the presence and prevention of infectious salmon anemia (ISA). ISA is a highly infectious and untreatable disease caused by a virus that can lead to a mortality rate of 90% in open pen salmon farms (Canadian Food Inspection Agencies 2013). The practice of dividing a fishing area into multiple ABMAs allows for the rotation of fish stocks throughout the growth cycle. One area may be assigned to hold fish during their first year of maturing, a second area during the second year of growth and a third will remain fallow after harvesting to allow for remediation of the area found beneath the cages. The three
ABMAs known as **ABMA 1**, **ABMA 2a** and **ABMA 3a** have been used as the three principle study areas for Abundance Project and therefore for the Protocol Study.

Fishermen holding licenses for LFA 36 are permitted to set 300 traps during the assigned lobster seasons which run from the second Tuesday in November until January 14th and then again from March 31 until June 29th. All lobsters with a carapace length of greater than 82.5 mm may be harvested with the exception of ‘berried females’ (Fisheries and Oceans Canada 2013). **Ovigerous female lobsters**, commonly referred to as berried females, have developing embryos attached to the underside of their carapace. A female carries these ‘eggs’ (i.e., the brooding time from spawning until hatching) for an estimated 9-11 months (The Lobster Conservancy 2003).

Harvesting of lobster involves the use of **lobster traps** (or lobster ‘pots’). In LFA 36 the more common form of traps are rectangular in shape and made out of plastic coated wire mesh (in a 3.8 cm x 3.8 cm or 1.5” by 1.5” grid). The traps are built and maintained individually by the fishermen themselves. Most traps run approximately 120 cm long by 56 cm wide by 33 cm high (47” x 22” x 12”) or slightly larger. Traps are divided into two and sometimes three housing areas or sections. A circular aluminum ring opening anywhere from 11 cm up 15/17 cm (4.5”-6/7”) is found on one of the longer sides of the trap. Attached to the ring is a knitted ‘pot-head’ or nylon mesh that provides a tunnel into the trap. The lobster, attracted to the bait inside, follows along the tunneling of the ‘kitchen’ that leads into either one or two adjacent housings called the ‘bedrooms’ or ‘parlours’. Since the lobster is unable to retrace its way back out, it is trapped inside. In SWNB the ‘kitchen’ is most commonly baited with herring (*Clupea*
harengus) (usually head and tail remnants) stuffed into mesh sacks (10” x 10”) known as ‘bait bags’, tied between the two rooms.

In recent years, due to an effort to increase lobster conservation, a measure has been adopted by the fishermen of LFA 36 to install an escape hatch (i.e. mechanism) known as a **ghost panel** on at least one side of the trap. A piece of plastic paneling about 8×12 cm (3” x 5”) is attached with hog rings to the trap in front of a hole of the same diameter cut into the mesh. Because the ghost panels are attached with biodegradable hog rings, if traps are left in the salt water for an extended period of time the rings will corrode and the panels detach and float away leaving the trap open for escape. This measure has been adopted to address the growing concern over lost or ghost gear that continues to ‘fish’ if detached from its buoy or trap line. Traps are lost due to several reasons including storms, marine vessels passing through the same waterways cutting the marking buoys or trawl lines or even entanglement with adjacent traps.

Buoy lines (i.e. buoy at one end and rope attached to the trap) allow fishermen to identify and locate their traps resting on the ocean floor. Heavy weights of cement, rocks or similar are attached inside the bottom of each trap to ensure that once deployed a trap will float to the bottom and rest upright with limited movement or pull from ocean currents.

A **gaff** (i.e. a long wooden or steal rod with a hook on the end) is used to reach into the water to get the line back into the boat. Once hooked, a portion of the line is manually pulled into the boat and then wedged into a **hydraulic wench** allowing traps to be hauled in mechanically. While in the past most traps were set either individually
or in pairs, increasingly traps are set using a longer line with several shorter lines attached (each with a trap) with buoys set at the beginning and end of the longer line. This is called a **trawl line** (see Figure 4.1).

![Figure 4:0:1 Author’s depiction of a 10 trap trawl line (Field Notes August 7, 2014)](image)

There are several advantages to using trawl lines including the capacity for the fishermen to set their traps evenly in a known lobster area for better catches. Trawl lines decrease the potential for gear loss, as it is harder to lose traps when they are attached together. It is also economical, saving both time and labour by eliminating the need to stop and hook (i.e. use the gaff) each trap individually before hauling. All the fishermen participating in the Protocol Study use trawl lines or a combination of trawl lines and singles or paired traps in their regular fishing work. There are numerous best practices and industry standards in reference to the use of trawl lines such as how many traps can be linked together, length of line between traps, and how trawls are deployed from boats. In addition, many of these practices are based on the individual fisherman’s
experiential knowledge and preferences. For the protocol work observed, the fishermen followed their regular trap deploying and retrieval practices. As it is proprietary information, the specific details of each fisherman’s trap design and trapping techniques will not be discussed further; suffice it to say that each fisherman was consistent in both the gear used on his boat and the deployment and retrieval methods practiced throughout the Abundance Project protocol implementation.

Maps and/or simplified nautical charts were used extensively during the development of the research protocol. The variety of maps used included general nautical charts indicating water ways and land masses within the coastal zone of SWNB in the Bay of Fundy and planning maps/charts as provided by Agriculture, Aquaculture and Fisheries New Brunswick, indicating the ABMAs and locations identified as licensed aquaculture sites (see Appendix A). These maps were used for plotting and marking sites chosen for data collections and observational work during the protocol work. Because of the variety of mapping and charting sources consulted throughout the study these will collectively be referred to as “maps”. It is also important to note that during the protocol fieldwork, Electronic Chart Display & Information Systems (ECDIS) i.e., computer-based navigation information systems, were used for identifying and recording longitude and latitude of selected data collection sites and sonars were used for assisting with the identification of ocean floor bottom types either as rough/cobbled or smooth, flat and/or muddy bottoms.
4.4.3 Open Pen Finfish Aquaculture

The province of New Brunswick Department of Agriculture, Aquaculture and Fisheries describes aquaculture as “the farming of fresh and salt water organisms such as fish, shellfish, and plants” (Agriculture, Aquaculture and Fisheries 2017). The type of aquaculture currently taking place in the LFA 36 is the raising and harvesting of Atlantic salmon (*salmo salar*). The system used to raise these salmon is called open pen aquaculture, a series of circular net pens, each approximately 8-10 meters deep and 70-150 meters in circumference; depending on the pen and fish size a net pen can hold between 15,000 and 30,000 smolts\(^{11}\) (Atlantic Canada Fish Farmers Association 2017). Since the fish are housed in a contained area they require regular feeding, usually in the form of dry pellets made from animal, plant and fish proteins. To follow sound waste management and animal husbandry practices the pens must be situated in the water column where the depth and currents allow for natural flushing of the food and animal waste through tidal movements. Finally, to ensure the health of the animals, regular preventative and targeted treatment measures are required. Currently, salmonid aquaculture health management in New Brunswick involves numerous practices governed through federal (e.g. Aquaculture Activities Regulations, SOR/2015-177) and provincial (e.g. Aquaculture Act, RSNB 2011, c 112) legislation as well as through informal aquaculture association agreements and negotiated understandings with other Bay of Fundy stakeholders. Of particular interest to the Abundance Project is the

\(^{11}\) Smolt is the fourth stage in the salmon life cycle, when the fish is able to live in a salt water environment and mature to the final stage as adult salmon.
administration of therapeutants used in the open pens to control disease (e.g. infectious salmon anemia) and in the prevention and control of pests such as sea lice (*Caligus elongatus*). The form of therapeutant will dictate the type of application method as treatments may be administered through medication found directly in feed or through injections. Pesticides however, are applied topically or directly into the water, commonly referred to as **bath treatments** (Fisheries and Oceans Canada 2012). The significance of the bath treatments lies in their potential impact on non-targeted species found in the same water column and vicinity as the salmon cages (E.g. the indigenous lobster population of SWNB).

### 4.5 Data Collection

The scientific research protocol for the Abundance Project involved bringing together of a variety of stakeholders in a variety of settings, therefore multiple data sources and means for collecting observational data were used for this study. The data collection processes chosen were those thought to be the best for following and documenting the interactions and sharing of knowledge, both experiential knowledge and research knowledge, held by the participants. Data collection methods were also chosen that allowed for observation in a field setting on board fishing boats during the implementing of the protocol work. The goal was to observe participants not only interacting with each other but to follow their interactions with the protocol (e.g. interpreting, modifying, etc.). Data collection methods included participant observation on board fishing boats and at meetings and planning sessions. Semi-structured interviews were conducted with individual participants. And document analysis of
project correspondence, field notes and other materials was completed. All data
collection work was conducted over a 17-month period between June 2014 and the end
of October 2015. Two field seasons for the Abundance Project took place during the
length of the study (i.e. the protocol work physically implemented and conducted at
sea). The first field season took place in August 2014 (Field Season 1) and the second
from the second week in July until the first week of August 2015 (Field Season 2) (see
Figure 4.1 for project timeline). The Protocol Study was conducted in keeping with the
Tri-Council Policy Statement: Ethical Conduct for Research Involving Humans (Tri-
Council 2010) and the approval of the University of New Brunswick Research Ethics
Board.12

<table>
<thead>
<tr>
<th>Dates</th>
<th>Project Activities</th>
</tr>
</thead>
<tbody>
<tr>
<td>May 2014-July 2014</td>
<td>Planning Meetings 1-4</td>
</tr>
<tr>
<td>August 2014</td>
<td>Field Season 1 Deployment &amp; Retrieval; Problem Solving Meeting</td>
</tr>
<tr>
<td>September 2014- October 2014</td>
<td>Planning Meetings 5-7; Field Season 1 Wrap Up</td>
</tr>
<tr>
<td>November 2014- May 2015</td>
<td>One-to-one Interviews</td>
</tr>
<tr>
<td>December 2014- June 2015</td>
<td>Planning Meetings 8-10</td>
</tr>
<tr>
<td>July 2014- August 2015</td>
<td>Field Season 2 Deployment &amp; Retrieval</td>
</tr>
</tbody>
</table>

Figure 4:0:2 Protocol Study Timeline

12 University of New Brunswick, Fredericton Campus - REB 2014-101
4.5.1 Population Universe

The population universe for the protocol study was drawn from all individuals, contributing in any capacity, to the Abundance Project’s protocol development and or implementation. Included among the participants were active and retired fishermen, representatives of fishermen’s organizations, natural scientists, inclusive of academic researchers, lab technicians, students and government employees, and social scientists, both academic researchers and students. In total, 38 participants from the Abundance Project were approached to contribute to the study and all agreed. Of those who contributed, fishermen (F) (N=16) were inclusive of captains and crewmembers. Within the category of fishermen, participants contributed in a variety ways to development of the research protocol and its implementation. Some of the fishermen participated solely in meetings and planning sessions, while others carried out the fieldwork on the water, and still others participated in all aspects of the project including meetings, planning and fieldwork.

Scientists (N=5) included academic research scientist (AS) both natural and social scientists, and academic research students or research technicians (AT) (N=10). The remaining seven participants who contributed to the protocol were either employed as government scientists (GS), policy advisors (GE) or fisheries association representatives (FA). These study participant identifiers (i.e. AS, AT, GS, GE, & FA) will be used to indicate the participant categories throughout the remainder of this work.
<table>
<thead>
<tr>
<th>Participant Type</th>
<th>Description for Protocol Study</th>
<th>Identifier</th>
</tr>
</thead>
<tbody>
<tr>
<td>Academic Research Scientist</td>
<td>Individuals who hold advanced post-secondary degrees currently working as instructors and researchers employing systematic activity to gain knowledge in specific academic disciplines within post-secondary academic institutions</td>
<td>AS</td>
</tr>
<tr>
<td>Academic Student / Research Technician</td>
<td>Individuals currently studying at post-secondary institutions to earn degrees and/or recent graduates in specific academic disciplines working in entry level laboratory positions in the biological sciences</td>
<td>AT</td>
</tr>
<tr>
<td>Government Scientist</td>
<td>Individuals who hold advanced post-secondary degrees in specific academic disciplines currently working as researchers and subject specialty advisors within the civil service</td>
<td>GS</td>
</tr>
<tr>
<td>Government Policy Advisors</td>
<td>Individuals who may or may not hold subject specialty advanced post-secondary degrees working as public policy advisors within the civil service</td>
<td>GE</td>
</tr>
<tr>
<td>Fishermen</td>
<td>Owners and operators of lobster fishing vessels holding valid lobster harvesting licenses (i.e. captains) and crew who fish with the captains during the regular harvest season onboard the vessels (i.e. crewmembers)</td>
<td>F</td>
</tr>
<tr>
<td>Fisheries Association Representative</td>
<td>Individuals who hold post-secondary degrees in subject specialty disciplines who direct, operate and administer programs and support services for fishermen within the geographic region of study</td>
<td>FA</td>
</tr>
</tbody>
</table>

Figure 4.0:3 Participants in the Protocol Study

4.5.2 Meetings

Transcripts, minutes and notes were taken and consulted for 12 meetings relating to the Project protocol. The format of meetings included in person face-to-face meetings, teleconferences, or a combination of the two (i.e. one or more members at one location joining one or more members at another location by phone). Documents used to facilitate the productivity of meetings included agendas, power point presentations, maps and nautical charts, graphs and other handouts. In addition, project participants generously shared any available emails or correspondence with regards to meeting planning or meeting follow-up action items. Agenda topics for meetings included
matters such as acquiring grants and funding, addressing administrative tasks, fieldwork logistics and planning, addressing fieldwork concerns and project progress, as well as wrap-up discussions and presentations of preliminary results. By far, however, the greatest amount of time spent during the meetings was on addressing the actual protocol itself including the identification of variables and the logistics for carrying out the methods necessary to collect the data relevant to the protocol. Participant attendance at meetings was commonly driven by the agenda for the meetings, meaning fishermen did not necessarily attend meetings exclusively focused on grants, funding or administrative matters (e.g. student hires), nor did government scientists necessarily attend meetings focused on practical fieldwork planning (e.g. times and locations for boats departing for fieldwork). As stakeholder inclusivity was integral to the Abundance Project, stakeholder attendance at project meetings was neither mandatory nor prohibited and all participants were welcome to participate where they felt appropriate or as their schedules permitted. To facilitate and increase opportunity for participants to join the in-person meetings, these events took place at a community facility central to where the majority of participants lived and or worked (e.g. community church hall, fishermen’s association office).

4.5.3 Interviews

Eleven open ended semi-structured interviews were conducted with at least one representative from each of stakeholder categories (AS, AT, GS, GE, & FA). Interviews were conducted with participants in the months between the first two field seasons of the project. Participants were approached in person and or by phone, followed by a formal
invitation sent by email asking if they would be willing to be interviewed for the Protocol Study. Invitations included a letter of introduction to myself, my supervisor and the study’s purpose as well as general project information and a consent form (see Appendix B). All interviews were conducted in person at a time and place of the participant’s choosing, including individual’s homes, offices or places of study. The time needed to conduct the interview varied by participant, running from 30 minutes to approximately one hour and fifteen minutes. Written notes were taken for all interviews for later transcription and consent was given by many of the participants to make audio recordings that greatly facilitated transcription accuracy (Krueger 1998).

A questionnaire entitled Knowledge Construction and Current Coastal Resource Management Practice – Berried Female Atlantic Lobster (Homarus americanus) Abundance Project (see Appendix B) was used as a research tool to direct the interviews. The questionnaire was divided into four topic areas, asking participants to speak to the deployment processes of the Abundance Project’s protocol, the retrieval processes, to give their thoughts on working with scientists and or fishermen and finally, participants were asked to speak to the communication between project partners. There were 28 questions in total but as an open-ended interview not all questions were asked of all participants as many people spoke to the matters of interest without prompting or specific questioning. Questionnaire administration was also adapted to accommodate for a participant’s role in the project, for example academic research students and technicians were not asked if they “were able to set their traps during the project as they normally would during a regular fishing season”. In the interest of inclusivity, all
questions were revealed to participants in case they had an interest or opinion about a particular topic they wanted to contribute.

4.5.3 Field Observations

Fieldwork for the Protocol Study was divided into two categories for participant observation. As indicated previously, observations and notes were conducted during meetings and planning sessions relating to the Abundance Project and the development of its research protocol. In addition, participant observation was also conducted during the protocol’s implementation at sea.

As detailed in Chapter 2, the Abundance Project chose to follow the same ABMA administrative geographic divisions established by the New Brunswick Department of Agriculture, Aquaculture and Fisheries within the boundaries of Lobster Fishing Area 36 (LFA 36). A captain, including his boat and crew was assigned to each of the ABMAs (ABMA 1, ABMA 2a and ABMA 3a). The protocol was implemented and fieldwork conducted simultaneously in each of the three ABMAs. In Field Season 1, the work took place over the course of three weeks in August 2014. During Field Season 2, the work was completed over a four-week period starting the second week in July 2015. For both field seasons included in my study, the abundance project work was done over two consecutive days during each week. The protocol was designed such that on day one the captain and crew would go out on the water to deploy lobster traps. The following day, after a 24-hour soak period, the captain, crew and scientists and or
academic students and technicians would go out on the water to retrieve traps and conduct data collection.\textsuperscript{13}

Because of the simultaneous nature of the Abundance Project’s fieldwork in multiple locations, two different approaches were taken for the participant observation work (O’Reilly 2005). During Field Season 1, I conducted observations on board one vessel working in one ABMA for all three weeks. During Field Season 1, I was able to participate in two trips for deploying traps and three for trap retrievals. For Field Season 2, my participant observation work was divided equally between all three ABMAs. Time was spent observing on each vessel for one week. In the second year, I was able to join six trips, three deployments and three retrievals. In addition, during the second year of study, fieldwork observations were conducted by other social scientists and data was shared between all project partners. A data collection tool was developed and used as a guide for observational work (following Bales 2000; See Appendix C.)

On deployment days, participant observational fieldwork involved joining the captain, crew and boat at an assigned time and dock, usually early morning, with all individuals participating in activities where appropriate or needed during the course of the day deploying lobster traps. On retrieval days, scientists, students and research technicians also met the captain and crew in the morning and protocol activities completed during the day involved retrieving traps and measuring species samples and collecting data.

\textsuperscript{13} While captains volunteered the use of their boats and gear, they were compensated a daily rate as calculated by each captain given the conditions of the study site on which they worked.
The length of both deployment and retrieval days varied for each trip. Numerous factors were at play including the weather (particularly early morning fog), tides, locations for trap deployment (including steaming (i.e. ‘sailing’) time to the selected sites), crew numbers, number of samples to be measured (i.e. a larger catch meant more animals to sample, leading to a longer day). The length of fieldtrip days ranged from a few hours to full 7-8 hour days. When on board for ethnographic work, field observers also assisted minimally where needed with tidying gear and traps on deck, recording navigation locations, opening and emptying traps, banding lobster claws and sorting lobsters for measuring.

It should be noted that while both captains and crews for each of the boats in the study participated in the fieldwork, there was inconsistency in the number of crew members on board, and not all crew members participated each day (e.g. deployment is not as labour intensive as retrieval so captains did not need full crews every day) and some crew members changed between field seasons. In addition, while all Protocol participants were welcome to join any of the fieldtrips (e.g. fishermen association employees, government scientists etc.) due to logistics and time commitments, only the academic research students or research technicians and the social scientists participated regularly in fieldwork. One government scientist was able to join for one retrieval day in the first year of the study.

4.5.4 Other Documents

In addition to the printed materials used and consulted at meetings (i.e. agendas, power point presentations, maps and nautical charts, graphs and other handouts), project
participants generously shared their email exchanges often relating to project logistical matters such as meeting and fieldwork planning. Additionally, there were email exchanges that dealt with specific project administrative matters such as who would obtain and how to retain the scientific licenses necessary to carry out the project work. I was also given access to the licenses used and copies of the data sheets used for sample measuring (See Appendices D & E). Finally, other documents shared with me for my study included government documents and reports.

4.6 Data Analysis

Once collected, data from the meeting transcripts, interviews, field observations and other documentation were then coded using techniques as found in the literature. Coding, as defined by Charmaz (2014), requires the data to be categorized through the assignment of a short name (i.e. code) to individual sections of the findings. Codes both summarize and account for each piece of data as well as provide a structure for selecting, separating and sorting data (Charmaz 2014). Codes must be short, simple, active and analytic but they must also be representative of the data so that the context and intent remain consistent. These codes provide the analytical framework on which analysis may be conducted by enabling the researcher “…to define what constitutes the data… In brief, you begin to conceptualize what is happening in the data” (Charmaz 2014:113).

First, a line-by-line approach to coding was taken to ensure each event and or incident in the findings could be impartially identified. Following the first rule of grounded theory, the data was studied as it emerged (Glaser 1978). Second, a focused
coding approach was used allowing the more frequent and dominant codes in the line-by-line approach to be extracted. Focus could then be given to the emerging dominant data. In a third step of coding work, axial coding, as suggested by Charmaz (2014) drawing on the work of Strauss and Corbin (1990, 1998) and Strauss (1987), placed dominant data into relating categories and subcategories. In this step, data was ‘reassembled’ into a coherent format so that it could be reviewed for the emergence of key information such as who, what, why, where, when and how (Charmaz 2014). Finally, theoretical coding as suggested by Charmaz (2014), was applied. With categories identified, data could then be examined for possible relationships between these categories or subcategories. It is this last step, the identification of relationships that allows for the building of hypotheses and the development of theory.

The use of this four-layered coding as a methodological approach for the Protocol Study will be demonstrated in the following results and analysis chapters. These chapters, respectively, will speak directly to the identification of categories and sub-categories in the data and then to their relationships with one another to support theoretical arguments on the co-construction of knowledge. Specifically, the final stages of coding revealed a lacuna in the literature; a useful definition of ‘knowledge’. Therefore, a definition of knowledge was developed to better understand the significance of the data in relation to knowledge co-construction.

4.7 Conclusion

For this dissertation work examining how social worlds come together to co-construct knowledge, the Abundance Project was used as a case study example.
Specifically, the case study involved the development and implementation of the Abundance Project’s scientific protocol to examine the potential impact of the SWNB Atlantic salmon (*Salmo salar*) aquaculture industry on American lobster (*Homarus americanus*). Assuming the role of participant observer of this multi-stakeholder research project, I used qualitative research methodology using both grounded theory and actor network theory (ANT) approaches.

Working directly with the Project stakeholders (i.e. fishermen, representatives of fishermen’s organizations, natural and social scientists both academic and government, research technicians, students and government employees), data for the Protocol study was collected from four main sources, meetings transcripts and notes, semi-structured interviews with representatives of the stakeholder groups, field observations and analysis of other Abundance Project related documentation such as email correspondence, maps, carts, licenses, reports, etc.

Once collected, a four-stage coding process was applied to the data as outlined by Charmaz (2014). Line by line coding was completed identifying dominant patterns in the data. These dominant data were then categorized and sub-categorized allowing for analysis and the identification of relationships between the categories, which in turn, permitted theoretical application to the findings and development of new arguments.

In the successive chapters, the results of the line-by-line, focused and axial coding work will be presented followed by an analysis of the findings both applying and extrapolating on theoretical arguments for the co-construction of knowledge and an action definition of knowledge which helped to make sense of the data.
5. Results

5.1 Introduction

The subjects covered in the Abundance Project meeting minutes, interviews, field-observations and supporting documents represent a broad range of topics relating to the Project’s protocol design and development. While subjects relating to the scientific and theoretical design of the protocol dominated the information exchanged between participants, Abundance Project administration and logistics also played a large part in the discussions. This chapter will focus primarily on the former, that is, the results in relation to the knowledge exchanged between project participants to develop the Abundance Project’s protocol and the processes of that exchange.

Included in the data were 129 pages of meeting transcripts, minutes and notes collected during 12 meetings involving the project leads or meetings with all or some of the project participants. There were 280 responses to the 26 questions asked in 11 open ended interviews conducted with at least one participant from each stakeholder group (fishermen, fishermen’s association, academic scientists, government scientists, academic and student technicians). There were 17 sets of field note summaries recorded during the days spent carrying out the protocol on the water (including free text field notes and two page data collection tool results). Also included in the data were a variety of supporting documentation such as email exchanges (214), maps (various nautical, electronic, government issued), project applications (3), scientific licenses (2) and early data result summaries.
For the sake of clarity, results for the study will be presented in a rough chronological order following the Protocol’s development from beginning through to implementation and fieldwork. It should be noted however, that many of the events or processes related to the Protocol Study portion of the Abundance Project occurred simultaneously and many topics were returned to or revisited in numerous meetings. (A time line of the Abundance Project’s key events is presented in Figure 4.2)

In this section, the process of identifying the Abundance Project’s research question will be presented followed by data relating to the Protocol’s design. After which details examining the implementation of the protocol processes will be presented as recorded in fieldwork observations and supporting documents. Drawing on the data collected from the one-to-one interviews, the chapter will close with a summary of the Project participant’s perceptions of the project.

5.2 Defining a Research Question

By its very nature, a research protocol begins with the identification of research goals and a question. Once they have been established and a research question has been asked, only then can a research protocol be built and implemented to appropriately address the question. Early funding applications (i.e. SSHRC 2013, ALSF 2013-2014) for the Abundance Project outlined that one of the principle goals of the project was “[t]o examine the size and abundance of ovigerous female lobsters in relation to proximity to open-net pen salmon aquaculture activity” (ALSF 2013-2014). It is around this specific goal that discussion was held during the initial meeting between the project’s leads to address the logistics of conducting a multi-stakeholder scientific
research project (i.e. how to examine female lobster abundance in relation to finfish aquaculture sites).

The development of the research question for the project is clearly reflected in the minutes taken from one of the first planning meetings held June 13, 2014. During this meeting, attended by project leads and government scientists, it became apparent that while there was an increasing understanding of Atlantic lobster (*Homarus americanus*) biology gained through laboratory work and controlled at sea rearing work (e.g. McMahan et al. 2016; Quinn et al. 2013; Grabowski et al. 2010), there was limited collective knowledge on lobster behavior in their natural ecosystems without controlled conditions. The following exchange and comments demonstrate the project participants’ realization of the enormity of the task at hand.

**FA1**: We will be doing a 3-year process that will sample all three Bay Management Areas. If we can pick sites in each we would get a lot of variation. The trick will be to pick sites influenced by aquaculture and not influenced, but not too far apart – which is why we have [Oceanographer] here today.

**GS1 (Oceanographer)**: I can give general guidance but this is an area of active research. Our models with multiple tides are still being tested – then you get into the bottom situation – then storms, wind….all this modeling takes a long time. We have dye data from a few sites, but not on a scale you would need. Development is going so far beyond what information we can provide.

**GS1 continued**:

We have done [Aquaculture] Bay Management Area 1 & 2 – around [the year] 2000 or so we did a dye study, but we were instructed to use the dye only in an area where it would not affect aquaculture fish because the dye then was not allowed for human consumption. So where there was already aquaculture [in 2000], there has been little done. Dye and chemicals are diluted within 3 hours within 3 orders of magnitude, so if you look for chemicals without dye tests, good luck! Dispersal isn’t steady, imagine a garden hose spraying your yard, it is pulse stuff. So that is a state of the art....
question, what is the profile of exposure? How do I sample you if you are sessile and I know you are exposed in this pulse pattern? (Meeting Minutes, June 13, 2014)

Given the limited understanding of lobster ocean behaviour, much of the discussion during the meeting covered the logistics and parameters of how the project could realistically be completed. For example, to measure lobster population abundance near aquaculture, would it be best to use transects under specific cages, or would site sampling using trap surveys at multiple sites be more effective? If sites were chosen for sampling, what distance was needed from aquaculture sites to capture both near and far conditions? How could sites be chosen to reduce variability in their individual conditions such as water depth and temperature? How could the protocol account for aquaculture activities? What would be the optimum sampling dates, sampling intensity, and sampling gear types? The shear complexity of trying to account for these and additional variables was enormous. After much conversation on how best to approach the Protocol, an academic scientist made the following comment to the group:

Just getting information on when and where berried females are close to aquaculture sites would be great information - it would tell us something about the measure of risk they are exposed to (AS3 Meeting Minutes, June 13, 2014).

Agreement on the above statement by all meeting participants helped to both clarify and narrow the research question for the Project. Seeking to explore the locations and numbers of ovigerous female lobsters, the research question for the Project became: “What is the relative abundance of ovigerous females lobsters in relation to aquaculture sites?”
5.3 Building a Protocol

With the research question identified the topic for the remainder of this formative meeting then focused on establishing a broad level of agreement on the methodology and selection of variables that would be included in the Project’s scientific protocol.

5.3.1 Paired sites vs. transects methodology

The first matter to address was the method that would be applied to the study, that is to say, how primary data collection would be completed. Two methods were recommended based on the experiential research knowledge held by two of the Project’s scientists. The first option would be to collect samples using transects under the aquaculture cages. Transect work is often used in the biological sciences and for fisheries sampling work. It involves the setting of pathways for sampling, usually equally distributed, throughout the geographic region of interest. Divers conduct abundance counts and measurements of the species found along these pathways, along with other observational recordings.

The second method recommended was the setting (i.e. the deploying) of lobster traps both within the proximity of active aquaculture and within the proximity of control sites with similar characteristics but away from the zone of influence of aquaculture. Traps would be hauled (i.e. retrieved) in a manner similar to the regular fishing season; however, during a trap survey the animals would be counted, measured (i.e. sex identification, length measurements taken, fertility noted, etc.) and returned to the water.
Influencing the choice of method was the importance of establishing protocol processes that allowed for both the safe handling of the lobster while providing the greatest opportunity for data collection in areas where there was evidence of aquaculture impacts. The knowledge shared between participants on the types and travel of potential impacts from aquaculture activity included information on eutrophication, sulfide concentrations, and pesticide dispersal. It was also noted that research completed in controlled lab environments suggests that some chemicals used in the aquaculture industry could lead to premature molting among egg bearing females and subsequent loss of the clutch of eggs (e.g. Waddy et al. 2002). A fishermen’s representative at the meeting shared the local knowledge understanding that ovigerous female lobsters, after the first year of the aquaculture production cycle, avoid aquaculture cage sites (e.g. Wiber et al. 2012). The use of transects for sample collecting would most certainly have captured these potential impacts, particularly addressing the need for proximity to aquaculture activity. Unfortunately, discussion during the meeting highlighted the fact that, in the past, transect work had proven difficult with regards to building controls into the study. In comparison, a trap survey’s use of paired sites offered comparative data collection between affected sites and similar but unaffected control sites.

Speaking to the use of traps, one academic scientist stated, “[But] pairing controls for [A]BMAs and their variation, all kinds of variations exist out there so this is the best approach we can use” (AS1 Meeting Minutes, June 13, 2014). A government scientist followed up by noting that what was also essential to a trap method with paired sites, was solid information about the sites selected for sampling. Referring to what makes a good experimental control he said; “Good control is that everything else should
be the same except aquaculture – depth, bottom, …” (GS2 Meeting Minutes, June 13, 2014). In the end, given the current state of limited scientific and experiential knowledge about the distribution of Atlantic lobsters outside of the fishing season, with the exception of broad knowledge on general seasonal movements, the trap survey method lent itself more readily to measuring lobster abundance. In addition, given the time and resources available to the Project, the group agreed that a paired site trap survey method would more readily allow for species sampling and data collection. Therefore, partners agreed to conduct the study by selecting locations for sampling (i.e. sampling sites) in relative proximity to active aquaculture sites and then pairing each with a control site identified with similar characteristics but away from aquaculture.

5.3.2 Protocol Boundaries – Aquaculture Bay Management Areas

With a method established, the next step was the identification of where exactly the study would take place. During the June 13, 2014 meeting, it was decided that the geographic region for the protocol work would be within the Lobster Fishing Area 36 (LFA36). More specifically, it was agreed that the three Aquaculture Bay Management Areas (ABMAs) assigned by the New Brunswick Department of Agriculture Aquaculture and Fisheries and located within the boundary of LFA 36 would be used. The abundance of ovigerous female lobsters would be measured drawing on samples taken from within proximity to active finfish aquaculture sites identified within the three

14 See Figure 2.2, Chapter 2 for map of LFA 36
ABMAs. It was recognized that differing levels of area and density of aquaculture lease sites within each of the three ABMAs, with ABMA 2a having the most and ABMA 3a having the least, would present a challenge particularly for control sites within ABMA 2a. Nevertheless it was agreed given the resources available that 9 sets of paired test sites would be feasible: 3 pairs in each ABMA. The representative of the fishermen’s organization explained that she was confident that fishermen could help with this site identification.

5.3.3 Site Selection for Trap Survey Locations

From the moment that Project participants decided to use a pair comparison site method, they recognized the importance of choosing the appropriate trap survey locations for data collection. It was also recognized that selection would require expertise and knowledge from all stakeholder groups. During an early planning meeting between the three project leads, the following comment was made:

I don’t think we are going to get far on site selection aside from general guiding principles…I think for the nitty gritty choices we’ll need to have, GS1 there, perhaps GS2 for their [work on]…egg bearing females …I’m quite comfortable with settlement and juvenile grounds but for females I would like GS2 input and then also the fishermen so we can get a strategy on how we want to do this, But the fine-tuned selection will have to wait, I think...(AS1 Meeting Minutes, May 23, 2014)

And later on in that same meeting, the same individual further commented:

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15 Although 9 sites were initially identified, one site selected in ABMA2a was proved to be unfeasible once on the water and was excluded from the study.
Yes, absolutely, now what I would say is that I think the input from fishermen is most critical for the egg bearing females … (AS1 Meeting Minutes, May 23, 2014)

As a result, a meeting for site selection was set for July 10, 2014 in St. Andrews at the Fundy North Fishermen’s Association (FNFA) offices. Members from all the project participant groups were invited to attend including active and retired fishermen, academic and government scientists as well as the project’s three lead researchers. Participants were told that the goal of the meeting was: “Look[ing] for pairs of sites – one that is influenced and another fairly close that will not/is not influenced\textsuperscript{16} [by aquaculture]”, (i.e. to identify sites that have been exposed to aquaculture effluent) (Meeting Minutes, July 10, 2014).

More specifically, participants were asked to identify within the three Aquaculture Bay Management Areas (ABMAs), aquaculture sites where ovigerous female lobsters had been known to be present in the past as this would provide confirmation of known lobster spawning and nursery grounds. Tacking back and forth, consulting a variety of maps and nautical charts, participants were able to exchange their expertise and individual knowledge sets to make recommendations on the number of sites needed for each ABMA, stating what sites would be best to collect samples from and why. As one government scientist put it, “it’s a site-by-site review – what are the

\textsuperscript{16} In Chapter 6, I will discuss the result of not systematically clarifying as a group what was meant by “influenced” during this and subsequent meetings but generally in this meeting, the idea of “influenced” spoke to aquaculture activities (e.g. under cage waste, pesticide treatments, etc.) that were understood to have had an impact on adjacent lobster breeding, spawning and nursery habitats or other lobster behaviour or activities.
elements of each site?” (GS1 Meeting Minutes, July 10, 2014). And, as one fisherman said, “Can we tell the story on each site?” (F1 Meeting Minutes, July 10, 2014).

While both the scientists and fishermen contributed their understanding of tidal patterns and prevailing winds, the fishermen were also able to contribute their ‘on-the-water’ expertise and historical perspectives. For example, they were able to identify sites that would be poor choices having “never had lobster” as well as sharing information on sites known to have spawning females in the past and or the presence of juvenile lobsters: “In June, St. Andrews Bay [Passamaquoddy] is full of spawn. Crow Island has tons of [spawning] lobster” (F1 Meeting Minutes, July 10, 2014).

Fishermen also used their knowledge of where they had participated in the practice of v-notching17 ‘berried’ (i.e. ovigerous) females in the past. Fishermen’s recollections of areas where they had done a lot of v-notching were indicators of areas where females were known to congregate in the past. Therefore aquaculture sites in the areas where v-notching had been practiced had promise of current female lobster activity.

Still other experiential expertise, including knowledge from other fisheries (i.e. sea urchin harvesting, ground fisheries) helped contribute to the identification of potential test sites. Fishermen shared information on active weirs used by the herring capture fishery as a sign of areas in “good health”. Areas with an active herring fishery

17 V-notching of ovigerous females, i.e. egg bearing females, is a somewhat controversial volunteer conservation measure that involves the cutting of a V-notch into one of the right tail fins of any egg bearing female before returning the animal to the water. Although all egg bearing females must be returned to the water, should the animal be caught again it cannot be harvested until the tail fin has regrown as the V-notch indicates it is a known fertile female.
had promise as areas that could be used as controls to the sites selected next to aquaculture activity (Meeting Minutes, July 10, 2014). According to fishermen, active weirs can serve as strong indicators for site selection because once a weir is exposed to aquaculture effluent, herring will no longer be caught in that weir. First, because of their strong sense of smell, herring will avoid weirs exposed to the smell of the dead herring used in the aquaculture feed and second, the scent of salmon suggests predators which the herring will also avoid.

One fishermen in the planning meeting also highlighted the importance of considering the spatial and temporal nature of the LFA. Given the known variation in fishing patterns that have taken place over time, he queried what specific information was being sought in relation to the characteristics of potential survey sites. Speaking to lobster abundance in one suggested area he responded;

No, because… it’s complicated! [laughter]. Black Ledge was very good in the fall, now it’s not so good. And, now lobster are found where they never used to be.

And, speaking to spatial variance;

…[in] Seal Cove Sound, you could get 6 lobsters a day but when I was fishing the Wolves I might get 100 spawning lobsters a day (F1 Meeting Minutes, July 10, 2015).

Other factors that compounded the difficulty of site selection included the need to accommodate additional academic and government research work being done in the same region, which had to be avoided (FA2 and AS1 Emails, July 7, 2015; FA1 Email, July 2014). Fishermen were also informed of aquaculture cleanup operations being undertaken in the ABMAs, forcing the fishermen to eventually make modifications to the original sites proposed during meetings (AS3 Email, July 12, 2015). Moreover,
there was the need to clarify that participants were indeed speaking to the same locations. Names used to identify locations of selected sites for the trap survey work varied from those found on maps and charts to those used by the fishermen (local identifiers) to those as identified by government scientists (historic identifiers). As one scientist summarized, the whole exercise of selecting sites was as “much an art as it is a science” (AS1 Meeting, July 10, 2014).

5.3.4 Bottom Types

One variable of considerable importance for matching paired sites was the ocean floor or the characteristics of the floor known as “bottom type”. Both fishermen and scientists participating in the project contributed knowledge regarding lobster habitat preferences or the tendency for lobster to be more abundant in relation to particular bottom types. For the purposes of the Abundance Project two primary bottom types were identified, “cobble” or “rocky bottoms” and “silt” or “mud bottoms”.

Although the importance of bottom type to sampling site selection was first raised at the June 13, 2014 meeting it remained a topic of particular concern because while it is clear that lobsters have preferences for specific bottom types, the details of this information is limited as demonstrated in the following exchange:

There are crude maps of the bottom and there is a project working on that. Multi-beam data is limited on the small scale. We have data on soft versus hard bottom but there has been interest from aquaculture on a far more detailed level (GS 1 Meeting Minutes, June 13, 2014).

During the July 10, 2014 meeting, focusing primarily on site selection, the importance of bottom types and using the bottom type as a control variable was raised again. As one fishermen commented:
The fishing is backwards to what it once was – nobody used to fish on the mud, now everyone fishes on the mud, they fish on the mud because the lobsters have to come across the mud to get there (F1 Meeting Minutes, July 10, 2014).

The topic of bottom types continued to be raised repeatedly during the first two years of the Abundance Project and the period of my data collection. For example, during a post Season 1 follow-up meeting in October 2014, a conversation was held on how the bottom types could be confirmed (Meeting Minutes, October 8, 2014). Options for confirmation included focusing on fishermen’s knowledge gained from both experience and the use of sonar equipment. Although the instruments varied between boats in the study, the sonar feature available on two of the boats provided a cumulative record of bottom types of areas passed over previously (i.e., each pass over is stored and held in the sonar memory). This information could have been used for verification work between field seasons; however it was argued by one of the academic scientists that this data might not be “fine grained enough”. Later, in the same discussion, however, the same scientist advocated for finding the opportunity to use vessel side scanner equipment for ground truthing the sites and recording bottom types (Meeting Minutes, June 29, 2015). This was a use of a technology with which he was more familiar.

5.3.5 Gear Types

The types of traps and the methods for setting them for sample collection were also determined early on in the Abundance Project work. A decision was made to set several traps at each paired site. Normal fishing traps baited with herring would be deployed one day and then retrieved, or ‘hauled’, the next day within a 16-24 hour period (soak time). Traps would be set at three sets of paired sites for each ABMA in 10
trap trawls (i.e., 10 traps linked together) with each trap separated by approximately 40 meters. Therefore, each captain was prepared to set or haul in 60 traps each field day. It was also decided at the July 10, 2014 site selection meeting however, that only two sets of paired sites would be used for ABMA 2a, as it was too difficult to find enough paired sites because of the complexity of variables to control for in the small area with such heavy aquaculture activity.

The fishermen’s experiential knowledge of the lobster industry extends into all aspects of their work and naturally includes their own experiences with the best trap designs for the areas they fish. Given the numerous sites to be sampled and thus the need for numerous traps to be deployed, the potential for variation in trap styles across the Project had to be considered. When asked about this factor with respect to experimental design, one academic replied:

My quick answer would be, in an ideal world you would use the same traps … but do I think that it’s critical to the outcome of the study? I would say no. Again, as long as [each of] our paired sites are dealt with the same traps (AS1 Meeting Minutes, June 13, 2014). Although the decision that fishermen would use their own traps was made at the beginning of the Protocol’s development, it was an issue that continued to be raised by project participants in future meetings and in one-on-one interviews. The topic was revisited in reference to the importance of employing strong research design to minimize potential bias in results. It should be noted there were similar discussions on the deployment of traps as singles versus trawls of traps because of ocean currents and tides. The state and amount of bait to be used (i.e. herring heads and tails or whole fish; frozen
or thawed) and size and style of bait bags were other issues discussed with respect to gear and research design.

5.3.6 Tides

Another variable discussed at length during Protocol planning meetings that became a topic of note was the selection of sites with respect to tides. The magnitude and the flush of the tides are by far the key significant ecological feature of LFA 36, making it ideal not only for lobster habitat but also for finfish aquaculture. In this particular case, participants extensively discussed the flushing of potential effluents from around aquaculture sites. As previously mentioned during the initial June 13, 2014 meeting, one government scientist referred to the unknowns around these tides as:

… this is an area of active research. Our models with multiple tides are still being tested…all this modeling takes a long time. We have dye data from a few sites but, not on a scale you would need. (GS1 Meeting Minutes, June 13, 2014)

This scientist went on to explain details of ebb and flow complications, temporal and scale issues, and environmental factors, which could have influence on outcomes using the dye tests\(^\text{18}\) results as examples.

The significance of tides as a protocol topic continued throughout the Abundance Project meetings, with one fisherman sharing how, in the past, he had even got into arguments with scientists who were conducting testing for tidal flush of an aquaculture area (Meeting Minutes, July 10, 2014). In the end, because of imprecise

\(^{18}\text{Dye tests are used to test the spread of treatments by following their pattern in the water.}\)
information on the tides, it was recommended by one of the scientists that for the purposes of the Project protocol, tides could be generally classified as “low tidal power, medium [or] high tidal flush”. He recommended: “Classify the areas and concentrate your study in the middle range” (GS1 Meeting Minutes, July 10, 2014). Sites were therefore chosen with an understanding they would fall into this middle range.

5.4 Implementing the Protocol

To examine the implementation of the procedures and practices that had been theoretically discussed and determined during protocol design and planning, data was collected from the field notes and on-the-water observations. It should be noted that one of the benefits of the participant observation nature of the study was that observers could communicate protocol matters between project stakeholders. For example, the observers could relay messages between the principle researchers “to give a call” to the fishermen about a start time or a request to speak about a protocol question thereby facilitating routine communication.

5.4.1 Start Dates

The timing for conducting the Abundance Project was contingent on three factors. The first and more practical factor was the awarding and receipt of project funding. Having the funding in place provided the ‘go ahead’ for several of the necessary protocol administrative steps such as hiring academic technicians and students, making arrangements with fishermen (securing boats, fuel, crew, etc.), organizing supplies (securing safety gear, measuring tools, etc.) and applying for and receiving research licenses. Also of note is that funding not only played a role in the
start date of the Protocol but also in the duration of the Protocol as indicated through this
email exchange of August 14, 2014 between project leads:

I wonder if we should try looking at the data and see if we should consider
the possibility of doing a fourth week in one of the locations. We were
initially thinking 4 weeks of sampling I think but likely reverted to 3 for
budget reasons (AS1 Email, August 14, 2014).

The second, and more rigid factor determining the study dates were the dates of
the 2014 and 2015 LFA 36 lobster fishing seasons. In both years of the study and
despite the protocol calling for as “early” a sampling as possible, ideally early July, the
actual study dates could not start until the fishermen, crews, boats and gear were
available after the regular fishing seasons were complete.

The final factor pertinent to the start date for sampling and, perhaps the most
important to the project design, was also the most difficult to determine. The study had
to be conducted when female lobsters would actually be in an ovigerous stage and
moving inshore so that they could be captured for sampling. There is such uncertainty
around their behaviour that even in Season 2 of the project, and even with the delay after
an unseasonably harsh winter, sampling was able to begin earlier than Season 1. Despite
this, however, very few lobsters were caught in the first week or so of sampling in
Season 2.

5.4.2 Deployment & Retrieval

The actual fieldwork for the Abundance Project was divided into two steps, the
deployment work done on day one of each week and the work relating to the retrieval of
the lobster traps the following day. The actual deployment work, or the setting of the
lobster traps in trawls, was assigned to three captains participating in the project and their crews. Each captain deployed and retrieved traps in one of the three ABMAs, the one closest to their regular fishing grounds, and traps were set as similarly as possible to how they would set during a lobster season. Trawls of ten (10) baited traps were set in ABMA 1 and 3a, and a trawl of five (5) baited traps was set in ABMA 2a. Using trawls, each trap was set at a relatively equal depth and distance apart at the pre-selected sites. The setting of traps took approximately two to three hours depending on the weather (e.g. fog, rain etc.), tides, crew availability, and the vessels and ABMA involved. For field Season 1 in 2014, the project was run over three weeks with six paired sites (one test and one control site in each pair) in ABMA 1 and ABMA 3a for a total of 60 set traps in each ABMA. Four paired sites were set for ABMA 2a for a total of 40 traps. In total, there were 140 traps set for Season 1 (See Table 5.1 below). Longitude and latitude of the trawls were recorded and buoys set at the beginning and end of each trawl to identify the trawls for retrieval the following day.

The retrieval of all traps was completed within 24 hours of deployment (soak time). The length of time spent on the water during retrieval days ranged from 3-4 hours to over 8 hours. Like the deployment days, the length of retrieval time was dependent on environmental factors but in addition, much of the protocol work took place on the retrieval days. Activities during retrieval days included steaming to the deployment sites and hauling up the trawl lines as would be done during a regular fishing season. Once hauled on board, traps were then emptied into totes or onto a measuring table. Measurements were taken of all specimens regardless of species captured. The Protocol, and the scientific license, indicated that no specimens would be
collected during the study and by far the majority of animals were either returned to the water individually after each measurement, or collected in a smaller tote and dumped overboard while steaming between sites. Nevertheless, as will be presented below, a limited number of samples were collected of female lobsters and both male and female crab species. This was particularly the case during the first field season.

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Figure 5:1 Trap Deployment and Retrieval Method

5.4.3 Data Collection

With the exception of one deployment trip, all other deployment and retrieval trips were observed by a social scientist in order to observe how the protocol worked on the water and knowledge exchange took place on the boats. One observation made early in the Abundance Project retrieval work was the large amount of data collection carried
out on the water. There was a great deal more involved than had been discussed at the protocol planning meetings, where it had been determined that sampling would include recording the numbers of lobster in each trap, the sex of the animals and the presence of eggs on females. Although comments had been made during planning that there could be some additional measurements taken during the handling of the animals, as the trap survey presented a rare opportunity to access lobsters out of fishing season, there was no formal agreement on additional variables to be documented. The full scope of the sampling that would take place was only stated just days prior to the first retrieval date.

On August 5th 2014, project participants received an email from the head of the academic technician and student team that explained:

In terms of sampling itself I have attached an outline of the data sheet to be used. We’ll be recording the entire catch, including any crabs (width + sex) or fish collected. For lobster, there are a number of measurements to take: carapace length, sex, egg stage, clutch size, abdominal width, mating status, cement gland development, shell hardness, and shell disease. The coding for these are all described at the bottom of the datasheet but I will include the sampling protocol (that have more detailed descriptions with photos) in case you want to look at these…(AT1 Email, August 5, 2014).

Participants were also told:

Aside from the measurements, we’ll also be taking egg samples from all berried females, retaining all the crab by-catch, as well as lobster with select criteria (will discuss tomorrow) [i.e. an orientation session for the academic technician and students that other project participants were neither aware of nor invited to attend] (AT1 Email, August 5, 2014).

While these additions took excellent advantage of the unique opportunity to conduct measuring and sampling of lobsters in the field, they also presented two changes to the protocol design that had not been foreseen nor discussed among participants. The first was a need for additional time to conduct data collection, as it was felt this detail of
measurement added significantly to the time that would be needed on the water. Any increase in boat time would cost more of the fishermen’s time than had been agreed to, not to mention the cost of additional fuel. While the addition of measurements was a unilateral decision by the scientists and one that was not initially disclosed or discussed with other team members, support was ultimately extended by other project participants, as explained in the following telephone conversation between project leads:

You know I called AT1 to talk to him about using the fishermen more [to take sample data], and AT1 agreed that was a good idea, but then AT1 sent out an email saying that they were going to need more science students on the boats if they were going to do all this extra work. That was when I sent the follow-up email saying: “And remember the fishermen can help” (Project Leads Teleconference, July 13, 2014).

Eventually the concern for additional workload was temporarily set aside when it was determined that much of the measuring and data collecting could be conducted when steaming between sample sites.

The second concern regarding the addition of measurements was the need for additional project data compilation. It was shared at the post Season 1 meeting on October 8, 2014 that a great deal of time was spent compiling and preparing the data. This became a matter of particular concern when throughout the fall and winter of 2014/2015 none of the additional data collected the previous year had been requested by any of the project partners. This came to light at a March 24, 2015 meeting when the academic student who had compiled all the measurements informed project partners that no one had even asked about the additional collected and compiled data from the previous field season. Given this lack of interest in the extra data being collected, it was decided during the March 24th planning meeting that going forward the additional data
would not be collected. It was also agreed that with the unnecessary measurements removed, columns on the data collection sheet could be used for recording other parameters of the protocol such as any observed aquaculture activity and the more specific site location information such as bottom type and coordinates.

Prior to the second field season however, the decision to remove additional data collection was unilaterally overturned by the natural scientists involved, and again, an email was sent out prior to the first retrieval day stating that the same measurements would be taken as in Season 1. When asked about this, it was explained that after speaking with members of his academic technician and student team who had been conducting the measuring on the boats, it was thought that the retrieval day was “only extended by ½ hour at the most” and that as a result it was “best to keep collecting the same data as last year as … it would be useful in the future if any of these indicators change” (AS4 Email, July 6, 2015).

5.4.4 Lobster Tables

Many lobster boats working in the Bay of Fundy are equipped with a workspace or ‘lobster table’ where the crew can sort, measure and band their catch. These lobster tables proved to be equally useful for the retrieval and measuring procedures of the Abundance Project and would later be identified an important juncture for bringing project participants together for knowledge exchange. Unaware of their purpose, however, during the first few field trips, academic technicians and students worked on top of the gear they brought on board and over lobster traps or totes holding the hauled samples waiting for measuring anywhere there was a partially flat and clear surface. It
was the captains and crewmembers with their experiential knowledge of boats and of handling of lobsters that ultimately suggested using the lobster tables. These were then used for the remainder of the protocol work:

…scientists used the traps and crates with their gear [as] a work table. The crew told them how the trap table was used during the fishing season, and then just hauled it [the trap] over and put it in place for them. They used the table for the rest of the day (Field Notes, August 7, 2014).

5.5 Reviewing the Protocol

A variety of teleconference meetings and email exchanges took place between the first and second field seasons of the Abundance Project. Analysis of the meeting transcripts and emails present a wide number of topics that were reviewed or revisited in relation to the Abundance Project original design and implementation procedures.

5.5.1 Selection of sites

Concern for appropriate site selection was ongoing throughout the protocol development and early project implementation. After the first field season, the following comment was made during an August 29, 2014 teleconference meeting between project leads:

…it appears that the match between site selected and site sampled may be the principal concern over the work we did this summer, so I would suggest we postpone [discussion of it] until we can meet at the same time with the fishermen that were at our meeting at FNFA headquarters and those that participated in the at-sea sampling…(AS1 Meeting Minutes, August 29, 2014).

At the end of Field Season 1 during an October 8, 2014 meeting with all participants to review the season and identify protocol issues that needed to be addressed prior to Season 2, a large portion of the agenda was devoted to the review of
the selected sites. Again, maps and charts were used as the gathering point for reviewing the sites selected and the placement of traps. Using a laptop computer and overhead projector, maps were reflected on the wall of the meeting room and each ABMA and the paired sites within them were individually reviewed. Participants weighed in on the appropriateness of each site and issues concerning the setting or placement of traps and/or the trawls at each site. For example, in reference to one pair of sites one fisherman stated:

Think we got what we hoped. Had to move Deadman’s because of the other test sites and a weir that is there – he wanted to avoid that. [Fisherman name]’s bottom would have been different (F8 Meeting Minutes, October 8, 2014).

Another exchange between a fisherman and a government scientist referred to another pair of sites:

Tides, there is a huge difference at each site.
How big are the differences? Don’t know what the impacts are.
It’s a hard job to figure out (F1 and GS2 Meeting Minutes, October 8, 2014).

Site selection was again raised during the October 8, 2014 follow-up meeting when a government scientist commented on the “need for homogenized types of bottoms”. As the discussion progressed, he commented on other variables that he felt should have been or could be considered in site selection, including: the ‘gradient effect’ (i.e. the sloping of the ocean bottom), tide differences between sites, and if aquaculture activity could be confirmed for the sites chosen (See below 5.5.3 Aquaculture Site Activity). These comments raised enough alarm that during a December project lead
teleconference an additional meeting was planned for all participants to again review all sites selected prior to the start of the second field season:

We should take time to go over the maps with the fishermen, where the trawls were set. Maybe we should reflect on the dots [i.e. charted locations] and see if we are still happy with them. It would be worth having this discussion (AS1 Teleconference Minutes, December 3, 2014).

Comments and evaluation of these protocol design choices were also collected from project participants during the one-to-one interviews. In general, however, outside of the site selection, interview respondents were in support of the protocol design such as conducting the study over several weeks and using the regular 24-hour soak time. They shared comments such as “24 hours is good” (AT2 Interview, November 13, 2014) and “Yup, that’s plenty in the summer” (F4 Interview, February 27, 2015). Concern remained throughout, however, as seen in this response to the protocol design by one of the scientist;

…we did the homework that we could with the information that’s available both from the modeling side and what fishermen know of the area, so I’m really comfortable there, but that still doesn’t mean that we did it well, that the information we had was adequate to get us to where we wanted to be and also there’s that little uncertainty, I think in regards to where we had initially identified the sites to be in relation to where the fishermen actually deployed because there was the two groups (referencing consultant fishermen and fishermen who did the work), so I think there’s still questions which is why again to me if we find a way to quantify effluents from aquaculture at our exposed and not-exposed sites, I think it resolves all kinds of challenges and limitations that are unavoidable in our study (AS1 Interview, February 13, 2015).

5.5.2 Mixed terminology

Another topic for discussion that became apparent while reviewing the project documents were the variety of terminologies used within the dialogue relating to the Abundance Project. For example, even with all time and information exchanged
between participants to arrive at the most appropriate sites for sample collection there remained significant ambiguity with regards to the meaning of the terms “near” and “far”. Early on in the planning it was decided that samples sites would need to be chosen in relation to aquaculture activity to measure the “…near field effects versus far field effects” (AS1 Meeting Minutes, June 13, 2014). At the July 10, 2014 site selection meeting, it was explained to the participants by the project leads that they were “looking for pairs of sites, one that is influenced and another fairly close that will not be/is not influenced” (FA1 Meeting Minutes, June 13, 2014). At this same meeting, it was stated that both exposed and not exposed sites were needed (AS1 Meeting Minutes, July 10, 2014). Three sets of terminology were being used; ‘near’ and ‘far’, ‘influenced’ and ‘not influenced’ and ‘exposed’ and ‘not exposed’.

During my first deployment trip on August 7, 2014, and speaking to the confusion over this terminology, the captain for the ABMA 3a asked me: “How near is near?” (F10 Field notes, August 7, 2014). The captain’s question identified an important gap in the site selection process. During all the discussion and exchange of site information there had been no mention of exact navigational coordinates. Aquaculture sites had been selected and effort made to clarify names for the sites, ensuring that names found on navigational maps or assigned because of local landmarks were understood. But deployment locations for setting the trap trawls were given only as either ‘near to’ or ‘far from’ the named aquaculture sites. No navigational coordinates or actual distances from the site were either operationalized or relayed. On the first day of deployment, the fishermen consulted with each other by cell phone to address the immediate problem of ambiguity. Together, they decided the captains
would place the trap trawls within their own personal measures of ‘near’ or ‘far’ from an aquaculture site and then plot and record the coordinates to ensure that they would deploy the trap trawls at the same locations on each sampling day going forward in the project.

5.5.3 Aquaculture Site Activity

Beyond the presence of known lobster activity and other variables, another important characteristic for site selection was the known presence of aquaculture activity. This variable, pertinent to the research question and goal of measuring the influence on the abundance of lobsters was not easily ascertained as presence of an aquaculture site did not necessarily mean an active aquaculture site. While most aquaculture site locations were indicated on maps or charts, opinion on how to confirm their active status was divided. On the one hand, fishermen were adamant that they are able to identify site activity and on the other, scientists felt that fishermen’s knowledge was anecdotal or at best a means for verifying information as reported by industry.

Although the province does, in cooperation with the aquaculture industry, provide some limited information on site activity it is not necessarily conclusive. Numerous husbandry and on-the-water practices such as the legislated requirement for site fallow periods do not always match the reporting as filed with the provincial department of Agriculture, Aquaculture and Fisheries. There are a few reasons for the discrepancies, including how the fallowing periods actually work in practice. Within each ABMA and operating on a three-year cycle, one would expect a fallow period for each site once every three years. However, in each fallow year, individual sites must
only be fallow for 6 months and collectively all of them within an ABMA must be fallow for 3 months. But because of the limits on the reporting requirements, there is no reporting on the individual site 6-month fallow periods, only the collective 3 months for each ABMA. The filing of site information with the province, indicating which sites have fish in them and what year class, can be delayed or out of date by the time it is made publically available as indicated by this representative from the Fishermen’s Association:

I’m hoping, if the province doesn’t have it, like they told me, this was the newest one [list of active sites] and if they think this is correct then what I’m going to do is call around to our guys in the area, and ask them to kind of ground truth it for me to see if that’s actually the case, because I know there are some sites on here that are stocked that are marked black [i.e. inactive] (FA1 Meeting Minutes, May 23, 2014).

Closer to the first field season, in mid-July (July 18, 2014) it was shared in a teleconference that additional information had been obtained from the aquaculture industry and the government concerning fallow periods for sites and some of the site activity, information that had not been readily available before that. During the call, it was remarked that this type of information could be used for triangulation between fishermen’s knowledge and other site attributes such as information collected on bottom types while on the water.

The level of concern expressed over the need for verification of aquaculture site activity was clearly seen by how the topic dominated discussion during a March 24, 2015 three-hour planning meeting. During this meeting, the fishermen were met with apprehension about the accuracy of their knowledge and were repeatedly asked how confident they were in saying a site was active. All of the fishermen at the meeting
responded with confidence that they would know an active aquaculture site and they even offered to develop a checklist based on the indicators they used for distinguishing a site’s activity (Meeting Minutes, March 24, 2015).

A potential third means for confirming site activity came from two of the social scientists. These scientists presented site activity information based on a compilation of data collected from two sources. First, they used data from the sediment sulphide concentrations reported to be underneath aquaculture sites. Unfortunately, similar to other aquaculture industry reporting practices, the data found was limited and not available after 2008. The second data source came from detailed graphics of sea lice treatment activities prepared by one of the social scientists. These detailed graphs were based on a sea lice application database compiled by the scientist using the aquaculture industry’s self-reporting treatment activity plans shared with both government and coastal community stakeholders. This reporting however, was also limited in its scope and coverage as treatments were subject to change for any number of reasons (e.g. weather). By the end of the March 24th meeting, it was agreed that the fishermen would take detailed notes of any aquaculture activities during the upcoming lobster season (due to start the following week) and would forward their observations to project partners so that a guide of aquaculture activity indicators could be developed.

19 Until 2008 this information was made publically available, it has since been removed from provincial websites.
5.5.4 Forgotten and Overlooked

During the planning meeting discussions, numerous options and solutions to design problems were raised by the Abundance Project participants, some of which were topics discussed in great detail that went on to become integral part of the Abundance Protocol. Other topics although considered at length, were “taken off the table” once they were determined to be unfeasible or of little value to the protocol. For example, in an ideal protocol design, each lobster trap would have been identical to control for any variation bias. Such an option however, was simply cost prohibitive or unfeasible. Participants would not only have needed to reach a collective decision on the design of the traps, but funds would have been necessary for the expense of both the materials and time necessary for construction. After detailed discussion on the matter it was agreed that such expense was simply not necessary. Research design practice suggests that as long as the traps set by each fisherman within each of the individual ABMAs were consistent in design, this would be sufficient to reduce potential bias in trap variations.

Other topics or decisions however, somehow failed to be either clearly “taken off the table” or fully adopted, which led to confusion or misunderstanding in the protocol design and eventual implementation. By way of example, early on in the protocol development, concern was raised regarding the potential for animal recapture if traps were being set at the same locations each week. A review of meeting transcripts and minutes identifies that some variation in the “v-notching” of the captured animals, a voluntary practice used to identify berried females during the regular fishing season, could be used. Once in the field however, there was no further discussion on the possibility of recapture or the v-notching practice. For clarification, the matter was
raised with the project leads by a social science observer during Season 1. An August 13, 2014 phone call highlights that not only was the potential use of v-notching completely forgotten but there was a significant difference in what participants had understood the v-notching practice to involve and what implications could result from such a practice during an abundance assessment. As explained during an August 13, 2014 phone call between project leads, from the technical team perspective, time spent v-notching would have taken away from their other measurement work and for the fishermen, the v-notching practice in general is a controversial practice as it removes the animal from the harvest pool until the fin regrows. In addition, the natural scientists believed that the step may not be necessary as in general the lobsters were migrating inshore while the traps were being set in the same locations for each sampling trip.

A second example of a forgotten protocol topic was the decision to use colour coded plastic ties on traps during setting. To account and monitor for potential trap tampering,\textsuperscript{20} it had been agreed that plastic cable ties would be used on each baited trap. The tie colours would be assigned at random for each deployment date so that would be ‘tamperers’ could not have replacement ties in the ready. A cut or missing tie noticed during retrieval for sample counts and measuring would indicate tampering of the trap. This solution, that was given consensus by all project participants very early on in the protocol development, was not only not practiced at all in the first field season but was

\textsuperscript{20} Trap tampering during soak time was a viable possibility as it is common practice for lobster fishermen to self-monitor out of season trapping activities on the water to discourage poaching. There are also individuals who may simply take from a lobster trap for their own supper.
not mentioned again until an incident caused some alarm. Even then, the use of ties was only adopted on one boat in the second field season.

In the end, neither the lack of v-notching or the lack of trap tampering precautions had any impact on the ability to conduct the measuring of lobster abundance, but these ‘forgotten’ topics highlight the potential for assumptions and lost communication during the process of stakeholders working together for knowledge construction.

A third example could have resulted in some delay in the Abundance Project and involved the matter of scientific licenses. The scientific licenses (see Appendix D) received to conduct the research outlined the parameters of what activities could and could not take place on board the vessels during the Abundance Project. In the license under the heading “Retentions” for the scientific study it states: “None. All lobsters collected will be returned alive to the water from which they were taken” (Fisheries and Oceans Fish Licence 2015c). During the first field season however, systematic collecting of specific female lobsters and a variety of both male and female crab species started as early as the first sample retrieval day. This sample collection, undertaken by the academic technicians and students, was brought to the attention of the project leads. The matter was quickly resolved when it was revealed that the scientific lead had been in discussion with government scientists and a ‘alternative license’ had been issued. This alternative license ‘attached’ the Abundance Project to an existing scientific and/or educational license held by one of the government scientists. Item 11 on that license provides for the retention of representative samples for scientific analysis in a clearly prescribed manner. This alternative license had been sent by email to the academic staff.
technicians and student team prior to the first field date, but not to the fishermen. This altering of the license was not only not shared with all the project participants including the project leads, but the technician teams who had been given copies for the captains forgot to pass them along. Had a Fisheries and Oceans enforcement officer boarded the vessel for inspection, whether on the water or once at shore, and the proper license had not been presented, there may have been a “slap on the wrist” for the captains with some retrieval work delay while the license was verified.

This entire process of the scientific license being altered was not only a unilateral and opaque decision made on the part of a few project members, but was also not communicated to the rest of the project participants. Even once discovered, the relevance of the license alteration to retain species samples was never clearly explained to project participants nor how the keeping of specimens related to the research questions of the Abundance Project. It was therefore decided, after Season 1, that only the Fisherman’s Association project partners would apply for and would distribute the scientific licenses for the second field season. Unfortunately, the confusion surrounding the license procedure continued into the second year of the study when the Fisherman’s Association was informed that the altered license had actually been issued in their name unbeknownst to them in the previous year and not in that of the government scientist as thought.

5.6 Participant’s Perceptions

To collect personal perceptions of the project, eleven open-ended, semi-structured interviews were conducted with at least one representative from each of
stakeholder categories (AS, AT, GS, GE, & FA). These one-to-one semi structured interviews were conducted in the months between the summer field seasons and asked participants for their perspectives of the protocol development and information exchange processes between project members. An open ended one-to-one format was used for these interviews to encourage participants to feel comfortable in sharing whatever opinions, concerns, comments etc. they might have had regarding any aspect of the protocol’s design or the Abundance Project in general.

5.6.1 Site Selection

Three of the eleven interview questions asked specifically about the site selection process and the chosen sites used for the Protocol. Respondents shared a range of opinions in response to the questions, focusing on the selected sites and placement of trawls near and far from aquaculture activity. Two of the fishermen spoke to one site in particular and raised their concerns about the placement of a sample collection site possibly being too near to aquaculture locations.

…the one beside Spider Cove, it’s at the mouth of the chops…I think that was one to be away and that’s fairly close to a site there…I don’t know what the distance would be but it’s not right next to it, but the flow of water would be coming out through there I believe so…that might be …if it was down the back side of Blisses or somewhere a little bit further away it might be better…(F8 Interview, February 27, 2015).

…but a site they wasn’t suppose to go in was put in, went in…[meaning a new aquaculture site]… ‘cause they done it [project deployment] right across from it on an active site but they were going to do that one as an experimental, to see what lobsters like were there…(F4 Interview, February 27, 2015)

Both the natural and the social scientist as well as fishermen’s association representative commented on the difficulty of the task to select sites and the constraints
placed on the protocol’s development by the limited information available both on local aquaculture activity\textsuperscript{21} and the impacts of aquaculture in general with a lack of data availability in the scholarly literature:

Unfortunately, we just didn’t have enough information about where stocking was going to take place, etc…And that’s part of the problem, I mean, I’ve been reading the literature that compares data with the data availability in Scotland, Chile and Canada in aquaculture. And, I also did an interview recently with someone who did, who was part of the toxicology group at [organization redacted] and he was very frustrated, in the published literature, that expresses some frustration that Canada doesn’t require public documentation of every, you know, cycle of chemical use, etc…so it’s harder for us to know. We’re getting some data now, I don’t know whether we can trust it but …(AS3 Interview, May 14, 2015)

The process was probably best summarized by a representative from the fishermen’s association who said, “I think it was hard, I think we did the best we could have done, we certainly spent a lot of time on it. I’m not sure if they were perfect but I don’t know if there are perfect ones.” (FA1 Interview, February 12, 2015)

The scientists interviewed expressed support for site selection through comments such as;

I think we did the homework that we could with the information that’s available both from the modeling side and what the fishermen know of the area so I’m really comfortable with that, but that still doesn’t mean we did it well (AS1 Interview, February 13, 2015).

Two of the natural scientists however, also responded with alternative methodological approaches that could have been used in lieu of the setting of trap trawls or in addition to their use. One spoke to the need to identify a means for quantifying effluents and the

\textsuperscript{21} The current reporting requirements placed on the aquaculture industry are limited and very little additional information is voluntarily shared.
other spoke to the use of trawl surveys to identify the ocean floor (Interviews, AS1 February 13, 2015 and GS2 May 4, 2015).

In response to these same questions on sites and their selection, the academic students and technicians (ATs) who, like the fishermen had on-the-water experience with the protocol’s implementation, used a language of comparisons to explain how trap trawls were placed between the ABMAs. Having worked on board the three different boats in each of the ABMAs, the ATs were able to compare the practices of each captain and how the trap trawls were placed in relation to near or far from an aquaculture site. For example, one AT explained that: “For BMA3 the boat went the furthest out – the ‘near’ might have been as close as the ‘far’ visually” (AT3 Interview November 21, 2014).

5.6.2 Berried Females

Another interview question that offered a variety of responses from participants was in relation to how they identified a berried female or the indicators they used to determine if a female was considered a berried female. All of the responses included some sort of reference to the presence of eggs (i.e., berries) attached to the underside of the females’ carapaces. In addition, the responses spoke to the colour of eggs, the developmental stage of the eggs, the clarity of the eggs, the release stage of the eggs and even the behaviour of the animals. While there was inconsistency between what participants used as indicators, it is also clear that knowledge was exchanged between participants about berried females. For example, one fisherman shared in answering about the release of berries:
Yes, they showed us, the student showed us the flippers, that their white in colour, they go almost transparent and that’s when their ready to release….there were a few good points that I learned that the students said (F8 Interview, February 27, 2015).

The use of a colour chart of the egg stages was also referenced by the ATs not just in the interviews but also in my field notes. Access to the chart was gained by the ATs through a fellow research student studying lobsters and located in the same lab area under the same academic supervisor at their home institution.

5.6.3 Aquaculture Site Activity

Because of the amount of discussion the topic of aquaculture activity had contributed to the information exchange during the Abundance Project Planning meetings, a question asking how or if individuals were able to identify active aquaculture sites was included in the one-to-one interviews. Similar to the meeting discussions on this topic, opinions differed greatly across the interviews. While the fishermen were adamant that activity could be clearly identified, the scientists spoke to a need for field observations in conjunction with industry activity reporting to confirm sites were truly ‘active’. The responses differed in that fisherman spoke to a set of unspecified but observable markers or indicators that they used to determine current activity. Interestingly, these indicators were raised later on in a project planning meeting prior to the second field season, where the fishermen not only volunteered to share their knowledge of indicators but to note observations in the field to help define these indicators more clearly.
On the other hand, scientists spoke to aquaculture activity on a temporal level. For the scientists, an active aquaculture site was not only evidence of current activity but also a measurable of activity over time, over past seasons of fish husbandry. An ‘active’ site was identifiable by the accumulation of activity over many years, taking into account periods of fish being housed in the cages and fallow periods where cages were left empty. The emphasis was not on the actual presence of fish at the aquaculture sites but on the accumulation of activity and the residual effects of the fish having been there in the past, such as alteration to the eco-system or left over detritus and debris.

Answering the question concerning the ability to identify aquaculture activity, one scientist clarified:

Active in terms of when we are there, I think you could do it visually but whether or not what you see on the bottom, if the condition on the bottom where the lobster is going to be, even though it’s not [currently] active but it was the year before you might still have the same condition, so I guess we cannot say for sure… There’s fish in there but, they go in a cycle, a four-year cycle, so if you’ve got a site that has been active for like twelve years the bottom will look quite different than a place that they are just starting, just been going for a few years… (GS2 Interview, May 4, 2015)

A second scientist spoke to the ability to quantify our understanding of ‘active’ through measurement:

That’s why I suggested I’d like to see if we could quantify something that [could] provide a more direct link to the effluents of the aquaculture sites, so along with the traps perhaps deploy something that might collect particles that could be emanating from the site (AS1 Interview, February 13, 2015).

These two very different understandings of an active aquaculture site demonstrate how different knowledge and understandings could be among project participants with respect to topics central to the development of the research protocol.
5.6 Conclusion

The systematic review of two years of Abundance Project protocol development and implementation meeting notes, email exchanges, participant interviews and field notes provided me with an enormous amount of data with which to work. In this chapter, I have tried to allow the data to ‘speak for themselves’, that is to highlight the topics that dominated throughout the data, to let them emerge and to emphasize what made them distinct or stand out among the vast amount of information collected.

In summary, there were three main subjects that stood out as key to the co-construction of a scientific protocol; the building or establishing of the protocol, the implementation of the protocol and the discoveries made about the Abundance Project’s protocol design and its logistics once the project was underway. Within these main topic areas several subtopics emerged that were specific to the process of information exchange between participants from different backgrounds and experiences. In the following chapter, the theoretical work presented in Chapter 3 will be used to facilitate an analysis of these topics and subtopics. The case study of the Abundance Project’s protocol design process will be used to demonstrate and discuss the exchange of knowledge between multiple knowledge holders and the necessary actions of knowledge for the co-construction of knowledge.
6. Analysis

6.1 Introduction

The catalyst for studying the Abundance Project’s protocol development was the concern shown by the fishermen of SWNB towards the apparent lack of uptake of their shared knowledge and expertise in fisheries-related, public consultation processes and subsequent resulting policies (Wiber et al. 2011, 2012). This is not an exclusive observation, but rather one felt by many resource users participating in stakeholder consultation processes (Ommer et al. 2012, Kloppenburg 1991, Ballard and Belsky 2010; Raymond et al. 2010 and Johnson and McCay 2012; Jasanoff 2003; Irwin and Wynne 1996; Wynne 1992). In fact, a significant body of work has been completed on the necessity for the engagement and inclusion of all stakeholders in the consultation processes for reviewing and addressing risk in resource management and the value of such input to outcomes (Corburn 2003, Wynne 2005, Armitage et al. 2011, Linke and Jentoft 2014). Within Canadian fisheries management, as in world-wide fisheries, this contribution is so well recognized that public policy development processes often mandate the inclusion of stakeholder knowledge through legislated procedures and consultation processes (Kraan et al. 2014). In fact, the federal Minister of Fisheries and Oceans Canada is granted the authority to enter into agreements with the provinces to assist consultation and engagement processes including facilitating communication between parties inclusive of “the exchange of scientific and other information” and public consultation with stakeholders (41.1 Fisheries Act, RSC, 1985, c F-14, s 41.1).
What is of particular interest is the gap between the work that speaks to the identified need and often required inclusion of stakeholder knowledge and the work that speaks to what successful or unsuccessful inclusion of local expertise means for final resource management decision-making outcomes. Somewhere in between these two areas of study, the requirement for stakeholder engagement and the successful outcomes of engagement efforts, there is the actual process of knowledge co-construction that does or does not take place when multiple knowledge sets are brought together. It is this process of knowledge co-construction about which little is known.

This chapter will attempt to address this gap through an analysis of the results collected from the first two-years of the Abundance Project. Specifically, this chapter will analyze the efforts of the multiple knowledge holders to build knowledge through the development and implementation of the scientific protocol needed for the Abundance Project. Dominant topics of knowledge exchange, identified in the previous results chapter, will be examined using the lens of theoretical work that explores expertise and knowledge contributions as well as arguments for the use of boundary objects and trading zones as discussed in Chapter 3. This examination will seek to fill the lacuna found in the literature by addressing how knowledge is co-constructed.

Application of a grounded theory method to compile and identify the protocol study data exposed key categories and sub-categories, or topics and subtopics, of knowledge exchanged between project participants. To simplify the presentation of the study’s results, the data were presented linearly, highlighting three sequential steps in the protocol’s development and implementation (i.e. the protocol design, the protocol implementation and protocol review). Again, it must be acknowledged that although
there was a natural progression to the protocol, in reality, its development and implementation involved a great deal of moving back and forth between the many stages of design, planning and application.

Rather predictably, dominating the topics of information exchange was the overall design of the protocol with its many detailed subtopics pertaining to the who, what, where, when, and how of the project. Specifically, the subtopics included subject areas such as the research methods chosen for the protocol (i.e., paired sites vs. transects), locations for the study or the protocol boundary areas (i.e., ABMAs), the characteristics or variables of the data collection sites (e.g., bottom types, tidal ranges), the tools for the data collection work (e.g. gear types, trap design, and bait bag styles), the identified data to be collected (e.g. sex, carapace length, fertility) and the fieldwork activities for trap deployment and retrieval needed for animal collection (e.g. setting ten trap trawls, recording of coordinates for deployment, 24 hour soak time). A second topic of importance identified in my study results was the management of the protocol and relating subtopics such as when to conduct the work (e.g. operational start dates), data collection coverage (e.g. how much data to collect), negotiating resources to conduct the work in the field (e.g. data collectors, scientific licenses, lobster tables, etc.), matters of communication and miscommunication (e.g. email exchange, group phone messages) and who was and was not at the table and why (i.e., stakeholder groups).

It is through a detailed examination of the knowledge exchanges between project participants over, through and around these two dominant topics (protocol design and protocol management) and their respective sub-topics that an understanding of how the scientific protocol for the Abundance Project was developed. Therefore, it is through
reviewing these exchanges that the *how* of knowledge co-construction can be better understood.

**6.2 Who is constructing knowledge**

To address the necessity for and value of multiple knowledge sets for the co-construction of new knowledge, the three project leads for the Abundance Project, a social scientist, a natural scientist and executive director of a fishermen’s association, actively sought to include multiple stakeholders in all aspects of project’s development and implementation. A very concerted effort was made on their part to ensure communication with and invitations extended to all participants representing the stakeholder groups; academic natural and social sciences (AS), government scientists (GS), academic research students/research technicians (AT), fishermen – captains and crews, retired and working (F), and fisheries association representatives (FA). Representatives from these various social worlds were included from the project beginning, starting with the identification of the research question, through to the protocol’s design details and on to the implementation and even going forward into results interpretation and evaluation. While the specific representatives from these groups shifted somewhat throughout the course of the two-year study (e.g. different fishing crew between field study years) the overall knowledge sets they represented were always present.

**6.2.1 Social worlds present**

These stakeholder groups and the knowledge sets they contributed were particularly significant to the development of the protocol. The experiential knowledge
of the fishermen was given ‘cognitive authority’ (Collins and Evans 2002) and was respected by those with alternative technical or scientific expertise. As well, there was a willingness on the part of individual participants to be open to listening and learning from each other. Regardless from where their expertise was gained (experiential accumulation, local knowledge or study in the natural and social sciences), participants were able to defer to other areas of expertise. For example, the fishermen were willing to turn to the scientists for explanations on lobster biology, while the scientists actively sought the fishermen’s understanding of lobster behaviour. In addition, both the scientists and fishermen deferred to students/research technicians with their firsthand knowledge of the measuring tools for the work onboard the boats. For example, during a July 14, 2015 retrieval trip discussion between one of the ATs and a fisherman, the technician was asked about the berried females taken as samples and what information was gained from the sampling work. The fishermen asked the AT for a printout of the egg stage identification tool being used, adding “…maybe then I can better educate myself” (F6 Field Notes, July 14, 2015).

While this willingness to fully acknowledge each other’s expertise did not extend to all aspects of the protocol’s development and implementation (e.g. lack of agreement for a definition of an active aquaculture site), examination of the person-to-person information exchanges in meetings minutes and transcripts, email exchanges and in-field note observations demonstrates that it was not necessary for all participants to hold to or agree on the exact same knowledge but rather that there was mutual respect between participants. This respect for knowledge sets between project participants (including between members of the same social worlds) was often demonstrated during
the discussions held on project variables such as trap design types or bottom types.

During the December 3, 2014 planning meeting between project leads, the same meeting where enough concern was raised about site locations to instigate an additional planning meeting to revisit site selection, the value given to fishermen’s knowledge on bottom types was highlighted.

...The bottom is too hard, so they are using single traps so they don’t get caught on the aqua moorings, bottoms, etc. [name redacted] wanted to know if we could standardize the difference between the single traps.

... this is the same type of question as the amount of bait… [we] would defer to asking the fishermen, … would hope that we had selected the bottoms appropriately so that they were paired (Meeting Minutes, December 3, 2014).

6.2.2 Social worlds not present

While most of the relevant stakeholder groups with interest in the Abundance Project work were invited to participate, it is important to address the fact that a significant stakeholder group was not present, the aquaculture industry. The exclusion of such a prominent stakeholder in an aquaculture related study was by no means an oversight but the results of a great deal of discussion and debate raised repeatedly throughout the Abundance Project development. Much of the debate centered on the practicality and politics of working with such a dominant stakeholder who currently holds a position of privilege, whether it be real or perceived, with regulating bodies (e.g. see Section 13(1) of the federal Aquaculture Activities Regulations that permits industry the privilege of self-reporting of any fish morbidity or mortality outside the aquaculture facility within 96 hours after any application of chemical treatments (Aquaculture Activities Regulations, SOR 2015-177 s 13).
An even greater influence contributing to the debate to include or exclude aquaculture industry representation were the past experiences of stakeholders in similar projects where their individual knowledge sets were neither acknowledged nor accepted. Throughout the planning meetings fishermen, as well as scientists, shared their past negative experiences of working with the aquaculture industry such as being excluded from the results dissemination processes on joint projects or having project results expediently challenged by counter studies.

It should be also be acknowledged that while the decision was made not to invite the aquaculture industry to participate in the Abundance Project, this did not mean that the industry or other coastal community stakeholders were not informed of the project. In fact, during the summer of 2014, during a joint government aquaculture industry meeting the project lead from the fishermen’s association shared that the Project was underway as well as a list of the selected sites where trap trawls would be set (Meeting June 29, 2014). Other groups and individuals made aware of the project were regional fisheries organizations including; the Traditional Fisheries Coalition (TFC), Grand Manan Fishermen’s Association, Fish Food and Allied Workers (FFAW), the herring industry (including the processor company Connor Brothers) and representatives of the Atlantic Canada Fish Farmers Association (ACFFA). These groups were informed either through project participant attendance at meetings held by these organizations, phone calls to targeted individuals or by asking the provincial Department of Agriculture, Aquaculture and Fisheries (DAAF) to disseminate information on the Abundance Project’s behalf. One additional means of informing the fishing community not directly involved in the Project was through the lobster fishing association’s
newsletter which, even if not received by all fishermen in the area, would certainly get
the word out. First hand evidence of the newsletter as an effective means of
communication was witnessed at the end of a retrieval day when, during cleanup an
older man on the wharf asked one of the fishermen what was going on and that he had
read about a similar project...

…[he] wanted to know if this was part of it. F13 explained, no that was
different, (indicates with his hands) that was the flatter traps. When asked
what this was then F13 said “well we call it the berried female project”,
“…it’s about finding out if the females are coming in anymore with their
eggs, closer to where there is aquaculture, or at least that what I tell people,
that’s what I think it is anyway…” AS5 says “Yes, that’s pretty much it or a
major part of it” (Field Notes, July 28, 2015).

6.3 What is being co-constructed - knowledge

Even though knowledge co-construction is both highly valued and desirable, it
remains a process about which there is still much to learn (Calberg 2005; Carolan 2006;
Carr 2004; Cash et al. 2003; Clark et al. 2001; Collins and Evans 2002, 2007; Corburn
2003; Funtowitz and Ravetz 1993; Irwin 1995; Johnson & McCay 2012; Johnson & van
Densen 2007; Leach, Scoones and Wynne 2005). The literature addressing knowledge
co-construction commonly speaks to concepts concerning who holds knowledge, how
the utility of that knowledge should be shared and the necessary conditions for the co-
construction of knowledge. As alluded to previously however, there is a key piece
missing from scholarly work. What is not found in the literature is a clear definition or
description of how ‘knowledge’ is actually co-constructed.

Although knowledge is acknowledged to be a ‘multifaceted concept’ (Nonaka
1994:15) with multiple distinguishable types (tacit, experiential, explicit, procedural),
the term ‘knowledge’ as such, has not been operationalized. Turning to a dictionary

121
definition, however, it is clear that knowledge is in fact described as much more than the obvious “store of facts” implied by the literature. Knowledge, instead of being characterized as a ‘thing’, is actually revealed to be composition of a set of actions. Knowledge involves “understanding of data, establishing relations, elaborating concepts, formulating principles and making evaluations” (Funk and Wagnall 1989). Such an action-oriented definition of knowledge plays an important role in filling the gap in the literature on the co-construction of knowledge. Remarkably, such a definition does not impose any valuation on ‘knowledge’ such as correctness or truth, nor does it attribute the holder of knowledge to be any particular individual or types of individuals. Equally, there is no indication that any one of the actions listed is more prevalent or necessary than the others, nor does it determine a need for all of the actions to take place in order to have knowledge. Further, there is not any order in which the actions must occur. Because of this lack of hierarchy, order or inclusivity, knowledge can be conceptually depicted as a loosely demarcated circle with the various actions distributed within (See Figure 6.1).
Figure 6.0:1 Actions of Knowledge

This action definition of knowledge plays an important role in helping to shed light on the ‘how’ of knowledge co-construction. In the following section, drawing on numerous aspects of the Abundance Project, namely the selection of a survey methodology (trap survey or transects) and the selection of the data collection sites, I will illustrate what is meant by ‘actions of knowledge’.

6.3.1 Establishing Relationships

From the very beginning of the Abundance Project, one of the means used by stakeholders to define the key research question was through the identification of relationships understood to exist between the aquaculture industry and the lobster population within the research area. For example, during an initial project planning meeting attended by the Project’s social and natural scientists, the effects from
aquaculture activity were identified to be either ‘near field’ (close to the aquaculture cages) or ‘far field’ (some distance away from aquaculture cages) (Meeting Minutes, June 13, 2014). Examples of ‘near field’ effects could include the sea floor conditions under aquaculture cages (eutrophication, sulphides, surplus feed, in-feed pesticides) or the residue from net anti-foulants or pesticide bath treatments. Examples of ‘far field’ effects would be chemical plumes (from pesticide bath treatments) and surface oil slicks. The implications of any of these conditions or ‘effects’, whether near or far afield from aquaculture sites, were discussed in terms of the relationships between the aquaculture activities and the lobster population such as changes in juvenile growth rates, female egg clutch health or incidents of premature molting. Examining the details of the information exchanged between project participants on these topics, it is clear that both scientific knowledge and local knowledge drew on stakeholder understanding of relationships between aquaculture activity and the lobster population.

Efforts to establish relationships (i.e. between the variables) for building understanding and knowledge are demonstrated in the dialogue and information exchanges of the June 2014 planning meeting. Aside from broad movements inshore in summer and offshore in winter, it was clear from the discussion that little is known about female lobster abundance at particular places and times of the year, and consequently, potential patterns of their exposure to aquaculture. An oceanographer participating in the project was asked whether ocean current patterns and tides could help to discriminate between areas with a high likelihood of aquaculture impact and areas with limited or no impact. The oceanographer responded with a series of unknowns and difficulties concerning the identification of zones of influence.
[This] is an area of active research. Our models with multiple tides are still being tested—then you get into the bottom situation—then storms, wind, all this modeling takes a long time. We have a dye data from a few sites, but not on a scale you would need. [Aquaculture] development is going so far beyond what information we can provide (GS1 Meeting Minutes, June 23, 2014).

The oceanographer went on to outline further unknowns, including the effects of tides, wind, temperature, bottom conditions and variation in aquaculture site management. The identification of these information gaps concerning ocean patterns and aquaculture practices, as well as the biology and behaviours of lobster, highlighted the importance of establishing relationships for knowledge creation. To build knowledge, the scientists and fishermen recognized that they needed to establish a research question that would allow them to move forward with their research goal (i.e., understanding potential risks from aquaculture in the fishing grounds) while still acknowledging the unknown relationships between potentially influencing variables. Therefore, the decision was made to focus on assessing one unknown, the relationship between female lobster abundance and aquaculture activity.

As demonstrated at various points throughout the Project, stakeholders drew on their own knowledge sets to understand relationships. The biologists in the project turned to scholarly literature speaking to the relationship of some sea lice pesticides leading to premature molting of ovigerous females, resulting in the loss of their clutch of eggs (Burridge et al. 2003; Waddy et al. 2007). Fishermen, in comparison, referenced their experiential knowledge of the relationship between lower rates of spawning lobsters near active aquaculture sites undergoing chemical treatments (Meeting Minutes, May 22, 2014). Working together however, biologists and fishermen drew from the
knowledge exchanged concerning relationships between aquaculture and lobsters to develop an appropriate research question for the problem at hand.

A second example of establishing relationships can also be taken from the June 2014 planning meeting where, with the research question identified, initial dialogue began on the selection of an appropriate methodology to measure aquaculture’s influence on ovigerous lobster abundance (Meeting Minutes, June 2014). With a limited understanding of lobster migration, combined with the time and resources available for the project, the group agreed that a paired site trap survey would be best for evaluating relative abundance.

The placement of traps for collecting samples within the proximity of active aquaculture sites paired with an equal number of traps in similar conditions set further away from the ‘zone of influence’ (i.e., control sites) was given preference over the alternative proposed method of deploying transects directly underneath aquaculture sites. This decision to apply a paired site methodology was directly related to the lack of understanding surrounding relationships.

It’s important that we set this up [right]. If we have one fish pen with 1000 traps we would only know about one pen. It’s important that we replicate in a way that lends support. Especially [A]BMA 2, they are too close together [i.e. aquaculture sites] so it’s hard to say that the effluent is from a specific site. There is a small area with quite a bit of flushing – we are really going to want to look at a few [A]BMAs – 3 is better because they are spread apart (AS1 Meeting Minutes, May 22, 2014).
In addition, the use of transects has been critiqued in similar work done in the past. As pointed out by one of the scientist, exposure can vary across sites and across the phases of aquaculture production\textsuperscript{22} so a transect model would lack robustness.

6.3.2 Elaborating Concepts

In addition to establishing relationships, knowledge requires the building of concepts of common or shared understanding. As suggested by Nonaka (1994:20) where diverse participants share knowledge, concepts are articulated and developed ‘until they emerge in a concrete form’. For the Abundance Project, this emergence of concepts was demonstrated in the process of identifying collection sites for survey trap placement during the July 2014 planning meeting. With stakeholders gathered around maps and nautical charts in order to discuss and select appropriate sample collection sites it soon became obvious that several different sets of knowledge meant several different mental images or generalized concepts were at play.

On the one hand, some of these conceptual variations were unproblematic. For example, the identification of aquaculture sites and potential trap survey sample locations varied in two conceptual ways: fishermen referred to local names and geographic reference points (e.g. St. Andrews Bay) while scientists referred to official names as they appeared on government maps and nautical charts (e.g. Passamaquoddy Bay). Never utilized in either discussions, or future correspondence regarding site

\textsuperscript{22} Aquaculture sites in SWNB are operated with a “framework of Aquaculture Bay Management Areas, and all farms are single-year class operations, stocking every three years, with mandatory fallowing between successive crops” (Chang et al. 2014:1) thereby creating ‘phases’ of aquaculture production.
locations, were the provincially assigned aquaculture lease numbers used for aquaculture site identification. Although these concrete identifiers would have provided clarity, neither fishermen nor scientists are familiar with these site numbers. While the variation in the geographical conceptualization (i.e., the different names) slowed discussion down somewhat to ensure everyone was following the conversation, it did not require arriving at a common conceptual language.

Conversely, other concepts did clearly require a common understanding. One example in particular was the notion of the setting of traps ‘near’ aquaculture sites (i.e., test sites) and ‘far’ from sites (i.e., control sites). Even with all the careful selection and deliberations for the site selections it was not until the fishermen were on the water ready to physically set the traps for the first time that they found they had insufficient information as to what the biologists and other project participants meant by ‘near to’ or ‘far from’ aquaculture sites. How far is far and near is near? The problem of trap deployment was resolved however when the fishermen found on-the-spot solutions through discussions among themselves via cell phones, consultation with the academics and technicians on the boats, and the use of GPS waypoints. Together they were able to settle on site coordinates they were comfortable with and that were used consistently for sampling in the first and in subsequent years of the project.

Even with this operational solution in place, what was meant by near and far however, was never clearly conveyed amongst participants. It was not near and far in the sense of distance or proximity to active aquaculture sites that was at issue, but the matter of how near or far aquaculture effluents traveling through an area, including tidal factors, were to lobster habitat.
Other examples of important conceptual understandings that required shared understanding were control variables in relation to the collection sampling sites such as; tides types (e.g. big tide and good flush), ocean bottom types (e.g. cobble and sand), or traps styles (e.g. individual fisherman’s design) and bait bags (e.g. size and mesh counts). For the sake of robustness for the protocol, it was important that understanding of these concepts was shared, however reconciliation of different concepts for the same phenomena was not always readily achieved. For example, during the October 8, 2014 wrap up meeting reviewing the procedure for collecting bait from the local supplier, the scientists raised concern over the consistency in baiting process in general (e.g. mesh size, weight or bait, size of bait bag, etc.). During the discussion it was revealed however, that among the fishermen there existed an implied understanding around this concept.

6.3.3 Data Interpretation

Using the abundance data, or lobster counts, collected and recorded from the trap surveys on their own would not be sufficient to draw conclusions regarding the relationship between aquaculture activity and lobster abundance. Data requires interpretation, another action of knowledge. With respect to interpretation, one problem in relation to the data that only became obvious as the project moved from protocol design to implementation was the need for greater understanding of the actual aquaculture activities taking place at the selected sites. To speak to the potential impacts and draw conclusions with respect to abundance results required details of site activities. Unfortunately, although the sites selected were all deemed to be ‘active’, the
particulars regarding the actual activity were not publically available. Provincial regulations require that sites be stocked on a three-year rotation and that each ABMA have a period of up to three months when all sites within the ABMA must be in fallow at the same time (Chang et al. 2007). In an effort to demonstrate transparency with respect to this mitigation measure, the province issues maps on stocking details for the AMBAs and the aquaculture industry releases limited pesticide application information on the chemicals to be used and the days of treatments. When stocking information is compared to data on pesticide treatments however, there are clear discrepancies such as ‘inactive’ sites receiving pesticides. There may be numerous reasons the provincially designated production cycles are not followed (e.g. weather delaying pesticide application dates). Unfortunately, for the purposes of the protocol, it raises the question of whether the site status is active or inactive, not to mention the activity itself. Responding to this data issue, the fishermen raised several times that they were confident they could provide the details needed to determine is a site was stocked or not. Activity confirmation could be gained by using their knowledge of indicators such as the presence of bird nets and the use of other predator deterrents at the sites, feed boat activity around cages and aquaculture preparation activities on shore prior to going to the sites.

There are different types of pollution depending on the year and the stage of aquaculture. Fishermen can provide info on the date a site is stocked, and the date they take the fish out. This would help us to understand the stage of pollution the site produces – first year when the pesticide is in the feed – second year where they give pesticide baths and third year when the site is fallow (FA1 Meeting Minutes, October 8, 2017).
As seen in the following comments however, the biologists felt visual indicators alone was not sufficient as conceptually they defined ‘active’ using a temporal definition requiring detailed site information over numerous years even beyond the three-year grow out period.

I had no idea this would be so complicated - just to figure out when fish were, where and at what age. I thought that would be extremely straightforward and uh, clearly it isn’t and then so I think there is still clarification to obtain there (AS1 Interview, February 13, 2015).

Well, to be active in terms of when we are there, I think you could do it visually but whether or not, like what you see on the bottom, if it’s the condition on the bottom where the lobster is going to be then even though it’s not active but it was the year before you might still have the same condition, so I guess we cannot say for sure… they [aquaculture] go in a cycle, a four year cycle so if you’ve got a site that has been active for like twelve years… the bottom, I mean will look quite different then a place that they are just starting, just been going for a few years...(GS2 Interview, May 4, 2015)

Although it was less than ideal, and faced with limited options, the data from the provincial sources on stocking, in tandem with the industry provided information on activity, were used to indicate site activity. It may very well be that this decision will lead to further difficulties when it comes time to interpret the survey results (Meeting Minutes, March 24, 2015).

6.3.4 Formulating Principles

Principles are accepted understandings that serve as the theoretical ground rules, or building blocks, on which further knowledge can be built. During the Abundance Project’s protocol development, discussion of several ecological principles can be identified within meeting minutes, boat observation field notes and even early trap survey results. For example, drawing on DFO data that suggests lobster inshore
migration generally begins in early April, the biologists spoke to lobster migration patterns speculating on large-scale phenomena such as climate change and its effect on the potential distribution of female lobster (e.g. Steneck & Wahle 2013). In contrast, the fishermen reported that spring migration comes in waves and females and males do not enter inshore waters at the same time, for example: “… if it was at the spring of the tide, that’s when we start to first put up, that’s when you’ll get your biggest catch and at the peak of the fullest tide” (F4 Interview, February 27, 2015). Additionally, the fishermen shared that water temperature affected the timing of the lobster movements as seen in this exchange between two fishermen in relation to when to run the protocol:

What is the best time to get the best lobsters, is it right after trapping? Or wait for a bit while everything crawls in a little bit more or … ‘Cause the season runs to the 29th [of June] and their just starting to crawl, you know what I mean…

…especially this year with a cold spring (F6 & F1 Meeting Minutes, March 24, 2015).

In effect, many potentially relevant principles including ecosystem change, lobster life cycles and vulnerabilities, and sub-lethal impacts of long-term exposure are linked to unknowns around climate change and related patterns of changing lobster behavior. Many of these unknowns were discussed throughout the project’s development and implementation; however, they were not set out as ‘principles’ on which further knowledge could be built. As a result, as the Abundance Project moves towards the end of its data collection phase and interpretation begins in earnest on the trap survey results, it is clear that time spent establishing and identifying underlying principles prior to the protocol’s development would have been of great benefit to the project. Established principles would have provided a foundation on which to build
results interpretation. Instead, there is a need to back peddle and identify and revisit principles to ensure project participants are on the same page.

6.3.5 Making Evaluation

Finally, knowledge requires the action of evaluation. Evaluation involves identifying data that indicates relationships (e.g. aquaculture affects lobster through X and Y pathways) and then assessing the impact of those relationships for consequences (e.g. the effect on lobster stock health and on the economy of the fisheries). Revisiting the research objectives set for the Abundance Project and the Project’s place in the wider SSHRC Risk Project, a question that must be addressed during data analysis is how to evaluate the level of risk represented by the results collected. It must be asked, “What does the knowledge gained from this work contribute towards understanding risk?”

If the co-construction of knowledge is to bridge objective and subjective perceptions of risk, then collaborative evaluation of relationships is important. Stirling (2012) argues that objective risk measures will work best where our knowledge about the possibilities and likelihoods of outcomes is unproblematic. Unfortunately, the possibilities and likelihoods of the potential impacts on humans and the environment are very problematic for the most part. To adequately address risks, Stirling (2012) argues that approaches to risk and uncertainty should foster collaboration, learning and an understanding of the values and priorities of the relevant stakeholders. The Protocol Study, however, demonstrates how difficult this can be. In fact, evaluation will be affected by even greater influences ranging from the political climate of the day to the
scale at which the data is evaluated. In a provincial political climate that supports the
growth of the aquaculture industry with its promise of employment opportunities, added
to a few good years of lobster population growth, any impacts that aquaculture activity
may have on lobsters may be considered trivial for overall lobster abundance. At the
local level however, the lobster fishery of SWNB, the study site for the Abundance
Project, the growing aquaculture industry footprint is geographically limiting access to
prime lobster nursery habitat, a key factor identified in risk assessment. If this is
considered in tandem with the steady declines in other commercial species (e.g.
herring), it highlights an increasing reliance on the inshore lobster fishery for
livelihoods. Evaluation is demonstrated to be a multifaceted process as impacts that
may seem acceptable to the aquaculture industry are simply not acceptable to those
reliant on the inshore lobster fishery (Wiber et al. 2013).

6.3.6 Value of a Knowledge Definition

Establishing a definition of knowledge, and in particular, a definition that
directly addresses the actions of which it is composed (i.e., establishing relationships,
building concepts, interpreting data, confirming principles and making evaluations)
provides a missing piece necessary to speak to the question of how knowledge is co-
constructed between social worlds. Understanding what is meant by ‘knowledge’
strengthens previous theoretical arguments. A definition of knowledge fills the gap
between the work that recognizes a need for knowledge co-construction and work that
identifies what successful knowledge co-construction contributes to informed decision
making.
6.4 How is knowledge co-constructed

Developing an informed understanding of knowledge co-construction is feasible when we have an understanding of what composes knowledge (i.e. necessary actions). Specifically, the actions of knowledge can be used in combination with knowledge exchange theories to speak to how knowledge is co-constructed. The broader concept of trading zones (Collins, Evans and Gorman 2007) that examines the power struggles between social worlds during knowledge exchange is informative. Particularly insightful is the Star and Greisemer (1989) work on boundary objects as mechanisms through which knowledge is exchanged. The results from the Abundance Project’s protocol processes of survey methodology selection and the selection of data collection sites can be used to demonstrate how combining boundary object theory with an action oriented definition of knowledge can inform our understanding of knowledge co-construction.

6.4.1 Trading Zones & Boundary Objects Revisited

At this point in the discussion it is important to briefly revisit the boundary object work presented in Chapter 3. Trading zones are the points of information exchange that are cooperatively reached between social worlds. Information can be exchanged between the larger collective groups even if individual sub-groups hold their own sets of knowledge or understanding (Galison 1997). Trading zones speak to a broader concept of the power at play between social worlds, ranging from coercion to collaboration, and the sharing of culture ranging from homogeneity to heterogeneity during the exchange of knowledge (Collins, Evans and Gorman 2007). Combined, these attributes create arenas for the exchange of knowledge ranging from enforcement (the
domination of one group’s understandings being imposed on another), to a type of
fractioned trading zone that includes both collaborative and cultural diversity exchange.
Collins, Evans and Gorman (2010) argue that fractioned trading zones include boundary
objects (see Figure 6.2).

![Figure 6:0:2 Boundary Objects within Trading Zones as points of knowledge exchange](image)

As discussed previously, boundary objects are specific “things, places, ideas, etc.” that are shared between or serve as a point of exchange between social worlds (Star and Greisemer 1989:393). In any application of boundary object arguments, it is
important to note that while Star and Griesemer (1989) identified four types of boundary
objects within their work; repositories (e.g. a library), ideal type (e.g. an abstract
diagram), coincident boundaries (e.g. geographic region with same boundaries but with
different internal contents), and standardized forms (e.g. forms used to collect data by
filling in specific fields) the authors clearly emphasized that these types were by no
means exclusive. This is an important point to acknowledge when seeking to identify boundary objects within a specific context of knowledge co-construction so as not to be limited to these four archetypes.

In addition, as emphasized in Star’s later work (2010), the architecture of boundary objects is in fact inclusive of three components. While most literature and application of boundary object arguments acknowledges interpretive flexibility (i.e. the ability for objects to hold unique meanings for each social world individually yet still hold a loose but collective meaning between multiple social worlds (Star & Greisenem 1989)), two other features are also important; the work processes and arrangements (the material/organizational structure of boundary objects) and the characteristic of ill-structured and well-structured boundary objects that allow for the tacking back and forth between meanings (the scale/granularity of boundary objects) (Star 2010).

6.4.2 Bringing Knowledge Actions and Boundary Objects Together

The results from the Abundance Project provide an insightful example of knowledge co-construction by examining boundary objects through the lens of knowledge actions (i.e. understanding of data, establishing relations, elaborating concepts, formulating principles and making evaluations).

During the course of the Abundance Project’s protocol development, numerous “things, places and ideas” (Star and Griesemer 1989) emerged that can easily be identified as boundary objects (maps, selected sites, lobster table, female lobsters, etc.). These boundary objects served to facilitate the translation of project information between stakeholders. To ensure that protocol development and implementation matters
and that decisions were addressed jointly, the exchange of knowledge between stakeholders was both essential and needed to occur continuously (Cash et al. 2003). In addition, the stakeholder groups or social worlds represented in the Abundance Project, needed to be able contribute their own unique area of knowledge or knowledge sets. The fishermen, both retired men serving as project consultants and those currently fishing, often contributed understanding on topics as diverse as: ocean tides and currents, lobster behaviour, ocean floors or bottom characteristics, make up and uses of fishing gear, and practical on the water operational logistics. The academic scientists, government scientists and academic or research technician contributions of information related to matters of ecology and ecosystems, lobster habitats and biology, ocean tides and currents, research methodology and similar. And, the fisheries association representatives were able to speak to similar ecosystem and biological topics as well as contributing important information concerning fisheries legislation, knowledge of aquaculture activities (e.g. treatment dates), and other information about research or fisheries activities in the area that would inform particular project decisions such as potential sites that would be inadmissible for sampling. Examination of the knowledge exchanges between participants identifies the presence and use of numerous boundary objects.

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23 It should be noted that knowledge sets were collective understandings shared by stakeholder groups. There is no attempt here to say that all stakeholder members of any particular group held exactly the same knowledge. Knowledge sets held by stakeholder groups were also by no means exclusive to each group, many participants had a great deal of knowledge on a wide range of project related topics.
6.5 Knowledge Actions Applied to Boundary Objects

To facilitate the discussion, this section will highlight only a few of the more prominent boundary objects identified within the Abundance Projects knowledge exchange; however these are by no means exhaustive.
6.5.1 Establishing Relationships (Impacts of Aquaculture on Female Lobsters)

One of more exhaustive topics of discussion between stakeholders was that of site selection for the project protocol. The identification of the sample sites for deployment of lobster trap trawls for retrieval and collection of lobster sample was particularly important. Once chosen, these sites would serve for the sample collections repeatedly over the three to four year period (3-4 field seasons) of the project.

Individually, each of the stakeholder groups held their own understandings of what was required of a sample site and which sites were ‘ideal’ or would make an appropriate project site. For the fishermen, a good site was an area with proven lobster abundance, a site where catch rates were known to be high. In addition, they placed focus on the project goal to test for aquaculture impact on lobster abundance, so they shared information on areas they believed were affected by aquaculture, given their
knowledge of tidal patterns and observed lobster behaviour. For the natural scientists, a good site was one with a likelihood of catching berried (i.e. ovigerous) females, as well as being a site that was documented to have experienced or was more likely to experience impact from aquaculture, or conversely a site that had no potential for such impact. Lobster reproductive stages held significant importance for the government scientists; however they also emphasized the seasonal migration patterns given the little that was known about lobster movement inshore and offshore during summer and winter (Meeting Minutes, June 2014).

Even with these various interpretations of a ‘good’ site at the individual group stakeholder level, collectively, project participants were flexible enough in defining project sites that they were able to reach agreement on the study and control sites needed for the protocol. These potential survey sites served as boundary objects because they facilitated the exchange of knowledge between project stakeholders. More specifically, the exchanges that went back and forth informing decisions contained information about established relationships or the lack thereof between lobsters and aquaculture.

Stakeholders spoke to site selection using their perceptions of relationships such as those established between the ecosystem and lobster populations or between the lobster population and the aquaculture industry. Fishermen contributed their experiential knowledge of lobster abundance and relationships with tides. Academic scientists contributed their understanding of the relationships between lobster reproductive stages and aquaculture activity. And the government scientists emphasized the lack of understanding about the relationships between lobster migration, aquaculture treatments and tidal movements.
6.5.2 Elaborating Concepts (Ovigerous Female Lobsters, Near and Far)

The elaborating or the building of concepts is important to knowledge because it is the process that identifies common or shared understanding about a topic. Shared concepts serve as the building blocks on which individual information pieces can further develop. During the course of the Abundance Project there was continuous discussion about the abundance of ovigerous female lobsters. In retrospect however, as the project is advancing into its later stages of data collection and analysis, it has become apparent that project participants have never come to a full agreement on the concept of ‘ovigerous female’. A loosely defined concept, the ovigerous females (or berried females) served as an ill-structured boundary object that was collectively understood by all project participants to be a reproducing female. Comparatively, as seen through the definitions provided during participant interviews, individuals held a wide range of understanding about ovigerous females in both level of detail and scope. Characteristics attributed to the concept of ovigerous females included physical characteristics of the animals themselves and the egg clutch, to the stages and colour of the eggs and their development, to the stage of clutch release. Generally understood by all participants, the concept of ovigerous female was ‘good enough’ and the term functioned as a boundary object permitting ongoing knowledge exchange even without a clearly defined concept.

Not all loosely defined or ill-structured concepts were as successful. As discussed previously, without clear definitions of ‘near to aquaculture sites’ and ‘far from aquaculture sites’ the fishermen could simply not deploy the survey traps. Clear consensus was needed on these two concepts (near and far) before they could proceed. During planning work, the concepts of near and far in relation to aquaculture sites
appeared to be an ill-structured boundary object because the project participants were looking at maps/chart. During implementation however, shared loose understandings of these concepts did not translate well when out on the water. It became a problem of scale. Necessary details concerning actual ‘meters’ of distance on the water did not translate from the scale of ‘proximity’ terms used for near and far discussions in reference to sites on maps. Without a clearly built concept, there was no ability to tack back and forth over the concept or to have exchange. Fortunately, the fishermen, in need of exact coordinates, formalized necessary protocol decisions that subsequently became accepted by scientists and other project partners.

6.5.3 Data interpretation (Pesticide Treatments, Bottom Conditions & Tide)

Knowledge involves data interpretation. Data, or information as described by Nonake (1994:15) is “a flow of messages or meanings which might add to, restructure or change knowledge.” Together, project participants developing the protocol for the Abundance Project had to decide what data were needed to inform the research question, the sources of those data and the interpretation of those data. While some data collection and interpretation such as the animal measurements collected on board the vessels raised little debate (with some exception to the quantity and details of those measurements), others were more problematic.

As mentioned previously, one data interpretation problem that only became obvious as the project moved from the protocol’s development to its implementation phase was information on aquaculture site activity. Not only was confirmation on site activity important but also so was an understanding of the nature of those activities.
Data on the sites where the survey was conducted were necessary for drawing conclusions on the relative abundance results. Both access to information about aquaculture operations and interpretation of that information however, proved elusive since important data was not publicly available. Data concerning sea lice (Lepeophtheirus salmonis) application treatments is just one example. In addition to provincially issued maps containing limited ABMA stocking year information, the aquaculture industry also provides the province and select community stakeholder groups with data on pesticide applications for individual sites. This information is limited to the general type of chemical use and number of days of tarp treatments; the public does not easily access it. Tarp treatments involve an aquaculture cage being surrounded by tarps, the pesticide added to the water with fish inside the tarp, and after a time, the tarps removed and the pesticide plume allowed to dissipate in the ocean. Other relevant treatment data, such as the volume of pesticides used in tarp treatments, or in in-feed pesticides, are considered proprietary information and therefore not accessible. Using the limited pesticide data available however, when project participants compared active site information (i.e. stocking information) with data on pesticide treatments dates, it became obvious that individual sites could be receiving pesticides in a supposed “inactive” period, and that for various reasons, some sites did not or were not able to follow the intended production cycles. This raised the question of the status (active or inactive) of individual aquaculture sites where the data collection

\[24\] It was the movement of such pesticide plumes that project scientists were referencing when speaking to the use of dye tests.
or trap surveys were completed; a question that the project team revisited during numerous meetings.

Identified as an ill-structured boundary object, site activity data could have been used by project participants to tack back and forth making important decisions about the Abundance Project’s protocol development and eventual joint data interpretation. Fishermen were confident that they could provide data on aquaculture operations, relying on the presence of bird nets and other predator deterrents, feed boat activity and tarp deployment. Fishermen even argued for the space on the data collection tool (see Appendix E) (i.e., a standardized forms boundary object) to record their aquaculture site observations and the indicators used for identifying a site as being active. The biologists, however, spoke to a more temporal and more inclusive definition incorporating site activity over time and unseen variables such as ecosystem impact. They argued that relying on fishermen to provide this data would open the project to critique as the information would be considered anecdotal and biased.

In the end, the natural scientists position was adopted for the protocol and identification of site activity relied instead on the data from provincial sources on stocking and from industry on pesticide use, but this “flow” of information was insufficient to significantly improve the knowledge on the relationship between lobster and aquaculture. The lack of certainty surrounding data accuracy prevented site activity from being an effective boundary object.

Similar examples can be seen in the lack of accuracy on tidal information as well as ocean floor characteristics. While the fishermen shared limited knowledge of tidal patterns and impacts on lobster behaviour, project scientists stated outright that there
was little known on the topic. In relation to the interpretation of this data there was enough understanding between participants to agree that tidal data for the project was insufficient. On the one hand the scientists claimed there was again insufficient data for ocean floor characteristics (e.g. muddy, sand, cobble, etc.), on the other, the fishermen were not willing to concede that their local knowledge held in combination with the cumulative data provided from their vessel sonars could not contribute meaningfully to the project results. While not a completely successful boundary object, there were some back and forth discussions. Ultimately, it was agreed by project participants that bottom type data could be interpreted as either ‘muddy’ or ‘cobble’. Having bottom type data reduced to a binary level allowed it to function as a boundary object, continuing the exchange of knowledge on site characteristics.

6.5.4 Principles - Lobster Ecology and Ecosystems

With so little understanding or research on American lobster ocean movements and behaviour, in retrospect the action of formulating shared principles between participants would have been extremely beneficial for the Project’s outcomes. For example, in addition to addressing project management logistical problems, slight modifications were made between sampling years because of a lack of clear agreement or understanding on principles such as what is meant by exposure to treatment, eutrophication, lobster ecology, and population dynamics. There is limited capacity for information exchange between participants on these topics because participants were operating throughout the project on their own individual assumptions. Very few principles concerning these topics were clearly formulated as a group.
Two topics that did emerge were large-scale ecological change and the response in population dynamics. These topics operated as boundary objects and facilitated in the formulating of principles. Here large-scale ecological change meant many different things to individual stakeholders. Unlike the scale translation problem of near and far concepts, there was enough collective agreement that a principle or a foundation was laid for further knowledge development. It is clear from participant discussions and concerns throughout the project that the large-scale ecological change was understood collectively to be a ‘negative’ leading only to further negative outcomes. For the fishermen, ecological change meant changes in lobster migratory patterns necessitating changes in fishing patterns forcing longer days at sea further from shore, which increases both financial cost and personal risk. For the biologists, ecological changes meant a decrease in lobster habitat leading to changes in migratory and reproductive patterns impacting both the lobster nursery locations and the general ecology of the area. Similarly, the related principle of population dynamics, while never collectively defined by the project team, served as a boundary object allowing dialogue between partners to move forward. In fact, the research question of the Project itself, to examine ovigerous female lobster abundance in relation to aquaculture activity, is built on the principle of population dynamics. A negative impact on female abundance due to aquaculture activity was collectively agreed to be a ‘bad thing’ regardless of the fine details of how the principle of population dynamics might be individually defined.

These shared principles for the Abundance Project protocol work are however limited. Effort made to lay out these principles earlier in the protocol’s development could have either strengthened their use and or identified other boundary objects that
would have facilitated the exchange of knowledge. Having not laid out principles clearly from the beginning, or even during the implementation, means greater time and effort on the part of participants during project conclusion. As the project moves towards the final phases, time and effort is required to visit or revisit principles that were not clearly laid out at the outset. For example it raises questions such as the effectiveness of the protocol if lobster stocks are rebounding because of a decline in their major predators (i.e., ground fish). It may be that lobster no longer require cobble bottom as a protective environment so their susceptibility to aquaculture in cobble bottom areas will be less because they are able to survive in other habitats.

6.5.5 Evaluation – Abundance Project Outcomes

The capacity to make evaluations is an important action of knowledge, and more generally, an important step in all research work. A continuous process, knowledge exchange between participants has required numerous minor evaluations to be made throughout the project development and implementation (e.g. better to conduct survey work in July or August, best type of bait to use, depth at which to set traps, etc.). As the Abundance Project enters its final stages of data analysis and results evaluation, the significance of participants being able to inform knowledge exchange will be amplified. The role of boundary objects for facilitating evaluation of information exchanged between project stakeholders becomes increasingly essential, as data results are interpreted and necessary judgments made about the Abundance Project’s outcomes. How, what and if boundary objects develop at this important stage are yet to be determined. Early data results indicate that evaluation is going to be needed with
respect to the density of lobster population in relation to the near and far sites (or exposed and controlled sites). There will also be a need to evaluate the data results found within each of the individual ABMAs and their value or relevance to the whole LFA 36 in which the ABMAs are located.

6.5.6 Actions of Knowledge as Boundary Objects Used as Indicators

The above analysis discusses only a few of the study’s examples of knowledge actions as boundary objects. These particular examples were chosen for illustration not only because they provide a variety of boundary object examples, but also because they serve to demonstrate how knowledge is co-constructed. Focusing on the actions of knowledge at play or exchanged through boundary objects, information can be gleaned not only from the successful information exchanges, but also from information exchange struggles and even breakdowns.

Using the examples given above, it is clear that the presence and use of some boundary objects facilitated the actions of knowledge and the co-construction of joint knowledge. Take for example, the establishing of relationships using site selection or the concept of an ovigerous female. In both of these examples, knowledge exchange successfully took place leading towards knowledge co-construction between partners. In comparison, when there was no agreement on data of aquaculture site activity, no exchange took place. Knowledge exchange was halted on this topic and this affected the co-construction of knowledge. The limited scope of bottom types for data interpretation or the somewhat limited formulating of principles regarding large scale ecological change and population dynamics could also place a spanner in the works,
obstructing the knowledge exchange between participants and slowing down and potentially hampering the building of knowledge.

Recognizing that knowledge is a set of actions can focus participant attention on each of those knowledge actions as they become necessary to further the process of knowledge co-construction. The knowledge actions can be conceptualized as a toolkit, and either project participants themselves or a facilitator could draw attention to potential solutions when one or another of these actions seems blocked. In fact, the boundary objects as identified in the example of the Abundance Project can serve as indicators to participants when they are confronted with ‘green light’ opportunities, or ‘amber light’ where more effort is needed and even ‘red light’ where exchange is no longer taking place. Evaluation of the actions of knowledge in an examination of specific boundary objects used in multi-stakeholder knowledge co-construction can serve as traffic light indicators, allowing participants to work collectively to address problems and thereby move the project forward instead of floundering with no idea of what is going wrong.

6.6 Application of Actions of Knowledge

In this chapter, an argument was made for the identification and operationalization of an actual definition of knowledge to help provide insight into knowledge co-construction. An action-oriented definition was proposed that spoke to knowledge as a composition of at least five actions; establishing relationships, elaborating concepts, data interpretation, formulating principles, and making evaluations. It was further suggested that by using this definition in tandem with
existing theoretical work on the exchange of expertise and the roles played by trading zones and boundary objects, an understanding of how knowledge is co-constructed is gained.

Using examples of boundary objects taken from the Abundance Project, each of the five actions of knowledge were illustrated. Examining the status of these actions of knowledge, their presence or lack thereof, in boundary object exchange, offered indicators as to the whether the knowledge exchange was moving forward, was hampered or even halted. Therefore, I have argued that identification and exploration of the actions of knowledge applied to boundary objects will assist in filling the lacuna in literature on how knowledge is co-constructed.
7. Conclusion

7.1 Introduction

The impetus for my dissertation came from the local knowledge and experiences shared by SWNB lobster fishermen. Their significant knowledge contributions to research efforts examining the lobster fishery within the region raised important considerations with respect to the interactions between a growing salmonid (*Salmo salar*) aquaculture industry and the behaviour of ovigerous female lobsters (*Homarus americanus*). In turn, the fishermen’s willingness to work with the scientific and research communities led to a research project examining the abundance of ovigerous female lobsters in LFA 36, the *Berried Female Abundance Project*. This joint fishermen-scientists project and its required development of a research protocol provided me with a case study in which to examine how social worlds bring their knowledge together to co-construct further knowledge. It allowed me to ask what processes are involved when various stakeholder group representatives come together to share their knowledge sets and how is the knowledge that is shared received or perceived by others? It gave me the opportunity to explore the process of fishermen and scientists coming together to jointly co-construct knowledge and to assess how better knowledge co-construction might be obtained in order to contribute to risk management for marine resources.

7.2 Lobster Fisheries Aquaculture Conflict

As presented in Chapter 2, resource access is a matter of concern to both the commercial lobster fishing industry and the salmonid finfish aquaculture industry...
located in the Bay of Fundy shores of SWNB. Validation for the claims to access for both industries lies in a complex set of New Brunswick provincial and federal legislation (e.g. *Aquaculture Act*, RSNB 2011, c 112; *Aquaculture Activities Regulations*, SOR, 2015-177; *Fisheries Act*, RSC, 1985, c F-14) as well as government fisheries and aquaculture policies and frameworks (e.g. Lobster Fishing Areas, Aquaculture Bay Management Areas, etc.).

Resource management decision-making for complex ecosystems can be daunting at the best of times. Navigating around such a governance structure only adds to the equation, not to mention the access needs of additional resource users such as the oil and gas industry, tourism, and tidal energy. Successful management requires informed decision-making based on the knowledge and expertise of industry stakeholders, as well as scientists and researchers. The knowledge sets exchanged between social worlds will hold both shared and unique understanding, including potentially conflicting perceptions of risks that will need to be addressed and managed.

In fact, it was knowledge from the lobster fishermen from LFA 36 that first raised concern regarding the potential impact that the aquaculture industry was having on the traditional lobster nursery and habitat areas. Specifically, concern has been raised about a potential shift in the behavioural patterns of lobsters in the ocean habitats adjacent to where pesticides were being applied in open pen aquaculture sites. A resulting joint fishermen-scientist research project examining this observation became the case study for this dissertation. The development and implementation processes of the necessary scientific protocol for the *Berried Female Abundance Project* were examined focusing on the knowledge contributions of the project stakeholders. This
Protocol Study focused on the co-construction of knowledge, arguing for a better comprehension of how co-construction takes place. In turn, an increased understanding for knowledge co-construction could lead to more successful joint stakeholder knowledge co-construction efforts, improving risk mitigation through informed resource management decisions.

7.3 Theoretical Context

7.3.1 Risk in Fisheries Management

Following the East Coast groundfisheries collapse of the 1990s, Canadian resource managers moved away from the exclusive use of population models for decision-making. Decision-makers began to apply models that were inclusive of multiple social-economic and operational as well environmental factors that influenced the fisheries. Approaches such as risk analysis permit a systematic setting and assessment of objectives and values, with consideration given to multiple factors. Risk however, when defined “as the statistical probability of an outcome, combined with severity of the effect…” (Boholm 2003:160) can be understood as being objective based on scientific values and concerns, or subjective based on understanding from local values and concerns (Boholm 2003). Because of this juxtaposition, perceptions of risk will vary. This variance in risk perception is reflected in what Ulrich Beck (1992) describes as ‘risk society’. Our expectations and acceptance of potential risks are insufficient to effectively understand the potential harm and risks, which in turn are beyond the capacity of our administrative responses. The result of this is conflict over
what is acceptable with respect to policy recommendations and mitigation measures necessary for managing these risks.

My dissertation research has been predicated on the assumption that taking into consideration diverse perceptions of risk and uncertainties can build towards more informed knowledge on which to base better assessments of threats and to identify potential mitigation measures.

7.3.2 Inclusion of Knowledge Sets

Faced with environmental and resource risks in their communities and workplaces, resource stakeholders have come forward to both challenge and build cooperative relationships with scientists. Since the post-World War II rise of the ‘environmental movement’ and the related citizen engagement work, the value and role of stakeholder participation in resource governance policy and decision-making has gained popularity. Similar to the ascending rungs on Sherry Arnstein’s Participation Ladder (1969:217), our understanding of stakeholder involvement potential has grown more inclusive. Calls for public and stakeholder engagement have advanced from basic informing, to information sharing, to state and public consultation, to dialogue, collaborative research work and joint decision making (e.g. see Andersson et al. 2014).

Since the mid to late 1980s there has been an increasing adoption of particular engagement methods calling for the inclusion of resource stakeholders and communities and their experiential knowledge (e.g.; Jentoft 1989; Pinkerton 1989; Cicin-Sain & Knetch 1998; Berkes, Colding, Folke 2000; Jasanoff 2003, Turner and Berkes 2006, Fortmann 2008; Jacobsen, et al 2012). This literature offers a variety of approaches
(e.g. co-management, citizen science, participatory research, etc.), with each having their own characteristics, however, all are inclusive of stakeholder knowledge and specifically locally held ecological knowledge.

Within marine resource governance, inclusion of coastal stakeholders’ knowledge has become the standard (Kraan et al. 2014). For example, within Canadian fisheries management, at least in theory, the inclusion of stakeholder knowledge in resource management practice has been a requirement for over ten years. Governance practices at the turn of the 21st century such as Integrated Coastal Management (ICM) explicitly called for such involvement in the Fisheries and Oceans Canada policy document: *Canada’s Ocean Strategy: Our Oceans Our Future* (Fisheries and Oceans Canada 2002). As a resource management approach, ICM acknowledged the multiple layers of jurisdictions and the variety of stakeholder interests at play in the governance of coastal resources. It established not only the need for participation of stakeholder groups in resource management processes, but specifically required the exchange and sharing of resource knowledge and information between these groups (Fisheries and Oceans 2002). Within the ICM approach, stakeholders, fishers, scientists, government bureaucrats and/or community members were to be given the opportunity to share their resource knowledge and information, regardless of its format, in the decision-making and policy formation processes (Cicin-Sain and Knecht 1998).

Unfortunately, even with all this engagement, there exists a gap between contributed knowledge and the resulting resource management decisions and policy outcomes (Irwin 1995). Curtis and Wiber (2010), for example, examined the lack of empowerment of fishermen from SWNB during information and knowledge sharing
about the local lobster fishery\textsuperscript{25}. Despite consultation processes, community and ‘non-scientist’ stakeholders often dispute that their evidence or a reflection on their contributions is evident in the resulting decisions and policy outcomes. Research into similar discrepancies completed in Science and Technology Studies (STS) confirms that stakeholder knowledge contributions are often devalued, overlooked or ignored in comparison to the knowledge provided by the scientific community (Leach, Scoones, and Wynne 2005). This lack of knowledge inclusion also extends beyond the exclusion of the multiple knowledge sets that do not meet the dominant western scientific traditions of knowledge. Knowledge exclusion is also found when individual scientific knowledge silos exist, and where scientists compete for the place of privilege in informing and developing Canadian federal and provincial fisheries policies, with resource management science contesting biology and biology speaking in isolation from anthropology or sociology.

In the context of this study and to address this discrepancy, theoretical work examining the difference and similarities between scientific and experiential knowledge was explored. In addition, work presenting boundary objects as facilitators of knowledge exchange between social worlds was drawn on to analyze case study results.

\textsuperscript{25} See Hind 2014 for an extensive historical review of fisher’s knowledge inclusion and its application towards the co-construction of knowledge necessary for resource governance.
7.4 Case Study Method

7.4.1 Stakeholder Population

The population universe for my study was by default the stakeholders participating (N=38) in the larger Berried Female Lobster Abundance Project, as all project members were invited to participate in the development of the protocol and its implementation. Participants included fishermen, representatives of fishermen’s organizations, natural and social scientists both academic and government, research technicians, students and government employees. It has been acknowledged that the project participants did not represent all stakeholder groups in the region. In particular, the aquaculture industry is conspicuously absent. The decision not to invite the aquaculture industry to the table was not entered into lightly, and as noted previously, their absence did not mean that they were not kept informed of the Project. During the course of the Abundance Project, effort was made to consciously inform the aquaculture industry, other groups and individuals of project details and progress (i.e., the Traditional Fisheries Coalition (TFC), Grand Manan Fishermen’s Association, Fish Food and Allied Workers (FFAW), the herring industry (via Connor Brothers) and the Atlantic Canada Fish Farmers Association (ACFFA)). Information was shared through several channels including direct communication from Abundance Project participants, phone calls, association newsletters and requests made to the provincial Department of Agriculture, Aquaculture and Fisheries (DAAF) to forward Project’s information to appropriate parties.
Feedback from these groups indicated news of the Abundance Project was positively received and by the August 25, 2014 progress report teleconference there were requests on the table from the ACFFA and the FFAW for updates. At the time, it was agreed by the project leads that is was too soon to share any data results as the academic technicians and students were only just starting to compile data and more importantly only one year had been completed in a multi-year time series study. Presenting results too early could have been misleading (Meeting Minutes, August 25, 2014). This sentiment was reiterated at the Season 1 October 8, 2014 wrap up meeting where it was cautioned not to share too much too early, but to share as much as they could:

If we don’t provide information they will make assumptions [but we need] to be cautious, [we] don’t [want to] present too much information e.g. offshore vs. inshore [but we can] speak to the importance of habitat (GS2 Meeting Minutes, October 8, 2014).

A great deal of the conversation around sharing ‘too much too early’ ran in parallel with discussions from project participants concerning their past experiences of having their research and results being rapidly dismissed by aquaculture industry research with contrasting studies and results. Past research efforts were described as part of the so-called ‘science wars’, where for every set of research results stating one conclusion, a counter study with conflicting results is presented. Unfortunately, during these ‘battles’ solid methods and well-conducted research is often compared to biased and poorly executed work and focus is only given to the counterpoint it has to offer. This practice both devalues good research and muddies the waters for those consulting research in an effort to inform policy decision-making.
The balance between information sharing and caution in the Project is demonstrated in a comment found in an August 29th email exchange:

Aside from a belief that scientific knowledge should be shared widely, I also think that this is the first year of data and any critique of that or of our methods would be premature before the project is complete…I also think we could over-anticipate problems from aquaculture for future years of sampling – just as it appears that we over-anticipated tampering with the gear this year [there was no gear tampering during the first field season of the study] (AS3 Email, August 29 2014).

The unfortunate result, however, was to affect who is and who is not at the table for joint stakeholder research. The reality of the situation is that not every stakeholder group is represented, nor does every stakeholder group want to be. The potential value of knowledge and expertise from these groups towards knowledge co-construction projects goes without saying; however, the politics must be acknowledged and it must be managed.

### 7.4.2 Qualitative Research – Grounded Theory

Using both grounded theory and actor network theory (ANT), the data collected from the case study (i.e., from the meeting minutes, semi-structured interviews, emails, correspondence and other documents) were coded and extensively reviewed for major categories or topics. These topics highlighted the points of knowledge exchange that came to dominate during the development and implementation of the Abundance Project’s scientific protocol. Three topic areas and their related sub-topics were particularly significant to the Project, including: 1) topics relating to the building of the protocol; such as the methodology to use and research boundaries; 2) matters concerning the actual implementation and carrying out of the protocol, such as study dates and how the data were to be collected and recorded; and 3) as a three-year study (with a potential
for additional sampling years) the protocol was reviewed between each field season. Examples of related subtopics that dominated the knowledge exchange were the selection of sample sites, details and characteristics of the variables.

7.5 Knowledge Actions & Boundary Objects

Once the key topics and sub-topics of information exchange for the Abundance Project’s protocol development and implementation were identified, the next step was to examine the exchanges in an effort to understand how it is that knowledge is co-constructed. It soon became apparent however, that to understand ‘how’, it is first necessary to be clear about ‘what’ is being constructed, therefore, a working definition of knowledge was needed.

7.5.1 Knowledge defined –Actions of Knowledge

Finding no definitions of knowledge in the literature, I consulted a basic college dictionary for a common language definition. Rather unexpectedly, the meaning assigned to the word knowledge was not concrete or descriptive of any one ‘thing’ but instead it was described as the outcome of actions (Funk and Wagnalls 1989). Therefore, to understand knowledge and its construction it is necessary to examine these actions. Five specific actions of knowledge26 were identified: establishing relationships, elaborating concepts, interpreting data, formulating principles and making evaluations.

26 Although five actions of knowledge were identified for this study arguably there could be more or variations on those identified. What is important is recognizing that actions are required; knowledge does not occur without action.
To understand knowledge co-construction, or its assemblage by more than one individual, requires identifying if these actions are present in the knowledge building process and how they play out between participants. The action of contributing an individual knowledge set in and of itself is not sufficient to build new knowledge. It is not a process of individual stakeholders coming together and dumping their information or knowledge sets into a collective pot from which others can selectively draw. Using individual knowledge sets as starting points, the participants, as in the case of this study both fishermen and scientists, had to share in the interpreting of data, in the perceived relations between people or things, in the elaborating of concepts, in the formulating of principles and, in the evaluation processes for knowledge to be co-constructed.

7.5.2 Boundary Objects – Just Enough

With a definition of knowledge identified, I explored work examining what is needed for knowledge co-construction, specifically, the use of boundary objects (Star and Greisemer1989) and trading zones (Collins, Evans and Gorman 2010). Boundary objects, with their plasticity and adaptability, allow social worlds to come together over a common understanding of a concept, idea or things. The creation and management of boundary objects, Star and Greisemer (1989) argue is key to social worlds having the capacity to collectively build knowledge. While the authors provide four examples of boundary object types (i.e. repositories, ideal type, coincident, and standardized forms), what is also essential to their argument, found in Star’s earlier work (1989), and argued somewhat more strongly in Star’s later work (2010), is the structure of boundary objects. Star (2010) reasoned that loosely defined and ill-structured boundary objects
facilitate greater understanding between social worlds. Ill-structured boundary objects, where there is limited buy in to a set collective understanding between knowledge holders, allows for the most knowledge exchange to occur. With ill-structured boundary objects, knowledge holders can remain open to new ways of knowing, because they are able to tack both and forth between their own individual meanings and a loose but sufficiently shared meaning between partners. In comparison, well-structured boundary objects often include the hesitant acceptance of a collective shared meaning when one group coerces the others into one line of thinking, removing the means for alternative ways of knowing to be included. Unlike well-structured boundary objects, with rigid meanings and the inability to adapt, ill-structured boundary objects allow for simultaneous translation. That is to say, the boundary object serves as point of translation between social worlds (Callon 1986, Latour 2005).

What is not a prerequisite for the co-construction of knowledge, according to Star and Griesemer (1989), is consensus. No one knowledge set must be completely adopted over others or taken on by other participants either willingly or through coercion (Collins, Evans and Gorman 2010). What is necessary is ‘just enough’ cooperation within the exchange of knowledge by stakeholder participants; that is, social worlds agree that ‘just enough’ can be agreed on to move forward, that is: collectively perceiving ‘just enough’ understanding of relationships, elaborating together on concepts ‘just enough’, being able to interpret data ‘just enough’, accepting principles ‘just enough’ and agreeing ‘just enough’ on evaluations for assessment.

As presented in this Protocol Study, there were numerous boundary objects that emerged through the course of the Abundance Project stakeholders working together to
develop knowledge (e.g. site selection, bottom types, gear types, etc.). As discussed, the ability for Project participants to tack back and forth between individual and collective meanings was dependent on the rigidity of the object structures. Those that were loosely structured such as the necessary characteristics of sites for project sampling locations, allowed for useful and productive knowledge exchange, facilitating wider knowledge co-construction. In comparison, those that held very well-structured meanings for individual stakeholder groups such as the defining or understanding of an active aquaculture site, became stalemates in the dialogue and required less than ideal work around solutions or became topics excluded from the project.

7.5.3 Knowledge Actions Applied to Boundary Objects

Finally, with knowledge defined and the tools needed for co-construction identified (i.e., boundary objects), this study proposed that to understand the how of knowledge co-construction, the actions of knowledge must be applied to boundary object exchanges. I argue that identifying the presence or absence of knowledge actions and examining them specifically in relation to boundary objects provides indicators. These indicators can help to identify when knowledge co-construction by multiple stakeholders is indeed moving forward smoothly, is being impeded or has ground to a halt.

7.6 In Closing

Public policy development processes are increasingly mandating the inclusion of stakeholder knowledge through legislated procedures and consultation processes. The Canadian fisheries are no exception. The value of this inclusion is shown to come from
the unique expertise, local knowledge and understanding of the fisheries that
stakeholders, such as fishermen, can contribute to research, thereby increasing the
relevancy of the work and producing policy outcomes that are both meaningful and
feasible. Although efforts to increase stakeholder inclusion in research is growing, the
results of such projects are not always successful. In addition, literature on joint
knowledge production can be limited with its focus geared toward importance of
inclusion and the identification of successful outcomes (e.g. Cash et al. 2003). While
the literature speaks to who should be included and what it is that successful knowledge
co-construction accomplishes, there has been little examination on knowledge itself in
knowledge co-construction. This study, while supportive of the knowledge exchange
literature that speaks to the importance of expertise and boundary objects for joint
knowledge efforts, also proposes an action-oriented definition of knowledge to be added
to the toolkit. The definition proposed outlines five actions of knowledge; establishing
relationships, building concepts, interpreting data, setting principles and evaluation.
The argument made is that efforts to identify and understand these actions that compose
knowledge as they occur through boundary objects can serve as valuable indicators of
successes, impediments or complete break downs in knowledge exchanges.

For stakeholder knowledge inclusion to be meaningful and to truly inform
decision-making and policy development, it must not only be salient, credible and
legitimate (Cash et al. 2003). Knowledge itself and the requirements for its composition
must be understood. For more informed risk assessment, our understanding must go
beyond the mere inclusion of joint knowledge, making it essential that we expand our
understanding of how knowledge is co-constructed.
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Appendix A

Appendix A: Map – Marine Aquaculture Sites with Fish 2014
Agriculture, Aquaculture and Fisheries New Brunswick, indicating the Bay Management Areas and locations identified as licensed aquaculture sites.
Appendix B

Appendix B: Project Introduction Letter, Consent Form and Questionnaire entitled Knowledge Construction and Current Coastal Resource Management Practice – Berried Female Atlantic Lobster (Homarus americanus) Abundance Projects

November 2014,

Re: Berried Female Atlantic Lobster (Homarus americanus) Abundance Study

Dear Project Partner,

My name is Donna Curtis and I am an Interdisciplinary PhD student at the University of New Brunswick (UNB) seeking to examine the development and progress of this joint fishermen/scientists project being led by the Fundy North Fishermen’s Association in partnership with a three year Marine Risk study led by my academic supervisor Dr. Melanie Wiber, Department of Anthropology, UNB.

In an effort to assess the collaborations shared between project partners I will be seeking permission to observe and participate in project related communications such as meetings, (in-person, online or by phone) and e-mail communications. From September to November 2014, I will also be seeking volunteers from the project to participate in one on one interviews about the project (approximately 20-30 minutes in length). I am very interested in your thoughts and comments and hope that you will be interested in participating. Neither names nor other information that might serve to identify interviewees will be released publically. It is intended that participants will be identified in written work by their roles taken in the berried female study (e.g. fisherman, scientists, etc.)

Collected data will be used for the completion of my doctoral thesis which includes the submission of work for potential publication in academic journals. Written summaries of my study will also be sent to all interested participants.

It is expected that this assessment, once completed, will contribute to a better understanding of the joint fishermen/scientist project and provide insight to increase the success of this project and similar projects in the future.

Sincerely,

Donna G. Curtis

Melanie G. Wiber

This project has been reviewed by the Research Ethics Board of the University of New Brunswick and is on file as REB 2014-101
Consent Form
Participant Observation
Participant Copy / Researcher Copy

Research Project:
Knowledge Construction and Current Coastal Resource Management Practice – Berried Female Atlantic Lobster (Homarus americanus) Abundance Study

Researcher:
Donna G. Curtis, PhD Candidate, University of New Brunswick Interdisciplinary Studies Program, donna.curtis@unb.ca ph: 506-451-5994

Supervisor:
Melanie G. Wiber, Professor, Department of Anthropology, University of New Brunswick wiber@unb.ca ph: 506-458-7995

Assistant Dean:
Linda Eyre, Assistant Dean, Interdisciplinary Studies University of New Brunswick leyere@unb.ca phone: 506 447-3044

Informed Voluntary Consent – Participant Observation During Berried Female Atlantic Lobster (Homarus americanus) Abundance Study Meetings & Activities

By signing this document I voluntarily consent to the receipt of emails, attendance, note taking and the audio recording of Berried Female Atlantic Lobster (Homarus americanus) Abundance Study related meetings and activities by Donna G. Curtis, Doctoral Student at the University of New Brunswick, Fredericton.

The purpose of meeting attendance, note taking and recording is to provide detail transcriptions of the dialogue, sharing of information and data with respect to the project protocol (e.g. site selection, methods for sampling, etc.) for examination. It is intended that the information gained from examination will be used to identify indicators which facilitate or hinder information sharing and learning between project participants. Identification of information sharing indicators may help with the success of similar joint community/scientist research projects in the future.

I understand that my consent for Donna G. Curtis to participate in meetings is voluntary and I have the right to withdraw my consent at any time, and should I request that my contributions or portions there of to the meeting dialogues and discussions will be removed from any notes or transcriptions.

My name, and any information that could result in my identification, will not be included in the project’s final report. It is also guaranteed that all data collected (written work, transcriptions, consent forms, etc.) will be stored safely in a locked cabinet in a secure office and will be destroyed once the final report is completed. These documents will only be accessible by Donna G. Curtis and/or her dissertation supervisor, before the time that they are destroyed. To guarantee confidentiality, researchers will not discuss any aspect of the project with anyone who is not directly involved with the project.

Name (Please Print):

Signature:

I would like to receive a summary of the findings and conclusions from the completed dissertation, please check one: ☐ Yes ☐ No

Please send my copy by email to: ______________________________

This project has been reviewed by the Research Ethics Board of the University of New Brunswick and is on file as REB 2014-101. Should you have any questions or concerns about this project please contact the researcher, supervisor or Assistant Dean of Interdisciplinary Studies at any time.
Consent Form
Interview
Participant Copy / Researcher Copy

Research Project:
Knowledge Construction and Current Coastal Resource Management Practice – Berried Female Atlantic Lobster (Homarus americanus) Abundance Study

Researcher:
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leyere@unb.ca phone: 506 447-3044

Informed Voluntary Consent – Interview Regarding Berried Female Atlantic Lobster (Homarus americanus) Abundance Study

By signing this document I hereby agree to participate in an interview pertaining to the Berried Female Atlantic Lobster Abundance Study to be conducted with Donna G. Curtis, Doctoral Student at the University of New Brunswick, Fredericton.

The purpose of the interview is collect information with respect to the project protocol (e.g. site selection, methods for sampling, etc.). It is intended that the information gained from examination will be used identity indicators which facilitate or hinder information sharing and learning between project participants. Identification of information sharing indicators may help with the success of similar joint community/scientist research projects in the future.

I understand that my consent to participate in this interview is voluntary and I have the right to withdraw my consent at any time and the interview terminated and, at my request, my comments or portions there of, will be removed from any notes or transcriptions.

My name, and any information that could result in my identification, will not be included in the project’s final report. It is also guaranteed that all data collected (written work, transcriptions, consent forms, etc.) will be stored safely in a locked cabinet in a secure office and will be destroyed once the final report is completed. These documents will only be accessible by Donna G. Curtis and/or her dissertation supervisor, before the time that they are destroyed. To guarantee confidentiality, researchers will not discuss any aspect of the project with anyone who is not directly involved with the project.

Name (Please Print):

Signature:

I would like to receive a summary of the findings and conclusions from the completed dissertation, please check one: ☐ Yes ☐ No

Please send my copy by email to: ______________________

This project has been reviewed by the Research Ethics Board of the University of New Brunswick and is on file as REB 2014-101. Should you have any questions or concerns about this project please contact the researcher, supervisor or Assistant Dean of Interdisciplinary Studies at any time.

Page 1/1
Knowledge Construction and Current Coastal Resource Management Practice – Berried Female Atlantic Lobster (*Homarus americanus*) Abundance Study

1. **Introduction and Voluntary Consent Protocol**
   1.1 Introduction and explanation and review of PhD project

1.2 Identify Potential Participant Role:
   - Fishermen - Captain / Crew Member
   - Scientists - Academic / DFO / Lab Technician / UNB Student
   - Other – Government advisor (non science) / Aquaculture industry rep

1.3 Review the scope and the nature of the interview; how it will be conducted
   - Open ended questions
   - May skip questions they do not wish to discuss
   - Duration 20 – 30 minutes

1.4 Review and complete Voluntary Consent Form
   confirm if they would like a copy of results summary

1.5 Provide participant with a copy of consent to participant
2. Open Ended Questions

2.1 Aquaculture and Berried Female Lobsters

2.1.1 As you know this past summer we were working on a lobster abundance study by examining lobster caught near and far from aquaculture sites. What have you heard or ever observed about lobsters in relation to aquaculture sites? e.g. Do you think lobsters avoid aquaculture sites, what makes you think this? Is the behaviour different between male, female or berried females?

2.1.2 Do you have any comments on why it is important to study lobsters at such a local scale? There is argument that aquaculture represents a low threat of risk because once aquaculture is removed the surrounding ecosystem quickly returns to normal. This assumes the scale of impact is very local.

2.1.2a Follow up questions on scale – What about population dynamics of American lobster do you think is project may or may not be relevant at that scale.

AND/OR

Why is it important to understand how aquaculture affects lobster in SWNB?

2.1.3 How do you know what a berried female looks like? What are the indicators? Can you tell if they are about to release their clutch, if yes how?
2.1.4 At the last project meeting held in St. George there was discussion about identifying active aquaculture sites is this something you able to tell when you are on the water? How do you know, what are the signs? E.g. what are the signs that a site is active, what are the signs that it is abandoned?

2.2 Deployment

2.2.1 What are your thoughts about the sites or areas selected such as the placement of trawls being near and far from aquaculture sites.

2.2.2 I've noticed we are discussing the latitude and longitude of the aquaculture sites but on the boat you are using Time Differences/TD (OR are you using TD on your boat and if yes…OR do you know how to use TDs?). What is/do you know the difference? If you know both, do you have a preference and why?

2.2.3 It was intended that this project be repeated over the next couple of years. What would be the best method to situate the test sites (in distance and time) so that the test sites are the same location each time? Do you think the placement of the test sites is important, why or why not?
2.2.4 When the sites were first selected it was that each near site would be paired with a far site with a similar sea bottom (e.g. two soft, or two hard). Do you think we were able to do this, is this even possible, does it matter to the study?

2.2.5 Do you think the tide heights matter in how we are running this study? That is, to you think the tides may contribute to what we were able to collect or not collect?

2.2.6 Should we use trawls or single traps? Can we improve this part of the study? Is there another way that you might want to have seen the traps deployed?
2.2.7 Do you feel you were able to set traps in a way you would have during a regular season? What was the same or different, how so? If it was different, what would you have done differently in a regular season?

2.2.8 What about the traps used, were they the appropriate size, design? Would you have done anything with the traps differently, how so?

2.2.9 We used herring for bait, do you think the bait bags worked sufficiently? Would you make any suggestions to do the baiting process differently? E.g. different bait, head and tails vs. whole fish?
2.2.10 Do you have any comments on the soak time? Should that have been longer or shorter? How does soak time affect a catch?

2.3 Retrieval

2.3.1 Do you have any comment on the v-notch of lobsters, should that have been done throughout the study? Just the berried females? Should we have used a method to mark all the lobster caught in the study week to week? How could we do this?

2.3.2 Do you think the lobster table worked well for taking measurements and samples? Do you have any suggestions to make this process simpler or more efficient?
2.3.3 Was the measuring and sampling ever explained to you (OR Did you explain the measuring or sampling to the fishing crew?) What were you measuring and sampling from the lobsters? (OR What is your understanding that was being measured and sampled (OR What was it you were measuring?) Would you have liked to have been more informed about the measuring and sampling (OR Would you have like to discuss the measuring and sampling with the fishermen)?

2.3.4 Why were these measurements necessary/important? Would you have measured or sampled for something different or differently, if yes how?

2.4 Working Together

2.4.1 Have you ever worked on a similar type of joint project before? Have you had scientist onboard your vessel before (OR have you been on board a vessel before)? How was this experience similar or different?
2.4.2 Did you have a chance to talk about the study at all with the scientists (OR fishermen)? Did you ask questions or were you asked any questions from the scientists (OR fishermen) about working on the boat or how things are done on the boat? If yes, what did you talk about, what did you learn?

2.4.3 Would you have liked to have had asked more questions of the scientists (OR fishermen) what would you have liked to discuss? Why would that have been helpful or of interest?

2.5 Communication

2.5.1 Do you think the way we ran the study this year is going to help us to get information on the abundance of lobsters near vs. far from aquaculture sites? What do you think we did right or well? What should/could we have done differently?
2.5.2 If we are able to run this project again next year what could we do differently? What would help to make it a better study?

2.5.3 Before the study started there was a meeting some phone calls emails; do you think we could have communicated about the study better? Did you have all the information you needed before we started? What other information would have been helpful to have/know before we began? How can we best share this information?

2.5.4 If you were designing a project about the effect aquaculture sites have on the lobster fishery how would you approach it? What would be the most important question to ask?
3.1 Scale
3.1.1 Are humans external drivers or internal variables?

3.1.2 Where are the boundaries of the ecosystem they are working on?
### Appendix C: Data Collection Fieldwork Tool

**SSHRC Marine Risk Project –Berried Female 2014-2015 Summer Sampling – Coding Sheet**

<table>
<thead>
<tr>
<th></th>
<th>Add participants initial for each count</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Positive Reactions</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 shows solidarity</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 jokes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3 agrees</td>
<td></td>
<td></td>
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<tr>
<td><strong>Attempted Answers</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4 gives direction</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5 gives opinion</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6 gives orientation</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Questions</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7 asks for info</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8 asks for opinion</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9 asks for suggestions</td>
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<td></td>
</tr>
<tr>
<td><strong>Negative Reactions</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10 disagrees</td>
<td></td>
<td></td>
</tr>
<tr>
<td>11 shows tension</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12 is antagonistic</td>
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</tbody>
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Other observations:

Observer: page 1/1
Appendix D: Scientific licenses

![Registration and Fishing Licence Image]

<table>
<thead>
<tr>
<th>Licence #</th>
<th>Species</th>
<th>Areas</th>
<th>Licence Type</th>
<th>Gear Permitted</th>
<th>Amt</th>
<th>VRN</th>
<th>LOA</th>
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</thead>
<tbody>
<tr>
<td>327924</td>
<td>LOBSTER</td>
<td></td>
<td>SCIENTIFIC</td>
<td>Trap</td>
<td>100</td>
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</table>

To be operated by qualified persons working under their direction, and

PURPOSE: To examine the size and abundance of ovigerous female lobsters in LFA 26 and to compare the condition and maturity of clutch of ovigerous female lobsters in LFA 26.

LOCATIONS: Lobster Fishing Area (LFA) 26: (IE ISLAND, BAY, LINGEON, BLACK'S HARBOR, MACES BAY).

GEAR: Regulation lobster traps. Up to 200 traps can be set at various locations throughout LFA 26.

VESSELS: Retentions: NONE. All lobsters collected will be returned alive to the water from which they were taken.

DATES OF ACTIVITIES: July 1 to September 31, 2015.

DESIGNATED OPERATOR STATUS

SCIENTIFIC AND/OR EDUCATIONAL LICENCE

PURSUANT TO SECTION 52 OF THE FISHERY GENERAL REGULATIONS, THIS LICENSE IS HEREBY ISSUED TO FISH FOR LOBSTER FOR SCIENTIFIC AND/OR EDUCATIONAL PURPOSES, SUBJECT TO THE FOLLOWING CONDITIONS:

1. That this licence does not authorize collections of lobster in areas that have been closed by prohibition order;

2. That this licence does not authorize collections in any marine protected areas;

3. That only those locations listed above are permitted to be fished. The gear and any tags issued under this licence, vessels and number of lobster that are permitted to be retained are also listed above. All other fish caught will be immediately returned to the waters from which they were taken with the least amount of harm;

4. That the area of operations is limited to those waters under the jurisdiction of the Department of Fisheries and Oceans (DFO), MARITIMES REGION;

5. That any unattended gear must have clear markings or if identifying the licence number, the organization and a contact person with an emergency phone number;

6. That any persons transferring live fish or introducing live fish into aquatic habitat.

It is a condition of this licence that the registration holder/licensee sign all pages of this document.

[Signatures]

FISHER          DATE

Canada
MUST BE IN POSSESSION OF A SECTION 56 TRANSFER LICENCE ISSUED UNDER THE FISHERY GENERAL REGULATIONS WITH THE APPROVAL OF THE NOVA SCOTIA INTRODUCTIONS AND TRANSFERS COMMITTEES FOR TRANSFERS INTO OR WITHIN NOVA SCOTIA OR THE NEW BRUNSWICK INTRODUCTIONS AND TRANSFERS COMMITTEES FOR TRANSFERS INTO OR WITHIN NEW BRUNSWICK;

10. THAT, EXCEPT FOR THE TIME REQUIRED TO RECORD DATA, I.E., LABELS, WEIGHS, OR TISSUE SAMPLES, ALL FISH MUST BE IMMEDIATELY RETURNED TO THE WATERS FROM WHICH THEY WERE TAKEN WITH THE LEAST POSSIBLE HARM;

11. THAT ANY FISH RETAINED AS PART OF SCIENTIFIC ANALYSIS, REPRESENTATIVE SAMPLES AND/OR RESEARCH MUST BE PRESERVED AND RETAINED AT THE INSTITUTION CONDUCTING THE STUDIES OR DISPOSED OF IN A SANITARY MANNER AT THE END OF THE OPERATIONS;

12. THAT THIS LICENCE DOES NOT AUTHORIZE FISHING FOR SPECIES THAT ARE LISTED AS "ENDEMIC" OR "THREATENED" NOR DOES THIS LICENCE AUTHORIZE FISHING IN WATERS IN WHICH "ENDEMIC" OR "THREATENED" SPECIES ARE KNOWN TO BE FOUND;

13. THAT THE CONSERVATION AND PROTECTION OFFICE CLOSEST TO THE AREA OF OPERATIONS BE GIVEN AT LEAST 24 HOURS ADVANCE NOTIFICATION OF THE DETAILS AND LOCATIONS OF THE COLLECTIONS:

IN NEW BRUNSWICK:
* ST. GEORGE PH: 506-755-5600
* SAINT JOHN PH: 506-849-1446
* FREMONT PH: 506-452-3618

IN NOVA SCOTIA:
* SYDNEY PH: 902-564-7868 / 7156
* TUSKET PH: 902-648-5000
* ERIN PH: 902-875-2760
* BRIDGEMAN PH: 902-527-5574
* WINDSOR PH: 902-532-2832
* LIVERPOOL PH: 902-364-6630
* DARTMOUTH PH: 902-426-9010
* NEWORS PH: 902-645-2045
* DRYH Ph: 902-243-2544
* BARKTON PH: 902-637-2851

14. THAT A COPY OF THIS LICENCE BE CARRIED DURING THE COLLECTIONS AND BE AVAILABLE FOR INSPECTION UPON REQUEST BY A FISHERY OFFICER;

15. THAT AN ANNUAL REPORT ON ACTIVITIES CONDUCTED UNDER AUTHORITY OF THIS LICENCE INCLUDING SAMPLING DATES, SAMPLING LOCATIONS, GEAR TYPE USED, WEIGHTS AND LENGTHS OF ALL FISH SAMPLES, WATER TEMPERATURES, CONCLUSIONS, ETC. MUST BE PROVIDED ELECTRONICALLY TO THOMAS.WEATON@NO-DO.GC.CA;

16. THAT THIS LICENCE IS VALID FROM DATE OF ISSUE UNTIL DECEMBER 31, 2013;

17. THAT ISSUANCE OF THIS LICENCE IMPLIES NO COMMITMENT BY THE MINISTER OR THE DEPARTMENT OF FISHERIES AND OCEANS TO REISSUE THE LICENCE IN SUBSEQUENT YEARS.

NOTE:
NOTHING IN THIS LICENCE SHALL BE CONSTRUED AS AUTHORITY UNDER THE SPECIES AT RISK ACT (SARA) TO KILL, HARMS, CARRY OR TAKE AN INDIVIDUAL OF A WILDLIFE SPECIES THAT IS LISTED AS "EXTINCTION", "ENDEMIC" OR "THREATENED" AS IDENTIFIED IN SCHEDULE 1 OF SARA. IF THE ACTIVITY AUTHORIZED IN THIS LICENCE IS EXPECTED TO INTERACT WITH AN "EXTINCTION", "ENDEMIC" OR "THREATENED" SPECIES, AN APPLICATION FOR A SECTION 73 SARA PERMIT CAN BE FOUND AT WWW.SARAENVIRONMENTGC.CA AND SUBMITTED TO THE DFO SPECIES AT RISK MANAGEMENT DIVISION ATfisherpermits@mowi.ca, FOR MORE INFORMATION ON SARA, INCLUDING A LIST OF PROTECTED SPECIES, PHONE 1-866-891-0771, VISIT WWW.SARAENVIRONMENTGC.CA, OR CONTACT DFO SPECIES AT RISK MANAGEMENT DIVISION ATfisherpermits@mowi.ca OR 902-424-4164.

It is a condition of this licence that the registration holder/licencee sign all pages of this document.
REGISTRATION(S) AND/OR FISHING LICENCE(S)

This document authorizes the registration card holder and/or licence holder to engage in fishing and related activities on the Atlantic coast of Canada subject to the provisions of the Fisheries Act and Regulations made thereunder.

FIN

The use of ALL of these licence(s) is subject to any conditions which are issued by DFO. The licence holder must ensure that they have received the licence conditions, and may NOT conduct any fishing activity with any of these licence(s) unless in receipt of the licence conditions.

It is a condition of this licence that the registration holder/licencee sign all pages of this document.

FISHER

DATE
Appendix E

Appendix E: Sea Sampling Tool

<table>
<thead>
<tr>
<th>Vessel</th>
<th>Date</th>
<th>Location</th>
<th>Vessel Type</th>
<th>Water Quality</th>
<th>Sediment</th>
<th>Notes</th>
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</thead>
<tbody>
<tr>
<td>Sample 1</td>
<td>2023-01-01</td>
<td>Southern Ocean</td>
<td>Research Vessel</td>
<td>Good</td>
<td>Medium</td>
<td>Collection successful</td>
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<tr>
<td>Sample 2</td>
<td>2023-01-02</td>
<td>Western Pacific</td>
<td>Commercial Vessel</td>
<td>Fair</td>
<td>Low</td>
<td>Sampling issues</td>
</tr>
<tr>
<td>Sample 3</td>
<td>2023-01-03</td>
<td>Eastern Atlantic</td>
<td>Survey Vessel</td>
<td>Excellent</td>
<td>High</td>
<td>Temperature anomaly</td>
</tr>
</tbody>
</table>

Note: All samples were collected using standardized protocols.
Curriculum Vitae

Candidate’s full name: Donna G. Curtis Maillet

Universities attended:  
MSc, Environmental Management, University of London, 2005  
MLIS, University of British Columbia, 1996  
BA, St. Thomas University, 1994

Publications:


Conference Presentations:


*MARE Conference People and the Sea VIII Geopolitics of the Oceans*,
Amsterdam, Netherlands, June 24-26.


Poster:


Book Review: