Exploring Risk and Resilience Concepts: A Social-Ecological Coastal Community Case Study from Southwest New Brunswick, Canada

by

Lisette Jieni Fuata Muaror Wilson

Submitted in partial fulfilment of the requirements
for the degree of Doctor of Philosophy

at

Dalhousie University

Halifax, Nova Scotia

October, 2019

DEDICATION PAGE

This work is dedicated to my family, especially, my mother, Maria Hilda, sister - Makereta Munivai, namesakes – Jieni with Markus, and Wilson, nieces, nephews, and their families - including Alan, Alex, and nana Ronnie, Makereta, Aliti and family, and George and family.

To the very special people who supported, encouraged and enabled my curiosity:
Jenny Parsons, Salome Collins, Scott Smithers, Dermot O'Gorman, Daniel McCall, Feddie McCall, Daniel Afzal, Veikila Vuki, Milika Naqasima Sobey, Robin South, Grant Shepherdson, Nina Morissette and Rob McGill, Barbara and Daniel Breen, Gillian Brodie and Fiu Manueli, Johnson Seeto, Seremia Tuqiri, Kesia Tabunakawai, Randolph Thaman, and Emily Volavola.

In loving memory of:
Lynn Baechler, George Wilson, Naomi, Peni Moore, Joan Petersen,
Creusa (Tetha) Hitipeuw and Miriam Philips.
Your lights will always be my beacon in the dark.

I have been privileged to walk a little way with you, along this pathway of life.

TABLE OF CONTENTS

List of Tables

List of Figures

ABSTRACT

Social-ecological systems (SES) are integrated systems of nature and society, with reciprocal feedbacks. The goal of this research was to better understand risk and resilience concepts, and their interactions, in a coastal SES. Both specified and general resilience are examined, as focusing heavily on the first, may reduce the overall resilience of the SES to unexpected events. The objectives of this study were to: (a) conduct a literature review on risk and resilience concepts and frameworks in the current literature of SESs; (b) demonstrate how these concepts and frameworks provide insights for one of the largest fisheries (Atlantic Canada groundfish) collapses in the world; (c) explore the roles of risk and resilience in stressed Atlantic Canadian fishing communities, using a case study from Southwest New Brunswick (SWNB), and (d) discuss approaches that contribute to a better understanding of risk and resilience concepts, and these interactions, for coastal communities. Using case study methodology, data were collected from a literature review and analysis of the Atlantic groundfish fishery, and 26 semi-structured interviews with community participants from SWNB. Applying content analysis software, the data were analysed for themes and examined through the lens of the Bigg's et al. (2015) resilience principles. Risk attributes were then assessed to better understand the characteristics and processes that could contribute to the development of an applied risk and resilience management perspective. Findings indicate that known risks can be managed to a certain extent, but building general resilience into an SES provides buffering options for adapting or mitigating the impacts of both known and unknown threats. Environmental impacts including warming oceans, lobsters migrating to deeper colder waters, intensity and frequency of storms, ocean acidification are already being felt. Yet the connectivity and understanding of slow and fast variables, and feedback loops, both within and across an SES, require stepping away from silo management and taking on a more integrated approach that addresses the complexity of the whole SES. The knowledge gained from this study incorporates a novel use of connecting risk and resilience that allows communities to better understand and respond to current and future threats and opportunities.

LIST OF ABBREVIATIONS USED

ANT	Actor Network Theory
AAR	Aquaculture Activities Regulations
ABMA	Aquaculture Bay Management Areas
BoFEP	Bay of Fundy Ecosystem Partnership
CAFSAC	Canadian Atlantic Fisheries Scientific Advisory Committee
CFRN	Canadian Fisheries Research Network
CAAHRD	Centre for Aquatic Animal Health Research and Diagnostics
Coastal CURA	Coastal Communities Research Alliance
CCRN	Community Conservation Research Network
CVC	Community values criteria framework
CAS	Complex Adaptive Systems
CCNB	Conservation Council of New Brunswick
DFO	Department of Fisheries and Oceans
DROP	Disaster Resilience of Place
DRR	Disaster risk reduction
DMC	Dockside Monitoring Company
DAPSI(W)R(M)	Driver-Activities-Pressure-State- Impacts (on Welfare)-Response (Measures)
DPSIR	Driver, Pressure, State, Impact, Response
EEZ	Economic Exclusive Zone
ES	Ecosystem Services
EI	Employment Insurance (EI)
FIRME	Financial Institution for the Recovery of Marine Ecosystems
FFAW-	Unifor-Fish, Food & Allied Workers
FRCC	Fisheries Resource Conservation Council
FAO	Food and Agriculture Organisation
FNFA	Fundy North Fishermen's Association
HIS	Homeland and Security Studies and Analysis Institute
ITQ	Individual Transferable Quotas
IAD	Institutional Analysis and Development Framework

ICM	Integrated Coastal Zone Management
MDGs	Millennium Development Goals
MEA	Millennium Ecosystem Assessment
NIFA	Newfoundland Inshore Fishermen's Association
NCARP	Northern Cod Adjustment and Rehabilitation Program
NCSFSI	Northern Cod Science and Fisheries Stewardship Initiative
NAFO	Northwest Atlantic Fisheries Organization
OCN-Canada	Oceans and Coasts Network-Canada
PES	Payments for Ecosystems Services approach
SSHRC	Social Sciences and Humanities Research Council of Canada
SES	Social-ecological systems
SESF	Social-Ecological Systems framework
SWNB	Southwest New Brunswick
Stats Canada	Statistics Canada
SDGs	Sustainable Development Goals
MAC	SWNB Bay of Fundy Marine Advisory Committee
TAGS	The Atlantic Groundfish Strategy
ICNAF	The International Commission for the Northwest Atlantic Fisheries
TAC	Total Allowable Catch
UNB	University of New Brunswick
WWF	World Wide Fund for Nature

ACKNOWLEDGEMENTS

Dalhousie University is located in Mi'kma'ki, the ancestral and unceded territory of the Mi'kmaq. We are all Treaty people.

I would like to sincerely acknowledge and thank my supervisor, Dr. Lucia Fanning (Marine Affairs Program, Dalhousie University) for her commitment, guidance and support that has enabled me to complete this journey. Despite my sometime faltering steps, she was always there to offer encouragement and inspiration that allowed me to get up and continue along the path. To my committee, Dr. Tony Charles (School of the Environment and the School of Business, Saint Mary's University), Dr. Melanie Wiber (Department of Anthropology, University of New Brunswick), Dr. Ronald Pelot (Department of Industrial Engineering, Dalhousie University), and Dr. Patricia Lane (Department of Biology, Dalhousie University) – thank you so much for not giving up on me - your guidance, encouragement and support were instrumental in getting me over the finish line. A very special thank you to Becky Field for your friendship, and for being there for me from day one (Sept, 2006). I would also like to acknowledge the very kind support from the Marine Affairs Family throughout my programs.

A very sincere thank you to my external examiner, Dr. Joshua Stoll, School of Marine Science, University of Maine for being able to accommodate my thesis within a very tight timeframe. I am very grateful for his time, commitment to the process and for the extremely helpful feedback.

To the participants of this study and the Fundy North Fishermen's Association – thank you so much for your time and the richness of your experiences, which are the foundations for this thesis. I hope that in the future some aspects of this thesis might have some useful contributions to supporting community-based initiatives in the Southwest New Brunswick and Bay of Fundy region. A very special thank you to Maria Recchia, Sheena Young and Family, and Dr. Wiber and family for hosting me during my field work, and for their very kind hospitality.

A sincere thank you to Dr. Lynne Robinson, director of the Interdisciplinary PhD program (IDPhD) for her support during my last years, and to our former directors, Dr. Jack Duffy, Dr. William Barker, and Dr. Raewyn Bassett for their guidance and support during the earlier years of my program. It was an honor to have Dr. Duffy at my presentation, and I am very humbled that he came to see his last student present. I would also like thank the IDPhD graduate administrators, especially Brenda, Rosemarie, and Angela, for their support and helping me navigate through the PhD process.

I am very grateful for the support from the Faculty of Graduate Studies. A special thank you to the Dean, Dr. Marty Leonard and Associate Dean, Dr. Fiona Black for their patience and encouragement throughout this endeavor. Thank you also to Alicia Kirk and Helena Martel for their guidance and support with my thesis administrative process.

This journey, although academically is taken by an individual (with guidance from the supervisor and committee), often feels like a process in isolation but this is far from true. I am very blessed to have been supported by a community of friends and family who were always there for me – especially through the dark hours, but also there to celebrate the small and major millstones. Thank you my Canadian friends and family – Jenny Baechler, Grant Wells and Lexi, for your friendship, home, family, support, and never ending encouragement. To Sandra Toze, Scott Comber and Heather Frausell, I am extremely grateful for your friendship, guidance and support along this journey. From one islander to another – thank you so much Suzuette Soomai, Troy Whalen, Diego and Jo, for your friendship, encouragement, hospitality, and the wonderful meals that reminded me so much of home. Thank you Ping Lu for the many evenings and meals that we shared on what seemed like an everlasting journey. I would also like to acknowledge Margie Muse for her gentle reminders of the big T-Rex, humor, and most of all the little angel – which is always close to me.

Faiaksia hanisit to my family, my mother, nieces and nephews for their prayers, thoughts, and encouragement during this journey. A very big thank you to my friends at home, especially, Kelera Liku, Lucy Peterson and family, Megan Streeter and Shelly Forbes, Marina Fesaitu and George Jiare, Thelma Smith and family, Rosemary Joe, Sereana Liku, and those that I have met on this journey – Dr. Robert (Bob) Capistrano, Jenna Stoner, Huong Thu Doan, Marina Winterbottom, Sonja Mills, and Jessica Kerwin.

Last but not least – I give thanks to the powers that be – without their blessing and guidance this story might have had a different ending.

I would like to acknowledge the funding agencies and Dalhousie departments that supported me during this adventure. Without these resources I would have been unable to complete my studies.

Faculty of Graduate Studies & the IDPhD Program

Philanthropic and Educational Organization

Robin Rigby Trust

FACULTY OF MANAGEMENT
School of Information Management

Faculty of Management
School of Public Administration & Faculty of Arts and Social Sciences

Faculty of Management
Rowe School of Business,

Chapter 1: Introduction

1.1 Introduction

Social-ecological systems (SES) are integrated systems of nature and society, with reciprocal feedbacks (Berkes & Folke, 1998; Becker, 2012, Folk et al., 2010). Ecological components include the ecosystems (e.g. species, habitats and processes interconnected across geographical and temporal scales), whereas the social systems include people, institutions, and global communities, interconnected through globalized markets, various types of resource flows, and migration (Lambin & Meyfroidt, 2011). Coupled human and natural systems concepts are recognised in international programs, including the Man and the Biosphere Programme[1] (1971), the Millennium Ecosystem Assessment[2] (2001), and Future Earth[3] (2015).

Fisheries depletion, food insecurity and ecosystem degradation arising from both human activities and natural drivers are examples of issues affecting SESs (Adger et al., 2012). Current and future impacts from climate change, include species migration shifts and changes in abundance further escalate these SES issues, creating governance problems at different spatial and temporal scales (Brondizio et al., 2009; Molinos et al., 2016). Highlighting the importance of sustainable development, the United Nation's 17 Sustainable Development Goals[4] (SDGs) and 169 targets focus on ending poverty, protecting the planet, and ensuring prosperity for all. As a social construct, sustainable development is produced through the cooperation of society to achieve a balance between human development and environmental protection (Breuer et al., 2019). The interactions among the SDGs is complex, reflecting the mutually reinforcing or conflicting nature of these goals thus requiring a holistic and transdisciplinary governance approach (Breuer et al., 2019).

Embedded within the SDGs is the concept of resilience, which aims to address the underlying drivers of a variety of shocks and stresses[5]. Resilience in its simplest form is the capacity of human and natural systems to deal (cope/live) with change and continue to adapt and function

[1] http://www.unesco.org/new/en/natural-sciences/environment/ecological-sciences/man-and-biosphere-programme/
[2] https://www.millenniumassessment.org/en/index.html
[3] https://futureearth.org/
[4] https://www.globalgoals.org/
[5] https://www.odi.org/sites/odi.org.uk/files/long-form-downloads/annual_report_2016.pdf

(Hollings, 1973). Resilience is also categorised into specified resilience and general resilience[6] . Specified resilience refers to the resilience "of what to what" (Carpenter et al., 2012, Folk, 2010) and also for whom (Lebel et al., 2006; Cutter, 2016). General resilience applies to the system as a whole, incorporating novel and unforeseen disturbances, and the ability of the system to cope with uncertainty in all ways (Carpenter et al., 2012). Walker et al., (2009) note the importance of distinguishing between these two aspects of resilience because there is a danger of focusing too much on known or suspected thresholds at the expense of potentially reducing the general resilience of the SES to completely novel surprises.

Risks accompany change and can include both negative and positive outcomes depending on who is/was affected and by what. Expanding from the traditional definition of risk (probability and likelihood of an event), ISO 31000 defines risk as the "effect of uncertainty on objectives" of which an effect can be either a positive or negative deviation from what is expected (Standards Australia, 2009). Objectives can focus on aspects such as finances, health and safety, and environmental goals, and can apply at different levels including strategic, organization-wide, project, product and processes (Standards Australia, 2009). Many risks are systemic (OECD 2014), complex (have multiple causes) and are compounded by uncertainty and/or ambiguity as they are embedded within the larger contexts of societal processes (Renn et al., 2011; Klinke & Renn, 2002). For instance, the United Nations Sendai Framework for Disaster Risk Reduction 2015–2030[7] notes the growing recognition that different types of risks emitting from violence and conflict, fisheries depletion, land degradation, climate change, disasters, and global shocks are also interconnected with expanding urbanisation and ageing populations (OECD, 2014a).

Yet the relationship between risk and resilience concepts is still fairly new (Cutter et al., 2010, Cutter, 2016). For example, an environment continually affected by single, multiple and accumulated stresses may be more vulnerable to hazards, which in turn may have flow-on (usually negative) effects on the social, natural and built environments. Furthermore, although resilience management and adaptability approaches are often used in the context of both risk and

[6] Specified" resilience deals with the resilience "of what, to what" (e.g., the resilience of crop production to a drought). "General" resilience does not consider any particular kind of shock, or any particular aspect of the system that might be affected. http://wiki.resalliance.org/index.php/1.5_Specified_and_General_Resilience
[7] https://www.unisdr.org/we/coordinate/sendai-framework

resilience thinking approaches (Mitchell & Harris, 2012), issues relating to power, equity and globalization may be neglected, although they could play an important role in creating risk events (Matin et al., 2018; Brown, 2014; Fabinyi et al., 2014). Park et al., (2011) also propose that while traditional risk management is useful in closed and predictable systems, it becomes problematic when confronted with unexpected shocks. As such, resilience management represents a complementary approach for responding to unknown and unexpected threats through adaptation, flexibility, diversity, and experimentation or innovation (Folk, 2016).

1.2 Research goal, objectives, rationale, and thesis motivation

The primary goal of this research is to better understand risk and resilience concepts, and their interactions, so as to help coastal fishing communities better cope with ongoing and future natural and anthropogenic changes. The study focuses on both specified and general resilience (as defined in the introduction). Thus, there is a need to consider both types of resilience to proactively address known threats (e.g. impacts on inshore fisheries from aquaculture activities) and emerging threats (e.g. climate change) to coastal fishing SES.

The four objectives of this research were to:

1. Conduct a literature review on risk and resilience concepts and frameworks in the current literature of SESs
2. Discover how these concepts and frameworks provide insights for one of the largest fisheries (groundfish) collapses in the world, which occurred in Atlantic Canada
3. Explore the roles of risk and resilience in stressed Atlantic Canadian fishing communities using a case study of the New Brunswick coastal communities
4. Present and discuss approaches that contribute to a better understanding of the role and interactions between risk and resilience concepts in a coastal community SES.

Motivation for the research

My interest in the topics of risk and resilience grew from previous community based work with the World Wide Fund for Nature (WWF), knowledge gained during my Master's program (Marine Affairs Program, Dalhousie University), and as an intern with Coastal Community – University Research Alliance (CURA) project. My Master's study focused on the community's perspective of Integrated Coastal Zone management (ICM) in the Annapolis Basin area (Nova Scotia side of the Bay of Fundy). Working with Coastal CURA partners: Bear River First Nation and the Bay of Fundy Marine Resource Centre, I interviewed participants from nine organisations, including First Nation's communities, fishermen's associations, NGO's, and virtual working groups, such as the Bay of Fundy Ecosystem Partnership (BoFEP). Findings suggested that communities are usually the first responders to many of the ecological problems that arise, and often end up taking responsibility for the management of resources that they are dependent upon. Interpretations of the term ICM differed between DFO and participants, yet many of the objectives and outcomes of community projects and initiatives reflected the principles of Canada's Oceans Act and strategy[8] (1997). Potential risks to the success of the ICM process included the failure of government agencies to consider cultural and social components, their limited attention to the interconnectedness of social and ecological systems, and apparent favouritism towards forming partnerships with the corporate sector, rather than with the people who directly rely on these resources for their livelihoods (Wilson & Wiber, 2009).

Using the knowledge gained during my Master's program, my PhD research sought to further understand how risks and resilience interact across spatial and temporal scales within a SES. I was particularly interested in how participants responded to such changes, and whether their actions (or lack of actions) led to new and/or highlighted current threats and opportunities. Working with the former Coastal CURA partner, Fundy North Fishermen's Association (FNFA) based in Saint Andrews, New Brunswick, in addition to my PhD research, I also assisted FNFA with their ghost gear project[9] for two summers (2008 and 2009). In 2010, I participated in a research project with Dr. Wiber and FNFA, conducting interviews with fishermen in the SWNB area on the impact of aquaculture on commercial fisheries. The results of this research were

---

[8]

[9] More information about the ghost gear project can be found at https://www.fundynorth.org/ghost-gear

published as a policy brief for the Oceans and Coasts Network-Canada (OCN-Canada) and in *Human Ecology* (Wiber et al., 2012). Participating in Coastal CURA activities and FNFA projects, included attending fishermen's meetings, and community-based observational and participatory research, and provided me with a great opportunity to gain relevant and valuable Maritime experience, which was very helpful when I was designing my PhD research.

From a scholarly perspective, the findings of this study will contribute to the current knowledge of how risk and resilience concepts are applied and understood in a coastal fishing SES. Users of coastal areas are diverse and the interactions between users and their ecosystems requires a holistic approach. As risk management has traditionally focused on identifying and preparing for known shocks and hazards, having a better understanding of risk and resilience concepts, and their interactions may help to better prepare a SES to unexpected shock.

The normative perspective of resilience is that it is good and/or something to be aspired for if systems are to absorb or buffer disturbances and still maintain their core attributes and functions (Walker et al. 2004). Yet, the resilience of certain social–ecological system configurations (e.g. a dictatorship, ineffective governance, or algal bloom) may not be desirable, even if it is only temporal (Carpenter et al., 2012), and as such could be considered a major risk source.

This study will contribute to the literature on general and specified resilience in the context of addressing and associated and/or newly created risks that may affect coastal fishing communities. Critical questions need to be asked about who is at risk and from what, and who is resilient, and why? Conducting this research from the perspective of fishermen and community members contributes to a practical understanding of how changes and coping mechanisms that have been previously applied to address threats and events, have influenced the future risk and resilience environment of a SES.

1.3 Definitions and approaches used in this thesis

1.3.1 Social-Ecological Systems (SES)

Complex systems are a set of interacting elements that behave according to governing mechanisms or forces (Maquire et al., 2013, Preiser et al., 2018). Within the SESs and resilience literature, the Resilience Alliance defines complex adaptive systems (CAS) as a class of systems whose macroscopic behavior emerges from self-organized local interactions of their elements, such as actors interacting with ecosystems and with other actors. Characteristics of CAS are their non-linear nature, often unexpected behavior, path-dependency (an event in the past determines the development of the system in the future), and the diversity of their elements, which enable adaptation to changing conditions[10] . SES research has also benefited from the works of Ostrom, including the development of the Institutional Analysis and Development (IAD) framework and the Social-Ecological Systems framework (SESF), which is an extensive multitier hierarchy of variables that have proven to be relevant for explaining sustainable outcomes in the management of forestry, fishery, and water resources (Ostrom 2009, 2007) and further developed by McGinnis and Ostrom (2017).

For the purpose of this thesis, SESs are defined as integrated ecological and social systems, with reciprocal feedbacks. As defined by the Millennial Assessment ecosystem services include provisioning, regulating, cultural, and supporting contributions that provide benefits for people (MA, 2005). Reciprocal governance feedback loops include environmental protection, and community based management programs, which in turn generate different environmental responses (Figure 1) based on ongoing natural changes. Figure 1, as an example, only shows governance institutions (political domain) and local communities (social domain), yet as noted earlier, the social system also includes horizontal and vertical economic and technological domains. The interactions between these two domains have a driving role in how natural resources are used/extracted and managed.

[10] https://www.stockholmresilience.org/research/resilience-dictionary.html

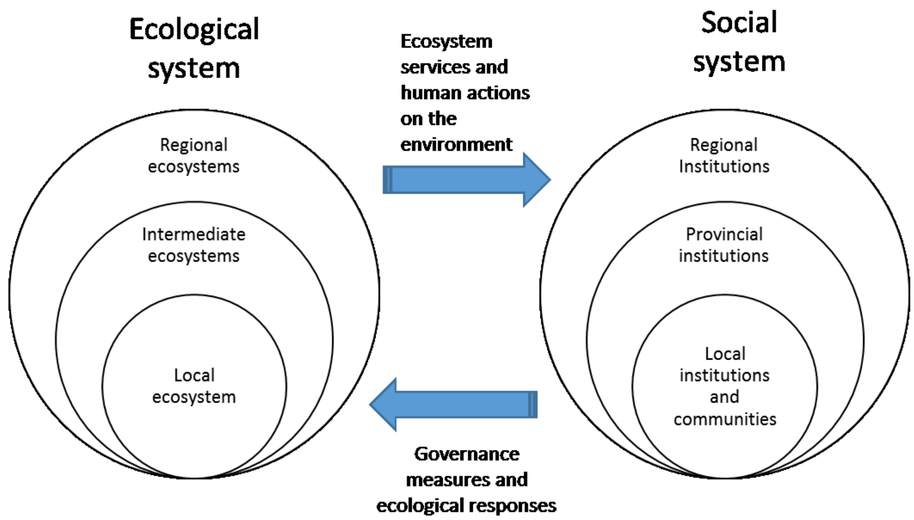


Figure 1: SES framework (Adapted from Berkes & Folke, 1998; Folke et al., 2002, Resilience Alliance, 2007; and Biggs et al., 2015)

Scale is important, and requires an understanding of the connectivity across different geographic and temporal scales, which in turn dictates the mandate and level of interest and attention from different stakeholders. For example, from a jurisdictional perspective, in Canada, fishermen may be interested in their specific fishing area and the species that they have licenses for. The Department of Fisheries and Oceans (DFO) has the mandate for managing all fisheries, oceans and freshwater resources. Their policies and legislations are nested within broader national and international conventions and guidelines/policies, resulting in horizontal and vertical linkages with other federal, provincial, and local agencies and institutions.

The social scale can be described demographically, geographically and/or as communities of interest/associations that span different locations. Economic aspects may include local and national corporative processing facilities (under the provincial jurisdiction), and local, national, and international markets. Similarly, from an ecological perspective, species may have residential populations and/or migrate, and are influenced directly by human pressure, but also by environmental factors, such as sea surface temperatures, ocean acidification, habitats, and life cycles. For sustainable development, it will be important to understand these different scales, who is involved at these levels, and how these scales interact and influence a specific area of interest.

Initially proposed by Holling (1986) with reference to ecological systems, the adaptive cycle (Figure 2) is now recognized as an applicable metaphor for SESs (Westley et al., 2002; Walker et al. 2006, Folke 2006, Walker & Salt, 2012). Assuming that (a) SESs are interconnected and that (b) both systems (i.e. human and ecological) move collectively, the adaptive cycle describes four main phases of development. Beginning with a rapid growth phase (r), a SES could move either to a conservation (K) or release phase (Ω). Although the conservation phase may eventually move to the release phase through small perturbations, it may also move back towards the growth phase.

The last phase (α) provides a window of opportunity whereby SESs can reorganize, adapt and/or transform. Between the rapid and conservation stages (fore loop), SES are considered fairly predictable, whereas the back loop is characterized by uncertainty, novelty, and experimentation (Walker & Salt, 2012). The value of the adaptive cycle is that it provides a useful way to understand why a system is behaving in a certain way at a specific time. Managers aware of these broad trends can then make decisions on how to move a SES back towards the growth phase and away from the release phase during the late stages of the conservation phase, one of the reasons being to have more gradual control over improvements rather than sudden and unpredictable changes.

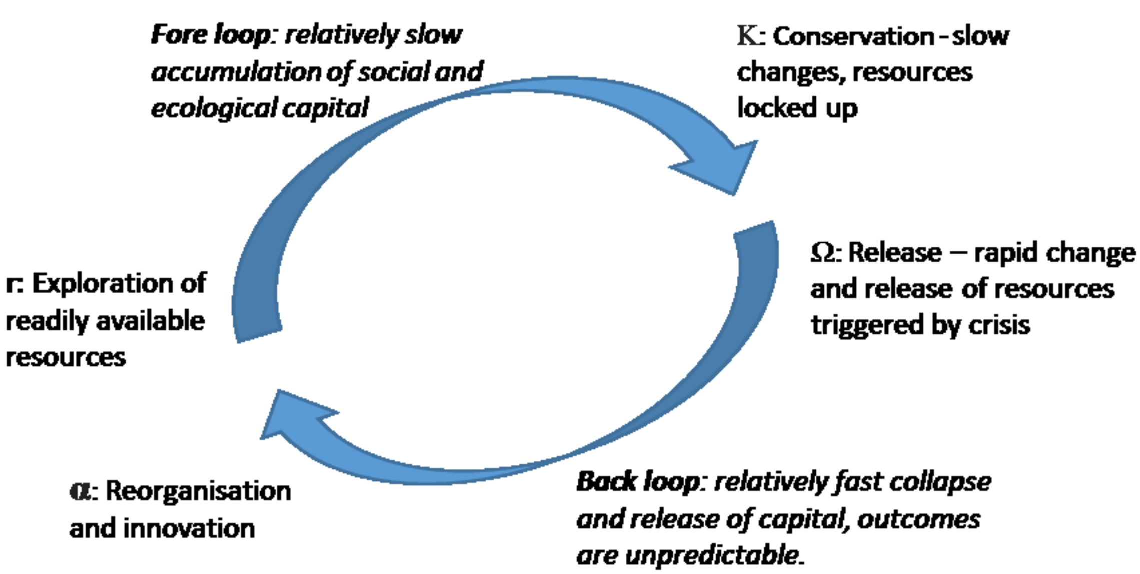


Figure 2: Adaptive cycle (Walker & Salt, 2006, 2012).

The Resilience Alliance established in 1999 is an international, multidisciplinary research organization that focuses on resilience in SESs as a basis for sustainability (Resilience Alliance, 2010). The Resilience Alliance perspective, Figure 3 describes how ecological components interact with social components at multiple levels (Resilience Alliance, 2010). Processes that are external to the system influence slow changing components, which in turn influence faster-changing components that impact people more directly (Figure 3). As such, people respond to system changes through institutional mechanisms that in turn create feedback loops that affect environmental benefits and human well-being (Resilience Alliance, 2010).

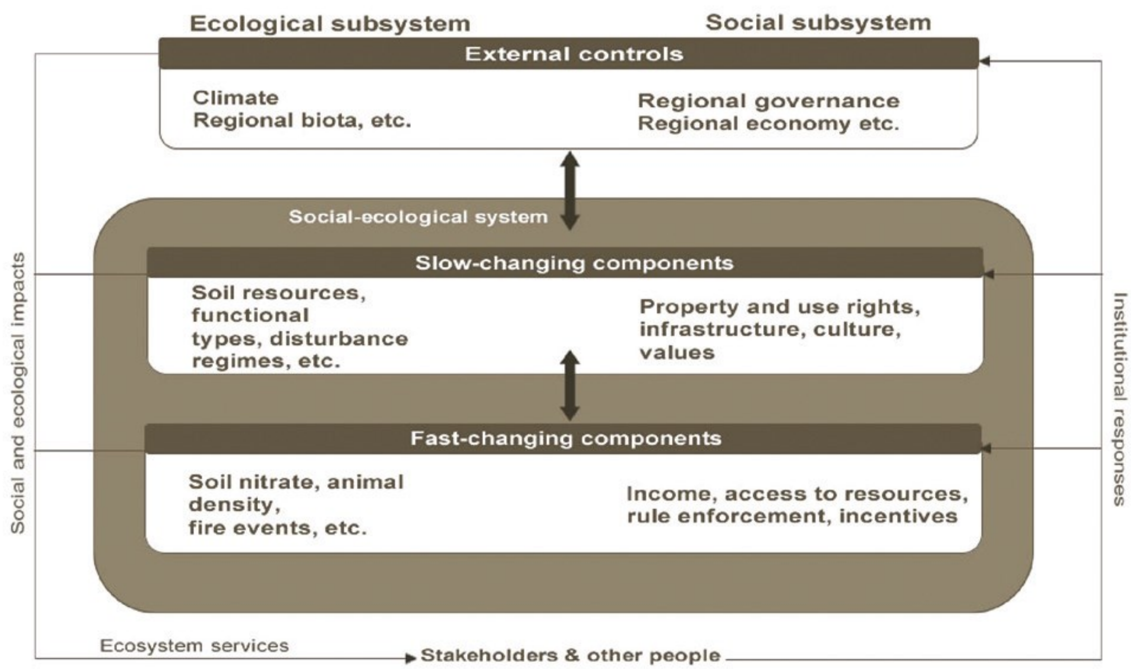


Figure 3 Conceptual model of an integrated social-ecological system (The Resilience Alliance, 2010)

Binder et al., (2013) discusses a comprehensive assessment of frameworks for analyzing SESs. Comparing 10 established frameworks[11] they found that despite having a similar objective i.e. the need for concepts that permit structured interdisciplinary approaches to address complex problems in social-ecological systems, the frameworks differed significantly with respect to the

[11] (1) Driver, Pressure, State, Impact, Response, (2) Earth Systems Analysis, (3) Ecosystem Services, (4) Human Environment Systems Framework, (5) Material and Energy Flow Analysis, (6) Management and Transition Framework, (7) Social-Ecological Systems Framework (8) Sustainable Livelihood Approach, (9) The Natural Step and (10) Vulnerability Framework.

conceptualization of the ecological and social systems and their interrelation (Binder et al., 2013). The Community Conservation Research Network (CCRN), building on earlier work (e.g. Andersson & Ostrom 2008; Folke et al. 2006), has also produced a set of guidelines to analyse social-ecological systems (Berkes et.al. 2016). More recently, Colding and Barthel (2019) provide an updated synthesis of the SES evolution from a literary perspective.

1.3.2 Resilience concepts

Resilience reflects the ability of people, communities, societies, and cultures to live and develop with change, with ever-changing environments (Folke, 2016). Folke (2016) states that there are two approaches to understanding resilience. The first approach defines resilience as a property of the state, in that it is the capacity of a specified SES to continue to self-organise, and adapt in the face of ongoing change (Walker et al., 2004; Folke et al., 2010). The second option recognises resilience as an approach for analysing, understanding, and managing change in a SES (Nelson et al., 2007; Biggs et al., 2015). For example, the Resilience Alliance defines resilience management as “an approach to managing natural resource systems that takes into account social ecological and economic influences at multiple scales, accepts continuous change and acknowledges a level of uncertainty that may or may not increase a system’s resilience and adaptive capacity (Resilience Alliance, 2010). In this thesis, resilience is bring determined as an approach for analysing, understanding and managing change in a SES.

For the purpose of this thesis, both specified and general resilience will be explored using the definitions provided in the first section of this chapter. Furthermore, although acknowledging that resilience is considered by some scholars as a systems property, this thesis focuses more specifically on the second approach (analysing, understanding and managing for change), guided by the application and assessment of how well the seven resilience principle objectives (Biggs et al., 2015) are being addressed/met. Biggs et al., (2015), drawing from the earlier work of the Resilience Alliance, identifies seven principles that are crucial for building resilience: maintaining diversity and redundancy, managing connectivity, managing slow variables and feedbacks, fostering complex adaptive systems thinking, encouraging learning, broadening participation, and promoting polycentric governance systems. Although these Principles can be applied in the context of specified or general resilience (Biggs et al., 2015), for the purpose of this thesis, they are being used to explore aspects of general resilience. The reason for taking this approach relates to the concept that both a fishery (e.g. lobster) and the aquaculture industry (e.g. Salmon aquaculture) are both SESs in their own right, and hence one might pose threat to the other industry (and vice versa). As such, each industry might identify management interventions to build their resilience, or reduce these specific threats, (or develop) mitigating actions, if these risks were to eventuate. However, if we were to consider a broader SES that includes both the lobster fishery and the aquaculture industry, there is a need to prepare this system for unexpected threats that may not be so easily evident and/or threats that will affect both industries. Some examples include warming waters that affect the physiology of resident species, bring in new species and potentially new stock diseases that could affect the livelihoods of coastal communities in the Bay of Fundy. As community have members that work in both sectors it is important to consider the wider contentions of economic loss to the overall Bay, in addition to individual sectors. Given that both sectors are reliant on the Bay, applying a general resilience lens could lead to deeper management insights at this broader level then if it was just applied to one sector or the other. Based on these insights, specific management actions could then be identified for each sector that would contribute to the overall general resilience of the Bay and its coastal communities. These principles are discussed further in Chapters 2 and 3.

Other terms relating to resilience are drawn from the terminology suggested by Bene et al. (2012) and Wamsler and Brink (2014) are defined as follows:

- **Coping** - the ability and persistence of people, organizations and systems, using available skills and resources, to face and manage adverse conditions, emergencies or disasters. An example would be fishermen remaining in the fishery through government subsides despite not being able to fish.
- **Adapting** - refers to ability of a people, organisations and systems to take advantage of opportunities or to deal with the consequences of an event in a manner that goes beyond just coping. An example would be fishermen switching to another fishery, diversifying their fisheries or expanding their business to include other related activities, such as making their own traps or selling bait.

1.3.3 Risk concepts

For the purpose of this thesis (and as noted earlier), risk is defined as the "effect of uncertainty on objectives" of which an effect can be either a positive or negative deviation from what is expected (Standards Australia, 2009). Known risks are those where managers have had previous experience dealing with them, and based on this knowledge can implement preventive or mitigating actions to address this event or threat. Unknown risks or threats generally are not envisioned until they happen, and as such cannot always be managed proactively. However, there may be initial flags highlighting that a threshold is being approached (e.g. climate change impacts on the health of lobsters) that if breached may lead to a significant impact to a community or SES. In the context of the ISO definition, risk management refers to a coordinated set of activities and methods (principles, framework, and process) that can be used to guide an organization in its handling of the different risks that may prevent it from achieving its objectives (Standards Australia, 2009).

Boholm and Corvellec (2011) make the argument that a risk itself is neither objective nor subjective, but it is how the "risk" is approached that makes it subjective or objective, and suggests that the concept of risk is more comprehensively defined as being an integration of descriptive/factual and normative elements, which are open to negotiation and contestation (Boholm 2003, Boholm & Corvellec 2011). Expanding further, Boholm & Corvellec (2011) note that to perceive and manage risks, these have to be identified and communicated. Risks are highly contextual, and the factors that influence this process are drawn from everyday experience (presence – personal relevance, integration of meaning, situation), and experience from afar, which includes both scenarios (cause/effect, probability, management driven by science) and collective narratives (actors/actions, meanings, morality, responsibility, drawing from the media). As such, risk is a cognitive frame that produces contexts which link an object of risk (a source of potential harm), an objective at risk (a potential target of harm) and an evaluation (implicit or explicit) of human (or environmental) consequences (Boholm & Corvellec, 2011). That is not to say that traditional risk management is not useful; in many circumstances, being able to identify and open a discussion relating to specific threats is often helpful in prioritising resources Boholm (2003). Boholm and Corvellec (2011) also note that risks develop when the focus of management is only on one specific element, and not the drivers of that issue that may emerge from ethical, legal, political, and cultural constructs of society. Through the literature review, desktop analysis of the groundfish fishery and SWNB case study, the insights gained through this process will contribute to a better understanding of the role and interactions between risk and resilience concepts in a coastal community SES.

1.4 Thesis outline

Chapter 2 presents the literature review on risk and resilience concepts and frameworks in the current literature of SESs (***Objective 1***). The chapter begins with a more in-depth discussion of risk and resilience concepts, followed by a review of complementary and integrated risk and resilience frameworks and approaches.

Chapter 3 describes the research methodology. Using a case study approach (Yin, 2015, 2018), the research design included both secondary (literature review, desktop analysis of the groundfish fishery) and primary data (26 semi-structured interviews with community participants from Southwest New Brunswick (SWNB) area). The groundfish desktop analysis and SWNB case study were analysed through the lens of the resilience principles (Biggs et al., 2015). Interviews were first analysed across five domains (Environment, Social, Economic, Technological, and Political) and four categories (changes, coping, threats and opportunities). A second and third round of coding using the software NVivo 12 identified key themes and sub-themes in the context of risk and resilience.

Chapter 4 addresses ***Objective 2*** as it explores and discusses the groundfish fishery desktop study. The chapter begins with an introduction to the case study, followed by an assessment of selected literature through the lens of the resilience principles. Risk factors that may have contributed to the principles not being achieved were identified and discussed to better understand the attributes and processes that could contribute towards a better understanding of the interactions between the risk and resilience (specified and general) concepts

Chapter 5 provides a general overview and context for the Southwest New Brunswick case study. A profile of the participants and assigned codes that used in the next two chapters are also described here.

Chapters 6 and 7 align with ***Objective 3***, and present examples of the data (using quotes) to illustrate the perspectives of the participants in relation to the five domains and four categories of interest.

Chapters 8 and 9 relate to ***Objective 4***, and present and discuss the analysis of data. Chapter eight focusses on risk and specified resilience, and begins with a summary of main themes and sub-themes drawn from the previous two chapters (six and seven). Examples of specified resilience (threats from aquaculture activities on inshore fisheries) are presented and discussed. Chapter nine begins with a discussion of examples focused on general resilience and risk. The second half of the chapter, discusses some general approaches to better understand the roles and interactions between risk and resilience concepts in a coastal fishing SES.

Chapter 10 concludes the thesis with a summary of the findings in the context of the four objectives, and a reflection on the overall process and next steps.

Chapter 2: Literature Review: Risk and Resilience frameworks

2.1 Introduction

The objective of this chapter is to explore potential relationships between risk management and resilience approaches using relevant literature from risk (specifically in the context of disaster management) and the resilience of social-ecological systems. The chapter is divided into three main sections. The first section describes current risk and resilience frameworks that could be considered complementary. The second section focuses on similarities and differences among these frameworks, followed by insights that have been gained from this review to inform this study.

2.2 Resilience concepts, principles and frameworks

Resilience reflects the ability of people, communities, societies, and cultures to live and develop with ever-changing environments (Folke, 2016). Folke (2016) states that there are two approaches to understanding resilience. The first approach defines resilience as a property of the state, in that it is the capacity of a specified SES to continue to self-organise, and adapt in the face of ongoing change (Walker et al., 2009; Folke et al., 2010). The second option recognises resilience as an approach for analysing, understanding, and managing change in SES (Nelson et al., 2007; Biggs et al., 2015). For example, the Resilience Alliance defines resilience management as "an approach to managing natural resource systems that takes into account social ecological and economic influences at multiple scales, accepts continuous change and acknowledges a level of uncertainty that may or may not increase a system's resilience and adaptive capacity (Resilience Alliance, 2010). In this thesis, I will be focusing on resilience using the second approach for analysing, understanding and managing change.

As noted in Chapter one, for the purpose of this thesis, the concept of resilience is being defined in two forms: Specified resilience, the resilience "of what to what" (Carpenter et al. 2001, Carpenter et al., 2010; Folk, 2010) and also for whom (Lebel et al., 2006; Cutter, 2016), and general resilience, which is applied to the system as a whole, thus allowing for the incorporation of novel and unforeseen disturbances, and the ability of the system to cope with uncertainty in many ways (Walker, 2009, Walker & Salt, 2012). In this context both specified and general resilience will be explored through the groundfish fishery and SWNB cases. As noted earlier, focusing on one form of resilience over the other, may in turn lead to a weakening of the overall SES system as the bigger picture (including risks from unforeseen events and circumstances) may be missed (Walker, 2009).

For both traditional specified resilience and risk assessment approaches a similar critique is that both focus on expert opinion, and are deemed to be scientifically objective. Still, what is sometimes missing in the management discourse is the consideration of who is doing the assessment and how it is being done. Taking this traditional approach assumes that we have the ability to accurately identify the hazard and determine the probability and consequence (risk) of its impact if it were to occur. Based on the assessment of a given risk, potential strategies could include (a) doing nothing, (b) applying proactive measures, or (c) mitigating the impact during and following the event. For example, if the objective is to make a system more resilient to storm surges or flooding, one approach might be to build a seawall or dams, but this may inadvertently lead to other parts of the system becoming less resilient, resulting in increased salinity in the water tables or the erosion of other areas of the coastline.

From a social resilience perspective, Folke et al., (2003) suggests four critical principles: Principle 1 relates to learning to live with change and uncertainty and that to enhance resilience, social-ecological management should take advantage of change and crisis, and turn these into opportunities for development; Principle 2 proposes nurturing diversity for reorganization and renewal, and suggests that diversity is insurance to counter uncertainty and surprise; Principle 3 highlights the value of combining different types of knowledge for learning, emphasizing the significance of people's knowledge, experience and understanding of complex ecosystems, their inclusion in management systems and as complementary to conventional management approaches, and Principle 4 discusses the potential for creating opportunity for self-organization, stating that this is an essential element of adaptive capacity. Furthermore, as noted by Folke (2006), resilience deals with the tension between persistence and change, i.e. understanding and managing the capacity to absorb shocks and maintain function, but also to maintain the capacity for renewal, reorganization and development at a variety of scales.

Biggs et al. (2012, 2015) presents seven principles that could enhance the resilience of ecosystem services. Table 1 describe these principles in more detail and provide examples on their application. The first three principles focus on generic social-ecological features of an SES (P1-3), and the other four on key attributes of the SES governance system. Biggs et al. (2012) differentiate between governance and management, in that governance is the social and political process of defining goals for the management of a SES, whereas management comprises the actions that are taken to achieve these goals.

Table 1 Principles for building resilience examples, application, and risks (Adapted from Biggs et al., 2012, 2015)

Principles	Reason	Examples/definition	Examples on how to apply the principles	Risks associated with the principles
1. Maintain diversity and redundancy	Diversity and redundancy are important for resilience because they provide options for responding to change and disturbance	The diversity of system elements, e.g. multiple species, management approaches, and institutions, provides the basis for innovation, learning, and adaptation to slower, ongoing change	Conserve and value redundancy Maintain ecological diversity Build diversity and redundancy in to governance systems Focus less on maximum efficiency, even if it costs more	• Low levels of either diversity or redundancy can reduce resilience (e.g. loss of keystone species or actors) • Very high levels of diversity and redundancy can undermine ES productivity and resilience in the longer term
2. Manage Connectivity	Connectivity in SES facilitates the exchange of material or information and also affects the spread of disturbances and facilitates recovery after a disturbance.	Connectivity is defined as the manner by which and extent to which resources, species, or social actors disperse, migrate, or interact across ecological and social "landscapes"	Map connectivity Identify important elements and interactions Restore connectivity Optimize current connectivity patterns	• Reduced connectivity has a strong effect on the viability of species' populations • Highly connected systems, disturbances can propagate rapidly, leading to widespread impacts on SES/ES • High connectivity among actors can lead to synchronized behavior and unsustainable resource extraction or to strong barriers for changing unsustainable practices • Highly modular or nested systems may lead to some components becoming overly important
3. Manage slow variables and feedbacks	Slow variables determine the underlying structure of SES, whereas the dynamics of the system typically arise from interactions and feedbacks between fast variables that respond to the conditions created by the slow variables	Changes in slow variables and feedbacks can lead to nonlinear changes or regime shifts in SES if certain thresholds are exceeded, with substantial impacts on the set of ES produced by the SES	Strengthen feedbacks that maintain desirable regimes Avoid actions that obscure feedbacks, & monitor important slow variables Establish governance structures that can respond to monitoring information	• Slow variables often not monitored as fast variables show more variability and response over short-time scales and are easier to observe • The absence of monitoring information on changes in slow variables and feedbacks can lead to environmental degradation • Vested and competing interests, and lack of agreement on the appropriate responses, may hamper the implementation of a coordinated international response • Management interventions that obscure, remove, or ignore stabilizing feedbacks that underlie the provision of desired ES can erode the resilience of ES

Principles	Reason	Examples/definition	Examples on how to apply the principles	Risks associated with the principles
4. Foster complex adaptive thinking (CAS)	Properties include the possibility of emergent macroscale SES behavior that cannot be predicted from individual system components, the fact that SES are continually evolving and adapting in response to internal system feedbacks, and an acknowledgment of the pervasiveness of uncertainty in SES	Fostering an understanding of SES as CAS among actors is thought to enhance the resilience of ES by emphasizing holistic (rather than reductionist) approaches, the management of multiple ES and trade-offs in an integrated way, and the importance of slow variables, lags, and feedbacks in SES dynamics	Adopt a systems framework Expect and account for chance and uncertainty Investigate critical thresholds and nonlinarities Match institutions to SES processes Recognize barriers to cognitive change	• Presenting the concept of complexity in ways that do not create a sense of bewilderment remains a key challenge in practical ecosystem management settings. • Challenges existing institutional arrangements and worldviews
5.Encourage learning	Is based on the assumptions that knowledge is always incomplete, and that uncertainty, change, and surprise are inevitable in complex SES. Hence, there is a constant need to revise existing knowledge to enable adaptation to evolution and change in SES.	Various inshore practices underpin the generation, accumulation, and transmission of knowledge and institutions Monitoring provides information, whereas experimentation involves the active manipulation of particular SES processes to observe and compare	Support long-term monitoring of key social and ecological components and provide opportunities for interactions that enable extended engagement among participants Encourage diverse participation and establish suitable social context for the sharing of knowledge Ensure sufficient resources to enable learning processes to take place and enable people to network and create communities of practice	• Power dynamics can influence how learning takes place, and what is shared • Experimentation applied at the wrong scale (for example, over short timeframes or limited spatial scales) can lead to inappropriate management decisions or fail to provide an adequate basis for decision making • The learning process also needs to guard against maladaptive or dysfunctional learning

Principles	Reason	Examples/definition	Examples on how to apply the principles	Risks associated with the principles
6. Broaden Participation	Participation refers to the active engagement of relevant stakeholders in the management and governance process.	Participation appears central to facilitating the collective action required to respond to disturbance and changes in SES and ES.	Clarify goals and expectations and get the right people involved Provide capacity building, resources and deal with power issues and potential conflicts	• Participatory strategies that fail to build social capital, or fail to effectively link to natural systems, can degrade the resilience of ES. • Participation of groups focused on short-term gains rather than long-term resilience can degrade rather than enhance the resilience of ES • Who participates and what they contribute are context specific and need to be continually revised throughout the policy process or adaptive management cycle (Stringer et al., 2006). • Weak forms of co management that promote the devolution of responsibility to local resource users without the authority to act to protect resources may degrade the resilience of ES
7. Promote polycentric governance	Match governance levels to the scale of the problem	Governance is defined as the exercise of deliberation and decision making among groups of people who have various sources of authority to act and may be practiced through a variety of organizational forms	Balancing redundancy and experimentation with the costs of involving members of multiple governance bodies and interests Negotiating trade-offs among various users of ecosystem services	• Scale mismatch • Negotiating trade-offs among various ES users • The process of resolving conflict and making collective decisions over how to allocate trade-offs

2.2.1 Resilience frameworks

Walker et al., (2004) and Walker et al., (2009) present a resilience process model (Figure 4) that integrates multiple issues, actors and scales. Using a four step process, the framework begins with (1) the description of the social-ecological systems of interest; (2) identifying and understanding the influences of external disturbances; (3) assessing the interactions of major issues about future states of the system that stakeholders are concerned with and describing the major uncertainties around how these systems will respond to shocks, and (4) stakeholder evaluations of the process and the implications for emerging understanding and needs for policy and management actions.

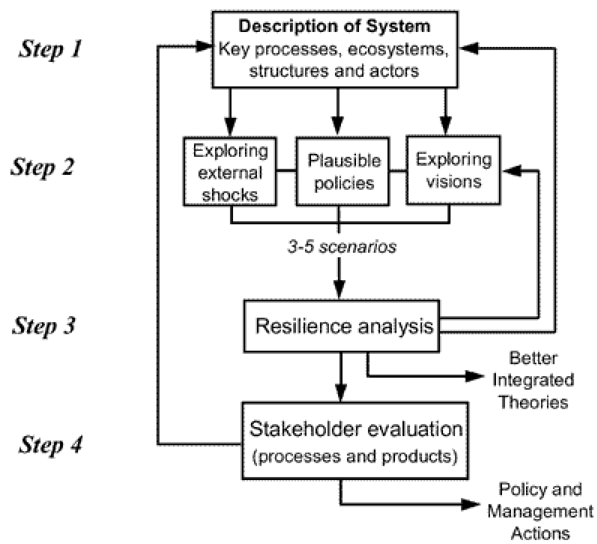


Figure 4: Framework for analyzing social-ecological resilience (Walker et al., 2002, 2009).

Feedback loops during different stages of the process allow for the findings to be evaluated and changes made to reflect any new information. Although, data collection and analysis methods are not explicitly mentioned, the use of qualitative approaches (e.g. focus groups, questionnaires and interviews) and quantitative modeling are mostly likely to be common practices for gathering and assessing different sources of information.

Advancing Walker and colleagues' (2002) model, the Resilience Alliance (2007; 2010), has produced a practitioners handbook that identifies five main steps for undertaking a resilience assessment. Figure 5 describes the five main stages of the resilience assessment framework beginning with (a) integrating ecological, social and economic understanding; (b) assessing alternative states and thresholds; (c) assessing and managing cycles of change; (d) building adaptability and transformative change into social-ecological systems and (e) developing interventions and management strategies and conducting on-going assessments to determine outcomes. Like the Walker et al., (2002, 2009) conceptual framework, feedback loops during different stages of the process allow for the findings to be evaluated and changes made to reflect any new information.

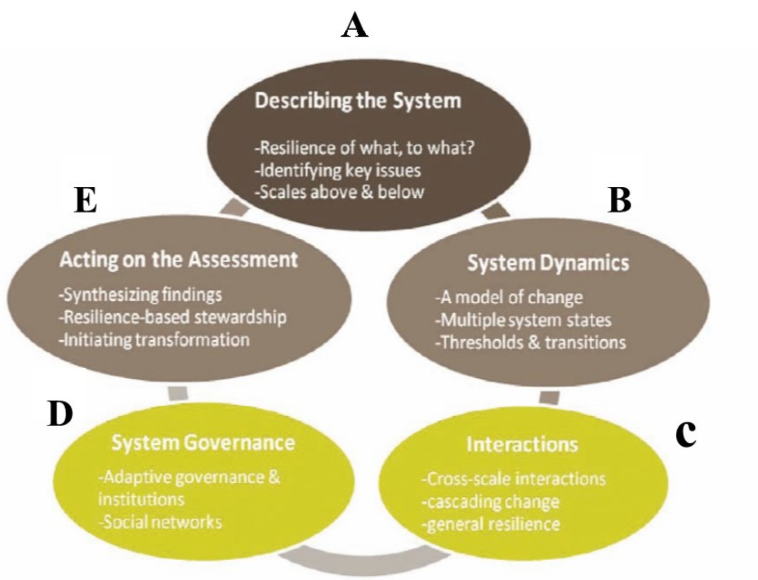


Figure 5: Resilience assessment framework. (Resilience Alliance, 2010)

Sheard (2008) takes a slightly different approach, by suggesting that there are five elements to a resilience framework. These are (a) the time period (before during and after an event), (b) the system (general, technological, ecological, social, organisational etc.), (c) the event (disturbance, perturbation), leading to (d) some change (external or internal) to the state, (e) resulting in some environmental shocks or harm that requires actions (adapt, resist, counter, cope etc). (Sheard, 2008). This approach has similarities with DPSIR models, but also includes a temporal dimension of before, during and after an event.

2.2.2 Critiques of resilience management and approaches

Brand & Jax (2007) have identified at least 10 interpretations of resilience, whereas a study conducted by the Homeland and Security Studies and Analysis Institute (HIS, 2010) identified

119 definitions for resilience. Resilience thus appears to be a vague concept that is used across many different fields (e.g. physics, biology, ecology, psychology, sociology, medicine, economics, politics, strategic thinking and crisis management), which in turn could weaken its original intent. Klinke and Renn, (2002) have suggested that the concept of resilience is in danger of losing its scientific integrity.

Stojanovic et al., (2016) and others (e.g. Armitage & Johnson, 2006; Coulthard & Britton 2015; Cutter et al., 2008; Walsh-Dilley et al., 2016) note that resilience management does not adequately conceptualize the social system given that the influence of power, rights and values play an important role in exacerbating an impact on the overall wellbeing of specific stakeholder groups and/or delaying their recovery following an event. In this context, Armitage (2006) suggests that social systems resilience can be enhanced through values and principles such as participation, knowledge sharing, trust, learning, leadership, accountability and networking. Adgar (2000) also suggests that particularly for social groups or communities dependent on ecological and environmental resources for their livelihoods, critical questions should include whether resilient ecosystems enable resilient communities and who is actually benefiting from actions that enhance resilience.

2.3 Risk management principles and frameworks

In the context of the ISO definition, risk management refers to a coordinated set of activities and methods (principles, framework, and process) that can be used to guide an organization in its handling of the different risks that may prevent it from achieving its objectives (Standards Australia, 2009). As such, it is often an accepted approach in standard management practice, whereas resilience is a newer approach, and has yet to be considered a standard approach in the day to day management of a SES. Table 2 provides a brief description of these principles. In a policy context, risks are framed against the objectives of the policy.

Table 2: ISO 31000:2009 11 key risk management principles
(Standards Australia, 2009)

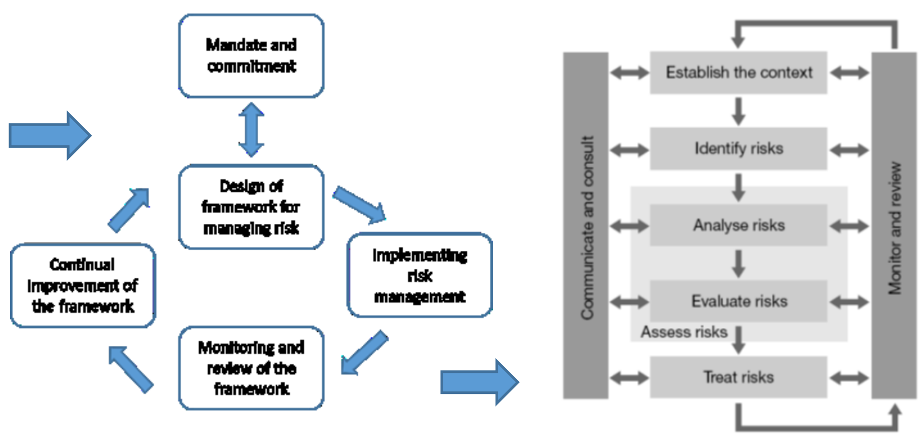
Principle	Description
1.	**Creates and protects value:** Good risk management contributes to the achievement of an agency's objectives through the continuous review of its processes and systems.
2.	**Is an integral part of all organizational processes:** Risk management needs to be integrated with an agency's governance framework and become a part of its planning processes, at both the operational and strategic level.
3.	**Is part of decision making:** The process of risk management assists decision makers to make informed choices, identify priorities and select the most appropriate action.
4.	**Explicitly addresses uncertainty:** By identifying potential risks, agencies can implement controls and treatments to maximize the chance of gain while minimizing the chance of loss.
5.	**Is systematic, structured and timely:** A systematic, structured and timely approach contributes to efficiency, consistency, reliability and comparable results.
6.	**Is based on the best available information:** Information sources include historical data, experience, stakeholder feedback, observation, forecasts and expert judgement. It is important to understand and consider all available information relevant to an activity and to be aware that there may be limitations on that information. It is also important to understand how all this information informs the risk management process.
7.	**Is tailored:** Risk management is aligned with the organizations external and internal context and risk profile.
8.	**Takes human and cultural factors into account:** Recognizes the contribution that people and culture have on achieving an agency's objectives.
9.	**Is transparent:** Engaging stakeholders, both internal and external, throughout the risk management process recognizes that communication and consultation is key to identifying, analyzing and monitoring risk.
10.	**Is dynamic, iterative and responsive to change:** The process of managing risk needs to be flexible. The challenging environment we operate in requires agencies to consider the context for managing risk as well as continuing to identify new risks that develop, and make allowances for those risks that no longer exist.
11.	**Facilitates continual improvement to the organization:** Agencies with a mature risk management culture are those that have invested resources over time and are able to demonstrate the continual achievement of their objectives.

2.3.1 *Risk management framework*

Figure 6a-c describes the relationship among the principles, framework and process taken directly from the Standards Australia, (2009) standards. The principles (Figure 6a) guide the organization in being able to implement effective risk management strategies. The risk management framework (Figure 6b) are components that provide the foundations and organizational arrangements for designing, implementing, monitoring, reviewing, and continually improving risk management throughout the organization. Finally, the risk management process (Figure 6c) describes the systematic application of management policies, procedures and practices to the activities of communicating, consulting, establishing the context, and identifying, analyzing, evaluating, treating, monitoring and reviewing the risk.

As described in Standards Australia, (2009), establishing the context (Figure 6c) allows the organization to articulate its objectives, defines the external and internal parameters to be considered when managing risk and sets the scope and risk criteria for the remaining processes. The risk assessment is the overall process of risk identification, risk analysis and risk evaluation. Risk identification refers to the different sources of risk areas, impacts, events, their causes and their potential consequences. The focus of the analysis is to develop an understanding of the risk, which includes consideration for the causes and sources of risk, their positive and negative consequences and the likelihood that these risks will occur.

ISO 31000: 2009 11 key risk management principles



6a: Principles that inform the framework

6b Framework for management

6c Risk management process

Figure 6a-c: Relationship across risk management principles, framework and process (adapted from Standards Australia, 2009)

Risk evaluation (Standards Australia, 2009) assists in making decisions that are based on the outcomes of the risk analysis (i.e. which risks need treatment and which are priorities). The treatment involves selecting one or more options for modifying the risks (prevention and/or response) and implementing those choices. Communication and consultation take place with external and internal stakeholders during all stages of the risk management process, whereas monitoring and reviewing are planned components of the risk management process and involve regular checking or surveillance (Standards Australia, 2009). Furthermore the framework (Figure 6b) ensures that information about risk derived from the risk management process is adequately reported and used as a base for decision making and accountability at all relevant organization levels (Standards Australia, 2009).

2.3.2 Critiques of risk concepts and approaches

In addition to the concerns raised by others about the risk framework (e.g. Jasanoff, 1993, Boholm, 2003; Boholm & Corvellec, 2011), others also support these critiques, in that this approach follows the rational actor paradigm perspective and may not always adequately capture the elements of equity and power relations (see Walsh-Dilley et al., 2016; Coulthard & Britton 2015). The rational actor paradigm states that risk is objective and understood from the perspective of the individual /institution in that when confronted with a decision they will choose the actions that will potentially bring them the most benefits (Dawes & Kagan, 1998). However, Renn et al., (2011) and others have noted that this view may not hold true for social structures where mutual trust and building social identity could help influence guiding principles. In addition, traditional risk management (like earlier resilience work) has also tended to rely and prioritize scientific and expert knowledge at the expense of local or traditional knowledge (Fletcher, 2014). An alternative paradigm to the rational actor perspective is cultural theory, whereby risks are subjective and cannot be quantified or calculable because these are embedded within the individual's or community's culture and value systems (Douglas, 1992).

Another critique of risk management is its tendency (in the context of disaster management) to just focus on emergency measures rather than the underpinning social, environmental, political and economic factors that may contribute to processes leading up to an event, during or after the event (United Nations General Assembly, 2015). Mitchell & Harris (2012) also suggest caution when aligning resilience and risk management strategies. Their concern is that because resilience draws from the traditional science, by bringing in this perspective, the focus is on nature (e.g. drought) as the major threat, and downplays social issues/threats such as poverty, vulnerability, and the role of agency, power and politics, which often create the enabling factors that escalate the impacts of natural and human induced disasters.

Park et al., (2013) also states that while traditional risk management is useful in closed and predictable systems, it becomes problematic when confronted with unexpected shocks. As such, resilience represents a complementary approach, which focuses on the adoption of design and management strategies for responding to unknown and unexpected hazards through adaptation, flexibility, diversity, and experimentation or innovation (Klein et al, 2003).

2.4 Complementary Risk and Resilience frameworks

Integrating risk and resilience approaches first appeared in psychological literature (Flach, 1997), adolescence development (Fergus & Zimmerman, 2005; Zimmerman & Brenner, 2010), and risk governance (IRGC, 2017). A definition from the psychological literature describes resilience as the positive capacity of people to cope with stress and catastrophe that includes their ability to bounce back to homeostasis after a disruption (Masten, 2007). Resilience in this context also corresponds to cumulative "protective factors" and is used in opposition to cumulative "risk factors" (Masten, 2007). For example, a key requirement of resilience in youth and adolescence development is the presence of both risks and promotive factors that either helps bring about a positive outcome or helps to avoid (mitigate) a negative outcome (Fergus & Zimmerman, 2005; Zimmerman & Brenner, 2010).

Luthar et el., (2000), notes that although concepts of risk and resilience in the psychological literature are quite common, there appears to be a shift in research from proactive factors towards proactive processes to better understand how different factors engage. For example, rather than focusing on a small area of risk factors initiating from the internal environment and individual, the trend has been to move to a wider systematic approach that consider the external environment (i.e. promotive factors) such as family, parental support, adults mentors and youth programs as opportunities to provide youth with the skills that could help them overcome the negative effects of risk exposure (Zimmerman & Brenner, 2010; Fergus & Zimmerman, 2005).

Examples of studies that have considered risk and resilience include international development studies (OECD, 2014b), home security assessments (Homeland and Security Studies and Analysis Institute, 2011) and disaster risk management research (Park et al., 2013; Brown & Westaway; 2011; Cutter et al., 2008, Cutter, 2016). Risk and resilience integrated concepts and frameworks have also been applied in the context of community resilience (Pasteur, 2011; Berkes & Ross, 2013), urban cities (Blackmore & Plat, 2008), and climate change work (e.g. Lavell et al., 2012). Some of the benefits for using these two approaches include the integration of a shared view of the risk landscape that people may face and a broader understanding of the resilient aspects of the system that supports their wellbeing (OECD, 2014b).

The resilience concept in the risk management literature is often combined with the concept of vulnerability, for example resilient communities are far less vulnerable to hazards and disasters than less resilient communities and places (Klein at al., 2003). In this context, vulnerability is described as the pre-event, inherent characteristics or qualities of social systems that enable the potential for harm (Cutter et al., 2008, Cutter, 2016). More specifically in the hazard research arena, resilience is defined to mean "the ability to survive and cope with a disaster with minimum impact and damage, and incorporates the capacity to reduce or avoid losses, contain the effects of disasters, and recover with minimal social disruptions (Manyena, 2006). The deciding factor that influences the ability of a community to mitigate or recover faster from the effects of a hazard or disaster is referred to as its adaptive capacity (Cutter et al., 2008). Another perspective is that resilience is the ability of systems to prevent or adapt to changing conditions in order to maintain control over a system property. Hence, to ensure safety, the system must be resilient to avoid failures and losses, as well as respond appropriately after the event (Leveson et al., 2006).

Within disaster management, climate change, and youth and adolescence development literature, vulnerability is also considered a key attribute in the context of resilience. For example, within the youth and adolescence literature, Luthar et al., (2014) refers to proactive (resilience) and vulnerability factors that influence life stresses in high risk adolescents.

In the context of an SES, climate change adaptation studies and disaster risk reduction research draw heavily on risk management practices to build resilience (Kelman et al., 2017), but there appears to be fewer studies done from a resilience perspective. A few exceptions are Bowd's thesis on integrating SES theory into natural resource management practice in South Africa using the concepts of resilience, risk and ecosystem services assessment (2015), and Tuler et al., (2008) on assessing vulnerabilities and integrating information on driving forces that affect risks and resilience in fishing communities. In the context of resilience, Berkes (2007) also explores uncertainty and reducing vulnerability in disaster management.

2.4.1 DROP model

The Cutter et al. (2008) DROP model (Figure 7) is "A place-based model for understanding community resilience to natural disasters". The model was developed to address natural hazards but could also be relevant to security and technological hazards and slow onset natural hazards like drought. The model focuses at the community level and on the social resilience of places, but also notes that other forms of resilience exist (e.g. environment and built environment) that cannot be separated from social processes (Cutter et al., 2008).

Cutter et al. (2008), describe this approach where the first stage is to understand the antecedent conditions that create relationships between inherent vulnerability and resilience factors (inner triangle), which in turn are a product of multi-scalar processes that occur within and among social, natural and built environment systems (outer triangle). Antecedent conditions interact with the hazard event, which may facilitate an immediate responses. The effects of the hazard are amplified (+) or attenuated (-) depending on the presence or absence of mitigating actions and coping responses. Here coping responses are defined as actions that allow a community to respond in a certain way and include, for example, predetermined evacuation plans, creation of shelters, information dissemination and emergency response plans (Cutter et al., 2008).

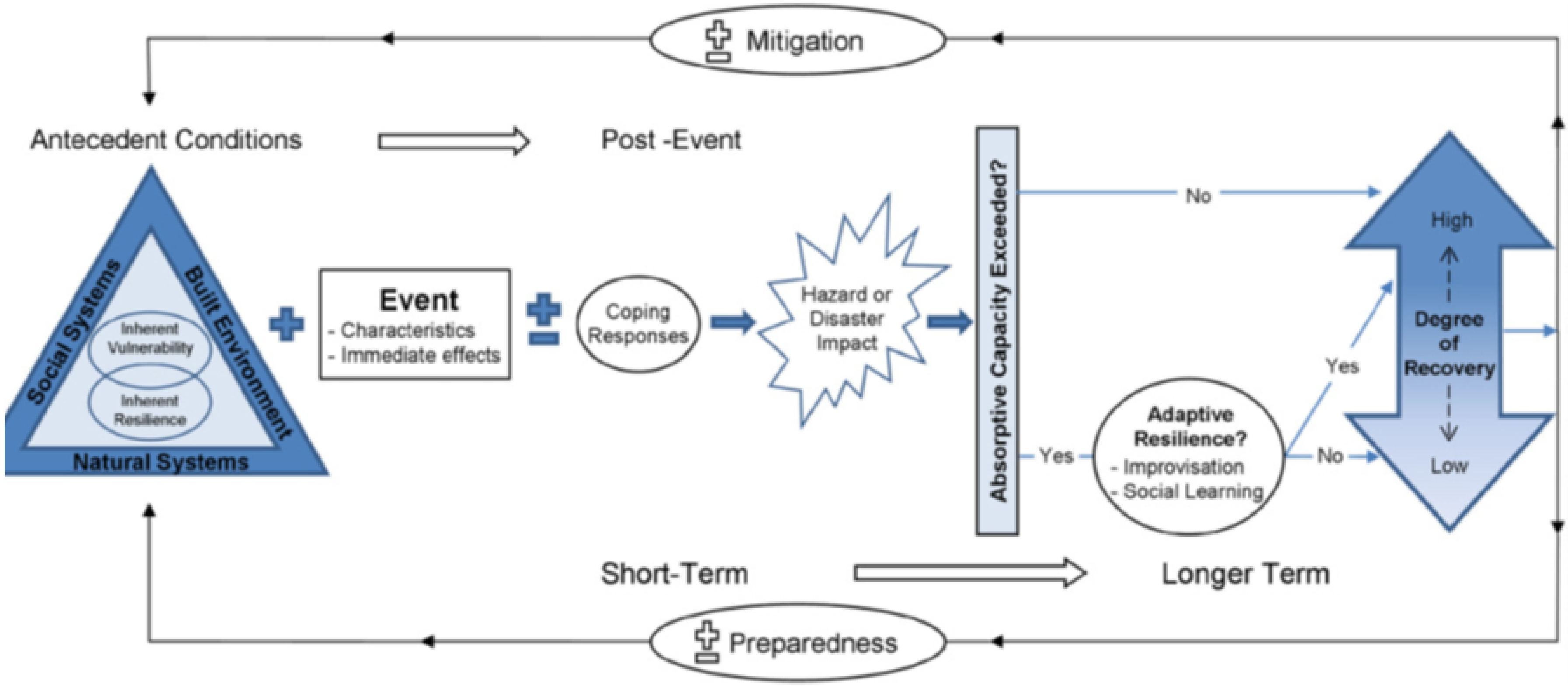


Figure 7: DROP model

The second stage of this model focuses on the absorptive capacity (or threshold) of the community (Cutter et al., 2008). If the absorptive capacity is exceeded (i.e. the hazard event is so large that it overwhelms local capacity or if the event is less catastrophic but existing coping responses are insufficient to handle the impact, this may push the community closer to a disaster. Still, if the community is able to implement effective coping responses and can absorb the impacts of the event then the degree and rate of recovery will potentially be much faster. Feedback processes occur when both the degree of recovery and the potential knowledge gained from adaptive resilience processes are able to influence the state of the social, natural and built environmental systems and the resultant antecedent conditions prior to the occurrence of the next event (Cutter et al., 2008).

2.4.2 Port security risk and resilience model

The risk management framework illustrated in Figure 8 describes the process that could be taken to support and enhance port security (Brooks & Pelot, 2008). Brooks and Pelot (2008) propose that the degree of vulnerability is a buffer between the threat and the system under attack, thus ultimately having a major influence on the level of consequences resulting from an event. The system's resilience is a moderating factor that affects the degree to which the damage radiates outwards from the immediate target in time and space (Brooks & Pelot, 2008).

This is a useful model as it presents a temporal frame, aligned with different strategies that could be developed. For example, prior to the event, control measures (interference) may help reduce the vulnerability of the port to a specific hazard. If these measures fail, and the event occurs, there are both immediate and ensuring consequences that collectively may change the state of the port or system. Resilience (i.e. the ability to bounce back after the event) is dependent on different variables that lessen the consequences of the event, and potentially leading a faster recovery and strengthening of port security.

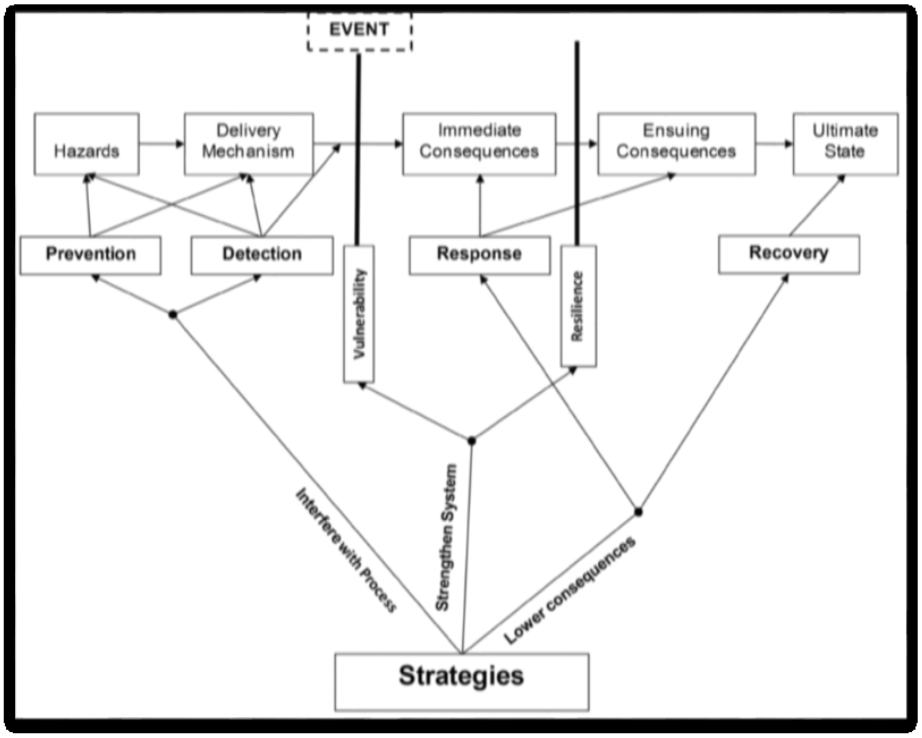


Figure 8: The port security risk –resilience management framework
(Source: Brooks & Pelot, 2008).

In the context of a SES, a potential risk to fishermen's livelihoods is the expansion of the aquaculture industry (event), resulting in consequences that have direct impacts (competition for fishing/farm space) or indirect long-term impacts, such as the poor health/quality of lobsters due to pollution and chemical run-off, which in turn has impacted water quality. The detection/indication of this hazard/event may over a period of time include: (a) the increasing trends in the number of aquaculture sites, b) ecological changes in water quality, and c) overcrowding of specific fishing grounds.

Prior to the expansion of the farms, "interfering with the process" strategies that fishermen could take include social protests leading to potential political reform. Alternatively, following the expansion, as an immediate response fishermen could lobby for compensation through legal recourse, which if successful may help to reduce ensuing consequences. Another strategy that could be taken by provincial regulatory bodies (in the Southwest New Brunswick case, the province issues aquaculture site licenses), would be to reduce the number of aquaculture sites, thus allowing time for contaminated areas to recover and/or create alternative livelihoods for the fishermen. A fisherman's resilience to cope under these circumstance would depend on existing skills, abilities and access to alternative occupations. An immediate consequence would be if they did not have these skills and/or there were no other jobs available, they would need to learn new skills and/or leave the community to find other work. Eventually, contaminated sites might recover, or a moratorium placed on the establishment of future aquaculture sites, which would return the SES (from a fisheries perspective) to a similar state that it was in before, or create a new state (e.g. changes in benthic communities).

From the aquaculture industry perspective, the loss of farm sites either through water quality contamination or a moratorium would most probably create economic risks to the business, which could lead to additional risks such as the loss of jobs for community and other workers, if a company was to close. Mostly likely the industry would also plan similar measures to ensure that they were able to maintain economic viability. Poor water quality is a shared environmental risk across both industries. Although fishermen may feel that they are the ones most impacted from pollutants and contaminated sites, there are also economic consequences for the salmon industry if they were losing fish to diseases and/or the value of their products decreased due to an infestation of sea lice. Resilience in this case would be considering factors that could lessen the consequences to the environment, and ensure a faster recovery that could either return water quality to its previous state, potential through technology strategies, or if these fail, results in a new and probably less desirable environmental state.

2.4.3 Examples from the general literature

Park et al., (2013) describes some of the major differences and similarities between risk and resilience management (Table 3). The authors note that general resilience is often defined as the capacity to adapt to changing conditions without catastrophic loss, form or function. Yet, this approach conflates resilience and risk perspectives by expressing resilience exclusively in risk terms, and as such they propose that resilience is an emergent property rather than a static property that the system has (Park et al., 2013). According to Park et al., (2013), resilience cannot be measured just by examining component parts but is better understood as the outcome of recursive processes that includes sensing (process by which new system stresses are efficiently and rapidly incorporated into current understanding), anticipation (process by which newly incorporated knowledge gained by sensing is used to foresee possible crises and disasters), adaptation (the response taken after information from sensing and anticipation are incorporated into understanding), and learning (process by which new knowledge is created and maintained by observing past actions). In this context, resilience analysis can be understood as differentiable from, but complementary to, risk analysis.

Table 3: Comparisons between risk management and resilience (Park et al., 2013).

	Risk Management	**Resilience**
Design principles	Preservation of status quo, that is, avoid transformative change; minimize risk of failures	Adaptation to changing conditions without permanent loss of function (e.g., changing paths, if not destinations) Acknowledgment of unknown hazards. Intentional failure may be allowed at subsystem level to reduce the possibility of permanent loss of function in larger system
Design objectives	Minimization of probability of failure, albeit with rare catastrophic consequences and long recovery times	Minimization of consequences of failure, albeit with more frequent failures and rapid recovery times
Design strategies	Armoring, strengthening, oversizing, resistance, redundancy, isolation	Diversity, adaptability, cohesion, flexibility, renewability, regrowth, innovation, transformation
Relation to sustainability	Security, longevity	Recovery, renewal, innovation
Mechanisms of coordinating response	Centralized, hierarchical decision structures coordinate efforts according to response plans	Decentralized, autonomous agents respond to local conditions
Modes of analysis	Quantitative (probability-based) and semi quantitative (scenario-based) analysis of identified hazards (Aven, 2016 & Renn, 2008) in context of utility theory (i.e., costs & benefits)	Possible consequence analysis of involving scenarios with unidentified causes

Aligning their approach with the adaptive cycle, Blackmore and Plant (2008) suggest that risk management is a generally accepted component of strategic operational planning and practice that usually has a deconstructionist approach and requires clearly defined objectives and measures. In risk management, the assessment predicts the likelihood of failure and magnitude of consequences, risk is considered the “risk of” something happening (internal causation), and addresses expected perturbations by adjusting performances to avoid collapse/failure, which then triggers corrective action (Blackmore & Plant, 2008). Although resilience is considered a theory that may still require validation and quantification, it is a holistic approach that uses systems analysis and assessment methods to predict the position on the adaptive cycle.

Blackmore and Plant (2008) propose that by understanding where a system is on the adaptive cycle identifies its adaptive capacity. Furthermore, these authors suggest that risk assessment thresholds based on human -derived criteria may fall short of representing true system failure, whereas breakpoint thresholds in resilience theory represent changes in system performance that lead to a collapse. Hence focusing on the proximity of the system to the collapse stage of the adaptive cycle and (its threshold) interventions can then be applied that might prevent collapse or reduce the consequences of the event (Blackmore & Plant, 2008). As such, thresholds can be identified for specific domains (e.g. governance and regulations, social issues, economics, natural environments, operations, and system infrastructure) so that controls for individual domains can be put into place to bring the system back into an acceptable (low-risk) state or hasten transition to a desirable new state with enhanced resilience (Blackmore & Plant, 2008).

From a theoretical perspective, the comparisons between risk and resilience by Blackmore and Plant (2008) are helpful as it brings into context the adaptive cycle from the systems and resilience literature. For example, a system may be at risk from a potential hazard, but if detected earlier enough may allow measures to be implemented that could prevent the impactful (negative) event from occurring by moving the SES away from the crisis stage. Conversely, depending on the circumstances and context, preventing the system from collapsing could also mean that the opportunity to transform or reorganize may be lost.

2.5 Similarities and differences between risk and resilience frameworks and processes

2.5.1 Framework assumptions

The frameworks and processes discussed above are useful for conceptualizing and presenting complex dynamics, multiple actors, issues, and potential consequences resulting from the interactions of these variables across different temporal and spatial scales. For example, the risk management process allows for different risks to be assessed and, based on the likelihood of the event occurring and the potential consequences (immediate and future), actions are identified and prioritized to manage or mitigate impacts following the event. Resilience frameworks are a little different in that although specified resilience is similar to the risk management approach, general resilience at a systems level focuses more on bouncing back from unknown and surprise events.

Traditional frameworks and processes still rely heavily on scientific quantitative assessments, although there seems to be more willingness from management agencies to include other forms of knowing, such as local ecological knowledge. While very helpful visual tools and process guidelines exist, these frameworks may not always represent and/or capture the variations in actors' behaviors, beliefs, values, and actions, which can cause additional risks to the success of management interventions.

2.5.2 Risk and resilience frameworks

Generally, traditional approaches to assessing resilience and risk factors (Figures 4 and 6c) are similar in terms of defining the scope, attention to temporal and spatial scales, and a methodology/methods/tools for conducting the assessment. Both approaches also identify guiding principles that inform assessment and management processes. Similarly, the DROP and Port Security frameworks include temporal and spatial scales. In the DROP framework, resilience and vulnerability are inherent features that are present in all three interacting systems (social, natural and built environments), prior to the event, and as such influence the community's ability to adequately prepare or cope/mitigate adverse effects post event. If a community is unable to cope with the impacts from the hazard/event, this affects their adaptive capacity, which in turn affects the time it takes to recover. The port security framework separates vulnerability (before the event) from resilience (post event), but is similar in that strategies are targeted at different stages of an event, and include both short term and long term consequences. Three sets of strategies are proposed, including interfering prior to the event, strengthening the system post event, or lessening the consequences both immediate and future.

Park et al., (2013) findings note the differences in design principles for risk and resilience - for example current risk management practices tend to preserve the status quo and thus avoid transformative changes so as to minimize risk failures. Table 4 provides a comparison of risk management strategies and resilience approaches (adapted from Blackmore & Plant, 2008), with additional insights based on the literature review.

Table 4: Comparison of risk management strategies and resilience approaches (adapted from Blackmore & Plant, 2008), with additional insights based on the literature review. *Text in italic is drawn from Blackmore and Plant (2008) list*.

Risk	Resilience
Definition and Context	
Risk is the "effect of uncertainty on objectives" and an effect is a positive or negative deviation from what is expected (ISO 31000). Risks are systemic, complex (multi-causal) and compounded by uncertainty and/or ambiguity as they are embedded within the larger contexts of societal processes (OECD, 2014a).	In a SES's context, resilience is the capacity of human and natural systems to deal (cope) with change and continue to adapt/function (Hollings, 1973). Recognizing the systematic nature of SES, the resilience of ecosystem services (ES) is defined as the capacity of the SES to sustain a desired set of ES in the face of disturbance and ongoing changes in SES (Biggs et al., 2012).
Strategies for dealing with risk include risk avoidance, risk acceptance, risk reduction /mitigation, and risk transfer	Strategies for dealing with resilience include coping, adapting and transformation.
Risks can be categorised into simple, complex, uncertain and ambiguous (IRGC, 2017)	Resilience can be defined as specified resilience (resilience of what to what, or whom) or general resilience, which applies to the system as a whole, incorporating novel and unforeseen disturbances, and the ability of the system to cope with uncertainty in all ways (Carpenter et al. 2001).
Risks reflect different types of shocks e.g. covariate shocks (infrequent events), idiosyncratic shocks (significant events), seasonal shocks and long term trends that weaken (stress) the potential of a system and increase the vulnerability of its actors (OECD, 2014b).	Resilience is sometimes referenced as the adaptive (complex) cycle, which includes: a growth phase (r) with resources that moves slowly towards a conservation stage (K), where resources become locked up/unavailable, or are less flexibility and in may be easily triggered to cause a crisis event, e.g. disease outbreak. Once a system collapses, the change is very rapid (alpha) as resources that were locked up are released, which then moves very quickly into a re-organization phase (omega). In this phase boundaries are tenuous and innovations are possible (Water and Salt, 2006, 2012).
In addition to events that are rare events but have a catastrophic impact, (as opposed to ongoing/more frequent events but with perhaps less consequences), hazards can also be described as slow (creeping) or acute (rapid) onset events.	
Risk can be assessed before, during and after an event	Resilience is often assessed before and/or after an event.
Theoretical underpinnings	
• *Deconstructionist approach, considers component performance; can accommodate local variance* • *Analysis accommodates fundamental laws of science, engineering analysis, expert opinion and consultative inputs and probability theory*	• *Holistic approach, considers whole-of system performance* • *Traditional analysis based on complex systems and stable states theory, emerging from science disciplines*
Can be traced back to 3200 BC and the Tigris-Euphrates area. Although risk management has a history in market insurance the study of risk management only began after World War II. Specific research areas now include: Ecological Risk Assessment, Microbial Risk Analysis, Occupational Health and Safety, Risk Policy and Law, and Security and Defense (Aven, 2016).	Has roots in psychopathology, Flach, 1997) and adolescence development (Fergus & Zimmerman, 2005). Resilience has also been incorporated into international development studies (OECD, 2014a), home security assessments (Homeland and Security Studies and Analysis Institute, 2011), disaster risk management research (Park et al., 2011), climate change (Lavell et al., 2012) and SES (Holling 1973).

Risk	Resilience
Theoretical underpinnings cont.	
Risk paradigms include: the rational actor, critical theory, psychometric paradigm and cultural theory. These theories underpin the different perspectives, understanding and approaches to addressing risks (Renn, 2006). The rational actor paradigm is the most dominant approach.	A broad perspective of resilience incorporates elements of complex adaptive system dynamics, true uncertainty and learning to live with change elements (Folke et al., 2016 and others). Resilience can also be conceptualized using metaphoric references to states, attractors and stability landscapes (Walker et al., 2004).
Risk perception is the subjective judgement that people make about the characteristics and severity of a risk. The risk society recognizes that risks have social and psychological dimensions, which are shaped by values, beliefs, political systems and cultural factors.	Resilience defined in the psychological literature is a positive capacity of people to cope with stress and catastrophe that includes their ability to bounce back to homeostasis after a disruption (Masten, 2007). Resilience also corresponds to cumulative "protective factors" and is used in opposition to cumulative "risk factors" (Masten, 2007).
Guiding principles, structures and attributes	
• *Requires clearly defined objectives and measures. Is generally accepted as a component of strategic and operational planning and practice* • *Tends to suffer from incomplete prediction arising from unrecognized controls, influences and feedbacks* • *Tends to concentrate on fast to medium term variables*	• *Addresses expected perturbations Tends to address unexpected. Relies on total, indiscriminate systems analysis – does not recognize "unusual" influences and local effects* • *Pays attention to both fast and slow variables. Multiple stable basins acknowledge alternative resilient states*
Standards Australia, (2009) recognizes 11 key risk management principles, including inclusiveness, systematic, objectivity, participatory, transparency, dynamic, addresses uncertainty and takes into account human and culture values.	Berkes et al. (2008), identifies three central features of resilience, whereas Walker (et al., 2004) describes four main attributes. In the context of social resilience, Folke et al., (2002) suggests four critical principles, and Biggs et al., (2015) describes seven principles.
Standards Australia, (2009) aligns the principles with the risk management framework and process. The risk governance framework also provides key questions that guide the alignment of its framework and the application process.	A number of studies explore the alignment of resilience principles and application. Walker et al., (2004) resilience assessment and management conceptual model and the Resilience Alliance (2007; 2010), practitioners' handbook lists five main steps for undertaking a resilience assessment. Biggs et al., (2015) is one of the most current guides.
Frameworks (conceptual & applied)	
• *Assessment predicts likelihood of failure and magnitude of consequence* • *Risk is risk OF something happening – internal causation* • *Failure" is determined by man-made thresholds and criteria that are vulnerable to misrepresentation* • *System state is determined by control state and uncontrollable factors* • *Adjusts performance to avoid collapse* • *Failure triggers corrective action*	• *Assessment methods predict position on adaptive cycle, proximity to thresholds* • *Resilience is resilience TO something happening – external causation* • *Collapse" involves crossing break-point thresholds into new regimes* • *System state is determined by system position in a 'stability landscape' and stage in the adaptive cycle* • *Accepts inevitability of collapse* • *Collapse is followed by natural reorganisation*

Risk management	Resilience
Frameworks (conceptual & applied) cont.	
The risk management framework (Standards Australia, 2009) provides the foundations and organizational arrangements for designing, implementing, monitoring, reviewing, and continually improving risk management throughout the organization.	Resilience is a framework for systematically thinking through system dynamics and helps in our understanding of complex systems behavior. Sheard (2008) describes five elements of a resilience framework (time period, system, event, required action, preserved qualities). Others include the Adaptive complex cycle, Panarchy, and the steps outlined in the Resilience Assessment Workbook for Practitioners (Resilience Alliance, 2007; 2010).
Contributions to the governance of an SES	
• *Tends to encourage maintenance of known, low risk control states – a defined path to achieve system performance*	• *Represents an overall measure of sustainability*
Latest approaches to disaster management, specifically the Sendai Framework recognize that underpinning social, environmental, political and economic factors may contribute to processes leading up to an event, and/or intensifies situations during or after the event (UNISDR, 2009).	Highlighting the importance of sustainable development and call for good governance, the modern Sustainable Development 17 goals and 169 targets focus on ending poverty, protecting the planet, and ensuring prosperity for all
The risk management process describes the systematic application of management policies, procedures and practices to the activities of communicating, consulting, establishing the context, and identifying, analyzing, evaluating, treating, monitoring and reviewing the risk.	Resilience management is "an approach to managing natural resource systems that considers social ecological and economic influences at multiple scales, accepts continuous change and acknowledges a level of uncertainty that may or may not increase a system's resilience and adaptive capacity (Resilience Alliance, 2010).
Critiques	
The rational actor paradigm suggests that individual benefits, markets and political debates dictate the actions that are taken by society, yet this may not hold true when building mutual trust and social identity are the guiding principles (Renn et al., 2008).	Brand & Jax (2007) identified at least 10 interpretations of resilience and the HIS report (2010) 119 definitions suggesting that resilience as a concept is vague as it is used across many different fields, which perhaps weaken its original intent.
Risk management may not always adequately capture the elements of equity and power relations (Walsh-Dilley et al., 2016; Coulthard & Britton 2015)	Resilience management does not adequately conceptualize the social system although the influence of power, rights and values play an important role in exacerbating an impact on the overall wellbeing of specific stakeholder groups and/or delaying their recovery following an event.
Traditional risk management tends to rely and prioritize scientific and expert knowledge, at the expense of local or traditional knowledge. (Fletcher et al., 2013).	Resilience (SES), draws from the ecological fields, with a scientific and expert knowledge base and methods that do not readily align well with incorporating human social systems such as scale and agency as these components are more complex than what the adaptive management literature suggests (Wiber, 2008).
While traditional risk management is useful in closed and predictable systems, it becomes problematic when confronted with unexpected shocks (Park et al., 2013).	Resilience is often considered a positive characteristic of a SES, but certain SESs configurations may not always be desirable (Carpenter et al., 2005). Although SES's are interdependent, resilience should be assessed separately as the resilience of the social system may be high, which in turn reduces the ecosystem resilience (Norris et al, 2008).

Resilience views transformative processes as windows of opportunity that help the system to recover after an event Another difference (again referring to engineering systems) is that risk strategies focus on armoring, strengthening, or building resistance, whereas resilience embraces diversity, adaptability, growth and flexibility. Lastly, the coordinating responses for risk management tends to be centralized with a hierarchical chain of command, whereas resilience appears to rely on decentralized autonomous agents responding to local conditions (Park et al., 2013).

2.6 Insights from the Literature review

The findings of this review support the assessment of Mitchell & Harris, (2012) in that both approaches take a holistic and systematic perspective that recognises the interactions between systems, acknowledges the need to focus on capacities and has an objective of better preparing systems to deal with uncertainty, surprises and change. In applying this view to an SES, the social system would include the interacting sub-systems such as economic, cultural and governance, whereas the ecological systems would contain the biological, physical and chemical components (as defined by the MEA as being the supporting, regulating, provisioning and cultural categories) that support ecosystem services. As such, both risk and resilience (in the context of general resilience) management approaches appear well positioned to address specific governance aspects of complex and dynamic SESs.

Within the management field, risk is an older approach with defined principles, objectives, frameworks, measures and process, and is often an accepted approach in standard management practices. Resilience (in the context of resilience management for SES) is a newer approach and has yet to be considered a standard approach in the day to day management of a SES. Applying a resilience thinking lens may help to better prepare a SES in situations of uncertainty and unexpected shocks as risk management has traditionally been more focused on identifying and preparing for known shocks and hazards. Biggs et al., (2015), drawing from the earlier work of the Resilience Alliance has explored the linkages among principles, objectives and applied frameworks in an SES context.

Both resilience and risk approaches have similar critiques in their methods, including the limited and narrow ability to conceptualize the social system and a reliance on scientific interpretations (as the prioritized knowledge system), based on models and frameworks. Consequently, from an applied perspective, any approach to conceptualize integrated risk and resilience management approaches will need to consider both the limitations and strengths of these two approaches.

Benefits for considering these two approaches include the integration of a shared view of the risk landscape that people may face, and a broader understanding of the system (in the context of general resilience) that supports both ecosystem health and societies wellbeing (OECD, 2014a-b). Incorporating a resilience approach with traditional risk management provides opportunities for adding elements that may address the complexity and inter-linkages of different risks: for example, when disasters trigger economic shocks or conflicts leave people more exposed to disaster (OECD, 2014a-b). Furthermore, taking a general resilience perspective might better prepare a SES to address areas of uncertainty and change by exploring how long-term trends from stressors (e.g. climate change, governance insecurity, economic marginalization, environmental degradation, and demographic changes) can change the nature and impact of shocks in the future (OECD, 2014a-b). Focusing on the system (rather than a single risk) could help strengthen existing interconnecting pathways by unpacking key elements such as power relations that may prevent the development of a resilient system.

Chapter 3 Methodology

3.1 Introduction

The purpose of this chapter is to first describe the steps taken to develop the conceptual framework used to identify approaches that could help better understand the relationship between risk and resilience concepts as discussed in Chapters one and two. Secondly, this chapter describes the data collection and analysis process. The chapter begins with a short overview of interdisciplinary research to situate the research design.

3.1.1 Interdisciplinary research

Repko (2007) makes two distinctions in the definition of interdisciplinary – those that are proposed by generalists such as Moran (2002) who understand the term to loosely mean "any form of dialog or interaction between two or more disciplines" while minimising, obscuring or rejecting altogether the role of integration. Whereas, Klein and Newell (1997) define interdisciplinary as:

> *A process of answering a question, solving a problem or addressing a topic that is too broad or complex to be dealt with adequately by using a single method, discipline or profession and drawing on disciplinary perspectives and integrating their insights to produce a more comprehensive understanding* (pp 393-394).

Building off the integrationist approach, Repko (2008) focus on interdisciplinary processes, which are reflected in other interdisciplinary studies. Borrego and Newswander (2010) propose four critical areas for conducting interdisciplinary research: (a) the degree to which a researchers' work is grounded in carefully selected and adequately employed disciplinary insights (disciplinary grounding), (b) integration by advancing knowledge and understanding through synthesis, frameworks, connections between seemingly dissimilar contexts and the ability to resolve conflicts; (c) communicating and translation across disciplinary boundaries and (d) critical awareness, in that "truth" and "knowledge" in any discipline are susceptible to influences by factors such as funding, resources and the biases of the researchers themselves. As noted by Repko (2008) and Ivanitskaya et al. (2002), critical awareness is not only an attitude for learning but also a method for analysing the benefits, challenges and shortcomings of one's own research.

3.1.2 Case study methodology

The case study approach is an empirical inquiry that investigates a contemporary phenomenon within its real-life context; when the boundaries between phenomenon and context are not clearly evident; and in which multiple sources of evidence are used (Yin, 2011, 2017). Alternatively, Merriam, (1988) describes the case study as an examination of a specific phenomenon, such as a program, event, institution or social group, whereas, Stake (1995) considers a case study as both a process of inquiry about the case and the product of that inquiry. The explanatory case study queries a phenomenon from the perspective of what it was, how it happened, and why (Lincon & Gubba, 1985; Yin, 2017).

Case studies tend to be selective, focusing on one or two issues that are fundamental to understanding the system being examined (Yin, 2011, 2017). According to Yin (2011, 2017) a case study design should be considered when: (a) the focus of the study is to answer "how" and "why" questions; (b) you cannot manipulate the behaviour of those involved in the study; and (c) you want to cover contextual conditions because you believe they are relevant to the phenomenon under study. When a single case study is used, the researcher can question old theoretical relationships and explore new ones because a more careful study is made (Yin, 2011). Yin's (2011, 2017) approach falls under a constructivist paradigm that recognises the importance of the subjective human creation of meaning, but does not reject outright some notion of objectivity (Baxter & Jack, 2008). An advantage of this approach is the close collaboration between the researcher and the participants that allows them to describe and tell their stories of reality in their own words, and this enables the researcher to better understand the actions of the participants (Baxter & Jack, 2008).

The justification for a single case study was based on Yin's (2017) third rationale in that it is a common case (i.e. fisheries governance being a wicked problem), and as such, the objective is to capture the circumstances and conditions about the social process related to some theoretical interest (i.e. understanding the relationship and interactions between risk and resilience concepts). A common concern about case studies is that they provide little basis for scientific generalization, specifically in the context of single case studies (Flyvbjerg, 2006). Yin (2011) although recognizing these limits, also argues that theoretical generalization is to the domain of case study, what statistical generalization is to the true experiment. Thus, the universal application is drawn from the theoretical concepts and categories that surface from a systemic and robust analysis of the data (Yin, 2011, 2017). For this research, consistent coding of interview text was undertaken to categories key themes and sub-themes.

3.1.3 Research design

The four objectives of this study were to:

1. Conduct a literature review on risk and resilience concepts and frameworks in the current literature of SESs
2. Explore how these concepts and frameworks provide insights for one of the largest fisheries (groundfish) collapses in the world, which occurred in Atlantic Canada
3. Explore the roles of risk and resilience in stressed Atlantic Canadian fishing communities using a case study of the New Brunswick coastal communities
4. Present and discuss approaches that contribute to a better understanding of the role and interactions between risk and resilience concepts in a coastal community SES.

Table 5 presents a brief overview of the methods that were used to collect and analyze the data used to address each of the objectives. The methods are then explained in more detail in the following sections of this chapter.

Table 5: Overview of methods

Objective	Data collection	Data analysis
1	Secondary data	Synthesis and comparison
2	Secondary data	Content analysis (codes and themes), and application of a scoring tool – Biggs et al., 2015 resilience principles.
3	Primary data	Interviews with fishermen and community members in the SWNB area – Biggs et al. 2015 resilience principles, content analysis (codes, themes, sub-themes)
4	Secondary and primary data	Content analysis, bow-tie visualisation, Biggs et al., 2015 resilience principles.

3.4 Data collection

3.4.1 Secondary data

Literature review

The literature review was conducted using an adapting integrated literature method. An integrated literature review is a form of research that reviews, critiques, and synthesizes relevant literature in an integrated way such that new frameworks and perspectives on the topic are generated (Torraco, 2005). The objective of the review was to firstly define the key concepts: SES, risk and resilience. Next the concepts of risk and resilience were compared and contrasted to better understand key attributes of each concept and presumed advantages and disadvantages of each approach. A comparison table was then used to present the findings. Categories that were used to compare the two concepts included: (a) definition and context, (b) theoretical underpinnings, (c) guiding principles, structures, and attributes, (d) frameworks, conceptual and applied, (e) contributions to the governance of an SES, and (f) critiques of the two concepts.

Seminal articles, although considered older literature, were initially reviewed so as to better understand the roots and disciplines from where these concepts were derived. Additional articles were added to the existing literature in 2014-2015, with a further brief scan of 2018/2019 articles.

The review also included peer reviewed literature, Government (e.g. DFO, Statistics Canada, Province of New Brunswick) and UN websites and resources, including grey literature, NGO reports and guidelines, online media platforms (e.g. CBC, Global News) and graduate theses. Databases used included Web of Science, Biological Abstracts, ProQuest Databases, and Project MUSE. Key word searches encompassed terms relating to risk, resilience, fisheries management, social ecological systems, community engagement in systems governance, and social risk. Examples of journals that contributed helpful articles included: *Ecology and Society*, *Global Environmental Change - Human and Policy Dimensions*, *Sustainability, and Biological Conservation* (SES and resilience); *Marine Policy*, *Oceans and Coasts*, *Plos One*, *Fish and Fisheries, and Ecosystems* (including topics on fisheries, social ecological systems and communities), and *Natural Hazards*, *Sustainability*, *Risk Analysis*, *Climate Change*, *Journal of*

Risk Research, *Human Ecology, and Disaster Prevention and Management* (e.g. risk management, fisheries, disasters, communities).

Groundfish fishery literature analysis

In addition to the literature review on key concepts, I also conducted an analysis of the groundfish fishery literature using Biggs et al., (2015) seven resilience principles as a framework. Groundfish[12] include the Atlantic Cod (*Gadus morhua*), Atlantic halibut (*Hippoglossus hippoglossus*), White hake (*Urophycis tenuis*), Redfish (*Sebastes marinus*), Pollock, (*Pollachius virens*), Haddock (*Melanogrammus aeglefinus*) and small flatfish including American plaice (*Hippoglossoides platessoides*), Yellowtail flounder (*Limanda ferruginea*), Witch flounder (*Glyptocephalus cynoglossus*), and Winter flounder (*Pseudopleuronectes americanus*).

In 1992, the federal government declared a moratorium on the Atlantic Canadian cod fishery. As noted by DFO (2009), the collapse of the Atlantic Canadian cod fishery is one of the most commonly cited examples in the world of overfishing, and its environmental, economic, social and cultural implications. Although closure was experienced throughout Atlantic Canada, the major impact was experienced in the province of Newfoundland and Labrador, where it is estimated that more than 35,000 people lost their source of livelihood (Hamilton & Butler, 2001; Hamilton et al., 2004; Milich, 1999). The event also led to a decline in the province's economy and demography, with many coastal town's loosing over 40% of their population (Palmer & Sinclair, 1992; Mather, 2013).

This topic was chosen for the desktop analysis because it provides a helpful lens to explore the interactions and linkages between social and ecological systems, and how risks may have emerged through different events and interventions. The richness of the literature across ecological, social and management systems, and the benefits of hindsight also provide an opportunity to explore how resilience attributes and risk are constructed, deconstructed and/or integrated within an SES. Numerous studies have assessed and described different aspects of the groundfish fishery, for example: from a biology/ecological perspective (e.g. Hutching & Myers,

[12] Fisheries and Oceans Canada, 2002

1994; Myers et al., 1996; Hutchings, 1996; Myers et al., 1997; Hutchings & Reynolds, 2004; Drinkwater, 2005, Rose, 2004; Hutchinson, 2008), the social/community dimension (e.g. Finlayson, 1994; Charles, 1995; Palmer & Sinclair, 1997; Newell et a., 1999; Neis et al, 1996, 2000; Neis & Williams, 1997; Brubaker, 2000; Hamilton & Butler, 2001; Mason, 2002; Hamilton et al., 2004; Ommer, 2007), and politics/management (e.g. Walters & Maguire, 1996; Charles, 1997, 1998; Halliday & Fanning, 2006; Rose et al., 2008; Fanning, 2008; Rose & Rowe, 2015). Other studies have reflected upon the cost to government and the economy (Schrank et al., 1995; Schrank & Skoda, 2002; Schrank & Roy, 2013), and the reconstruction of the fisheries (e.g. Schrank, 2005, Murray et al., 2008; Sinclair et al., 2009; Mather, 2013; Rose & Rowe, 2015). There have also been multiple reports by DFO and other fisheries resource and advisory committees (e.g. Kirby report, 1982[13]; Alverson report, (Alverson, 1987); Harris report, 1989[14]; Wappel, (2005); and Simms, (2017).

Searches were framed to firstly provide context around the cod fishery (i.e. who was involved, what happed, when, why, what actions were taken, and by whom, and with what result), and secondly, to begin to explore a potential framework for bringing components and attributes of risk and resilience together to better understand how their interactions may affect different outcomes. The time period for articles (peer and grey literature) used in the analysis was from 1993 to 2018, and included 41 key papers. These papers were selected based on the subject area and the depth of coverage. This was an important period for managers and scientists and generated the most articles and insights following the collapse. As noted above, other articles outside this timeframe were used to set the context for the analysis.

3.4.2 Primary data

The SWNB area was chosen for the field study based on the following reasons:

1. Local and small scale: The fisheries are small-scale, multi-species and are restricted to boats that fish within the coastal and near shore areas of Southwest New Brunswick. The definition

[13] https://www.canada.ca/en/health-canada/services/health-care-system/health-human-resources/strategy/kirby-report.html
[14] https://waves-vagues.dfo-mpo.gc.ca/Library/114276.pdf

of a small-scale fishery is drawn from Food and Agriculture Organization (United Nations), FAO, 2004[15] and is noted in detail below.

2. The fishery system has had an impactful event. The collapse of the groundfish fishery in the early 1990's and the resulting legislations that followed brought significant changes to small-scale coastal fishing communities across Atlantic Canada.
3. Participants were accessible and key community/university members existed that could help with the research and facilitate entry into the community.

FAO describes a small-scale fishery as having the following broad characteristics:

1. A dynamic and evolving sector employing labour intensive harvesting, processing and distribution technologies to exploit marine and inland water fishery resources.
2. Activities are conducted full-time or part-time, or just seasonally, are often targeted on supplying fish and fishery products to local and domestic markets, and for subsistence consumption.
3. Export-oriented production has increased in many small-scale fisheries during the last one to two decades because of greater market integration and globalization.
4. While typically men are engaged in fishing and women in fish processing and marketing, women are also known to engage in near shore harvesting activities and men are known to engage in fish marketing and distribution.
5. Other ancillary activities such as net-making, boat-building, engine repair and maintenance, etc. can provide additional fishery-related employment and income opportunities in marine and inland fishing communities.
6. Small-scale fisheries operate at widely differing organizational levels ranging from self-employed single operators through informal microenterprises to formal sector businesses. This sub-sector, therefore, is not homogenous within and across countries and regions and attention to this fact is warranted when formulating strategies and policies for enhancing its contribution to food security and poverty alleviation.

Béné (2006) note tha technological implications in that small-scale fisheries are also characterized by fishing crafts with non-mechanized propulsion systems (sails and oars) or low-horsepower outboard or inboard engines, use of passive fishing methods, manual operation of

[15] http://www.fao.org/fishery/ssf/en

fishing gear (setting, shooting and hauling), and the absence of electronic fish-finding and navigational devices.

Interview questions and ethics

Interview questions for the field component were drawn from previous studies e.g. Wiber et al., (2008) for New Brunswick, and from the literature e.g. Resilience Alliance practitioners' handbook. The advantage of this approach is that these questions have already been validated in the field, and could potentially providing a comparative data set (or reference source) for this research. Interview questions explored stakeholders' perceptions of changes, coping mechanisms, threats and risks through examples that focused on key environmental, social, economic, technological, and management issues surrounding their use of local marine and coastal areas. The interview questions were not designed to align or apply the seven resilience principles in the field. However, the interview data allowed for insights into key events as they occurred naturally and in the context of lived experiences of the participants to be derived and then assessed against the resilience principles. This approach follows a similar method undertaken in a study by Mason et al., (2015).

Prior to data collection, an ethics application was submitted to the Dalhousie Research and Ethics Board and was approved August 27, 2011.

To guide this research, the following research questions and sub-questions were asked:

1. What are the most important SES changes that participants have experienced between 2000 and 2012?
2. What are the most important threats and opportunities that participants anticipate over the next eight years (2013 to 2020)?
3. How might a better understanding of risk and resilience concepts and their interactions help address ongoing and emerging threats to a coastal SES?

A semi-structured interview schedule (Appendix 1) was developed to explore the participants' observations and experiences relating to five main domains (environmental, social, economic, technological, and management). Categories under these five domains focused on changes and coping strategies from 2000 to 2012, and threats and opportunities from 2013 to 2020. These timeframes were chosen because it allowed fishermen to recall events more easily, and it was not too far into the future for them to speculate upon. One of the limitations of this approach is that in looking forward, fishermen were more likely to focus on current issues, rather than unexpected threats and/or events.

Demographic questions including, age, gender, education, years in the fisheries, were asked, plus type of species fished, gear utilized, and family involvement in the fishery, as a means for establishing context. An example of a set of questions that was asked for each of the five domains is listed below:

Environmental changes and coping strategies

- Can you please give me some examples of environmental changes that you have noticed in the areas that you have fished (how, why, when, who). Probing questions included:
  - How you were able to cope with these changes or events?
  - What were some of the challenges that you faced in coping with these changes or events?
  - Were there any opportunities that helped you cope with these changes or events? Please explain?
  - Can you please give me some examples on how successful you thought these coping strategies were?

Environmental threats

- Can you give me some examples please of what you think will be the most important environmental threats to your fishery or business in the next 10 years? (how, why, when, who)? Probing questions included:
  - How certain are you that these threats could happen?
  - What affect do you think these threats would have on your fishery?
  - Can you please give me some examples of what you think might be future environmental opportunities available to your fishery over the next 10 years?

Planning for threats and opportunities

- Can you please give me some examples of the types of plans you would make to address these threats or make use of the opportunities that you have mentioned? Probing questions included:
  - Can you please give me some examples of resources that you think you will need to carry out your plans successfully?
  - Can you please give me some examples of who else might be involved to help make your plans successful?

Originating in grounded theory (Glaser & Strauss 1967), saturation is used in qualitative research (sampling and as a criterion for discontinuing data collection and/or analysis (Saunders et al., 2018). Inductive thematic saturation (sampling of the data) was obtained through the key themes and sub-themes, where saturation was reached when no new codes emerged. A priori thematic saturation was obtained by actively searching for codes that related and/or reflected key elements of the resilience principles. In both approaches an excel code book was developed. In the field, informant responses were considered saturated when additional probing of a specific participant during an interview revealed no new information. Overall saturation was reached when participants continued to repeat similar experiences/narratives and/or events.

Figure 9 demonstrates the conceptual relationship among the four categories of the interview questions. Changes across the five domains occurred between 2000 and 2012, leading to participants developing different coping strategies to deal with these system dynamics.

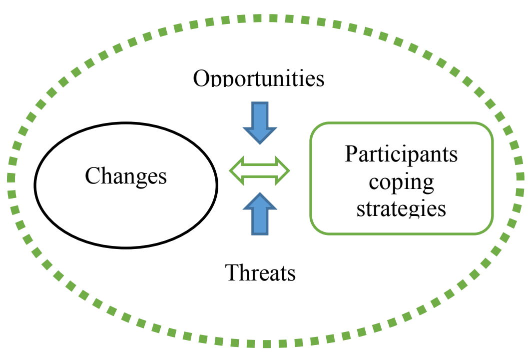


Figure 9: Conceptualisation of the relationship among these four guiding questions

As noted in the literature, coping strategies are often considered a positive factor, in that it allows a community or SES to continue to function. Conversely, although these strategies may be helpful in the short-term, they may create additional difficulties within the SES over the long term. Furthermore, some groups may be more at a disadvantage than others, depending on how vulnerable they are or the length of exposure to other threats. Understanding how these changes influence coping strategies and/or create/enhance threats and opportunities, could provide helpful insights into the interactions between risk and resilience.

Study location

New Brunswick's marine activities occur along two coasts: The Gulf of St. Lawrence (Gulf) and in the Bay of Fundy (Gardner & MacAskill, 2010). The New Brunswick Study area is along the Bay of Fundy, which is the northern most extension of the Gulf of Maine, with Nova Scotia to the east and New Brunswick to the west. The Fundy Coast Ecoregion spans the entire southern coastline of New Brunswick along the Bay of Fundy from the east side of Passamaquoddy Bay to the east side of Shepody Bay. The area also includes the Western Isles and Outer Isles - Grand Manan, Campobello, Deer, and Machias Seal islands (Conservation Council of New Brunswick, 2002). Interviews for this study were conducted in two of the three counties of Southwest New Brunswick, Charlotte and St. John. Participants were from areas along the coastline from Saint Andrews to Saint John, as well as Deer Island and Campobello Island (Figure 10a).

Campobello Island and Deer Island lie off the southeast end of New Brunswick and the North east tip of Maine, at the entrance of Passamaquoddy Bay, and are part of Charlotte County. The 2011 census recorded the permanent population of Campobello at 925, but in 2016, the number had fallen slightly to 872 (Statistics Canada, 2017). Deer Island falls under the West Isles Parish, and in 2011 the population was 731, whereas in 2016 there was a small increase to 797 (Statistics Canada, 2017). Deer Island is connected to the mainland by a year-round ferry, but for Campobello the ferry only runs in the summer, via Deer Island. Campobello is connected to Lubec, Maine in the United States by road. The traditional fishing and salmon aquaculture (*Salmo salar*) industries are major drivers in the local economy, although tourism has become an important economic driver.

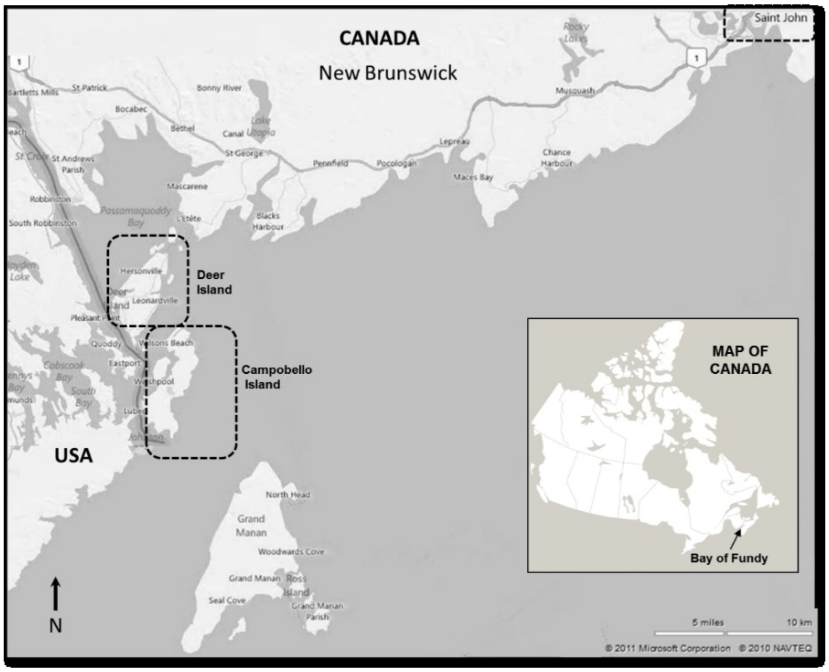


Figure 10a: General study area (source: adapted from Google maps)

The county of Saint John is heavily influenced by the city of Saint John with some 68,000 of the 74,600 county residents located in the city (Department of Post-Secondary Education, Training and Labour, 2012-2013). The city of Saint John dominates the economy of the region, and includes the towns of Rothesay, Quispamsis, Hampton and Grand Bay-Westfield. The city is split by the south-flowing Saint John River and bordered in the north by the Kennebecasis River. The Saint John Harbour is a deep-water port and ice-free all year long and is Canada's third largest port by tonnage (Port Saint John, 2017). Saint John has a long history of shipbuilding at the city's dry dock which is one of the largest in the world. Since 2003, shipbuilding has largely declined to be replaced by other industries such as those run by the Irving companies in oil, forestry, shipbuilding, media and transportation (Department of Post-Secondary Education, Training and Labour, 2012-2013).

Recruitment and interviews

Fundy North Fishermen's Association (FNFA) represents small-scale commercial fishermen from the St. Martin area to St. Stephen, including the communities of Deer Island, Campobello Island and fishermen who work the Saint John and Magaguadavic River Systems. Interviews were conducted in areas from Saint Andrews to Saint John, as well as Deer Island and Campobello Island (Figure 10b).

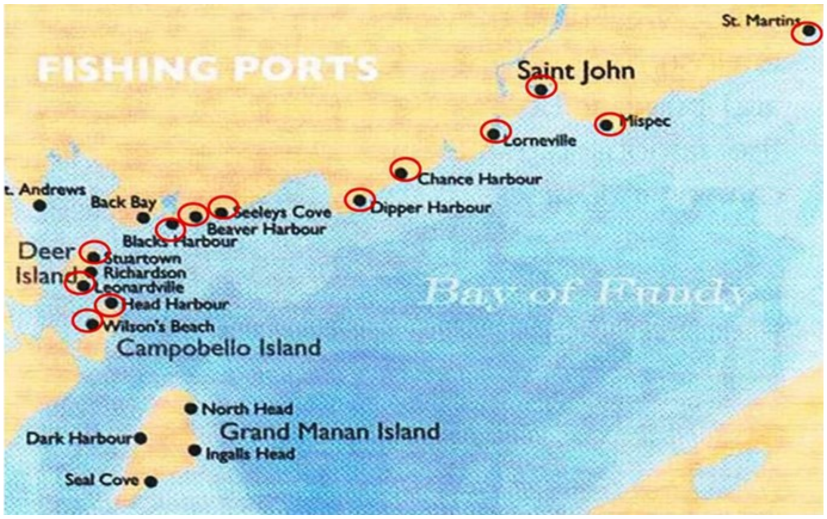


Figure 10b: Locations representing the community study area (Source FNFA n.d.)

Seven participants were from Campobello Island, eight from Deer Island, and eleven from Upper Bay (mainland). Their members are primarily engaged in lobster (*Homarus americanus*), scallop, herring, groundfish, shad, gaspereau and freshwater eel fisheries. Participants were recruited based on their availability and recommendations from FNFA drawing on the number of years fishing, experience, and type of fishery. During the interviews I was accompanied by a staff member of the FNFA who, based on her knowledge of the area and contacts, greatly helped with the recruitment of participants. Except for two interviews (where two people participated together), interviews were conducted individually. Interviews took place at several locations include the participants' home, business or at a central point (e.g. local fire hall). Interviews lasted between 1-2 hours, the average being just over an hour. At each interview, research notes were taken and audio recordings made of the sessions.

3.5 Data analysis

ISO 31000 defines risk as the "effect of uncertainty on objectives" of which an effect can be either a positive or negative deviation from what is expected. From a management perspective, one of the most obvious approaches of integrating risk and resilience concepts would be to consider each of the resilience principles and assess how well they are being met (or not); for example the risks to fishermen if these objectives are not met, and at a larger scale, how not meeting these principles could affect the overall SES. As noted previously there are other system dynamics to be considered when discussing the interactions between the two concepts including spatial and temporal scales, and issues of power, such as who/what is resilient and/or at risk, why, and by whom/how.

3.5.1 Groundfish desktop analysis

The analysis began with a review of the literature, including grey material, to set the context and identify important changes, coping strategies, threats and opportunities that pertained to the groundfish fishery. The review focused on events leading up to 1992, and through to 2017, and reflected ecological, social and management systems. A content analysis was conducted using a sample of approximately 40 peer reviewed articles, media reports, and grey literature. This qualitative approach borrows coding and thematic techniques from grounded theory (Corbin & Strauss, 2008).

Applying the seven resilience principles (Biggs et al., 2015) as broad themes, the literature was coded using NVivo 11. Examples of codes for each of the seven themes included: diversity (e.g. multiple species, livelihoods etc.), connectivity (e. g food webs, oceanic and environmental changes, recruitment[16], harvesters and processing plants, subsidies), slow variables and fast feedback (e.g. environment and ecological dynamics, economic/management changes), adaptive thinking (e.g. research trends, geographic locations/stock assessments), learning (community studies, government reports, traditional knowledge vs science), participation (e.g. unions, fishermen associations, groups outside of government that could provide recommendations on the fishery), and polycentric governance (e.g. contributions by groups outside of government, challenges, opportunities).

[16] Recruitment in ecology is the addition of new individuals to populations, and is a fundamental process in population dynamics. Recruitment is typically highly variable (temporally and spatially), and in response to a large range of biotic and abiotic factors. Variation in recruitment has immediate numerical effects by changing population size. Variation in individual quality of recruits from different cohorts can also generate delayed effect on population dynamics. (https://www.sciencedirect.com/topics/earth-and-planetary-sciences/recruitment-population-dynamics)

Based on these themes, a simple scoring process (Table 6) was developed to assess which resilience principles appeared most at risk of not being achieved. The assessment was subjectively administrated using a 1-5 point scale, ranging from 1 very poorly, 2 poor, 3 satisfactory, 4 good, and 5 very good. As the literature covered periods before and after the groundfish collapse (1992) a subjective assessment of the status of the principles is presented and indicated by noting any shift between the two timeframes in a different color (**X** – prior to 1992, X, post 1992)

Table 6: Scoring tool

Principles	**1**	**2**	**3**	**4**	**5**	**NA**
1. Maintain diversity and redundancy						
2. Manage connectivity						
3. Manage slow variables & feedbacks						
4. Foster complex adaptive thinking (CAS)						
5. Encourage learning						
6. Broaden Participation						
7. Promote polycentric governance						

Drawing from this subjective assessment, insights that could help to better understand the interactions between risk and resilience concepts are presented.

3.5.2 SWNB case study analysis

Similar to the groundfish desk top analysis, audio files were transcribed, and transcripts coded using the software NVivo 11. Responses were first broadly coded according to the five domains (environment, social, economic, technology and management) to explore the four categories (changes, coping strategies, threats and opportunities) resulting in 482 reference points. The data was then coded to identify and synthesize main themes (14) and sub-themes (33) relating to the research questions.

Chapter 8 focuses on interactions between specified resilience and risk. Using a bow-tie visual diagram, two examples describe (a) general threats to traditional fisheries and (b) threats to traditional fisheries from the aquaculture industry. In this context the two sectors each represent a unique SES in their own right, although they are part of a bigger SES (e.g. the Bay of Fundy). The data used in this synthesis and analysis are drawn from themes and sub-themes but also supported by the literature. A bow-tie method visualises the relationship between causes and consequences (Lewis & Smith, 2010).

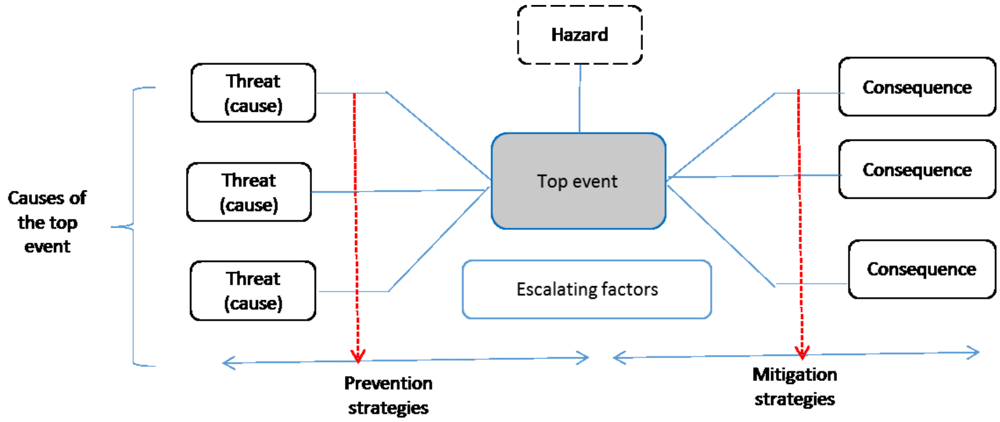


Figure 11: Generic bow-tie diagram (Source: adapted from Ramsden et.al. 2013[17])

The left side of the diagram represents causes and the right side consequences (Figure 11). The hazard (part of the system that has potential to cause damage) and the top event (damage of what) are in the middle. To the left of the bow-tie, strategies are identified to avoid/prevent the problem from occurring, and to the right, if the problem cannot be avoided/prevented, strategies that may mitigate the impacts (and thus lower the consequences) are noted. On both sides of the bow-tie, escalating factors positively (create enabling environments) or negatively (create barriers) affect the implementation of these strategies, adding another layer of uncertainty to governance of an SES. Initially, this approach was used in the petrochemical industries as a health and safety assessment (e.g. Lewis & Smith, 2010), but it has now been used in various marine and coastal management fields. For example, Cormier et al., (2016) applied the bow-tie in the context of a risk management process (ISO 31000) to assess DFO's legislative and policy context of the Fisheries Protection Program, and Smyth e al., (2016) combined the bow-tie with the DPSIR model contributing to a marine strategy framework for the EU.

Chapter 9 focuses on exploring the interactions between general resilience and risk. Taking a similar approach to the groundfish fishery desktop analysis, the data used for specified resilience are recoded to the seven resilience themes and discussed. Codes applied to each principle were similar to those used in the groundfish analysis but also included variations of similar themes and

[17] https://www.erm.com/en/news-events/platform/ten-rules-for-smart-bowtie-analysis/

sub-themes identified in Chapter 8. Another round of coding was then conducted to determine negative and positive comments, as a broad indicator of how well the objective for each principle may have been met. Negative comments for example referred to impacts participants had experienced or current or future threats that they were concerned about. Positive comments included changes that were helpful, successful projects, or current and future opportunities. Neutral comments referred to informative codes that did not reflect negative or positive opinions.

A similar scoring tool (Table 6) used in the groundfish desktop analysis was then applied to the 2000-2012 time period. In this context the scale ranged from 1 where the objective of this principle was at high risk (highest priority), 4 medium risk, 3 some risk, 4 low risk and 5 no risk. The second time period (2013-2020) was not assessed as the interview questions asked in 2012 were focused on future opportunities and threats. However, the extension of this thesis into this timeframe allowed for a discussion of principles that might be most at risk of not being met (e.g. foster complex adaptive thinking) could be used as a guide to enhance general resilience in the face of current and future threats that could impact the overall SES of the Bay.

3.6 Study limitations

The research focused on gathering information primarily from the community, including fishermen, processors and NGOs. As such, other stakeholders such as Government agencies, academics and private industries were not actively sought out. Consequently, initiatives conducted by these stakeholders, for examples ecosystem-based management approaches by DFO or the integration of large data sources (e.g. ICES Working Group on the Northwest Atlantic Regional Seas), which could inform resilience principles 1-3 that contribute to fostering complex adaptive thinking were not included. This could have created a biased approach as other views were not included. However, given that fishermen often feel that they are excluded from the decision making table, the focus on their views contributes to the literature on resilience and risk management from their perspective.

A second challenge was the duration of the study. The key challenge was making the older data relevant with current issues. Still, issues that participants highlighted in the interviews such as mistrust of government and large corporations, impacts from changing weather and environmental factors are very relevant today, although the context may have changed.

One disadvantage of the scoring tool is that it is based on my interpretation of the data as opposed to participants directly indicating a specific principle. Yet, the reality of risk and resilience assessments is that not everything can be known. Although they are often framed by experts as being objective, there is often some degree of subjectivity (e.g. determining what the risk factors are, who is resilient etc.). Simple scoring tools provide a quick method to identifying what trends might have become apparent, but it also the triangulation of information sources (e.g. interviews, literature) that provide important insights.

The scoring tool was not the only analytical approached used as themes and sub-themes were also derived from the data and discussed in the context of how these could be (a) applied to produce a visual risk diagram that could be used for community discussions, and (b) gain insights into potential connections between risk and resilience concepts. The study was conducted from the perspective of the community (with an emphasis on having their voices heard). Other methods such as the Delphi method may not have been a suitable approach as a first step to investigate these complex phenomena but could definitely be used if the study was to include other stakeholders. However, caution would need to be taken to determine who the "experts" were (and why they were chosen) to ensure that power relations were addressed. This has been added to the limitation section in the methods chapter.

Many participants noted the important role of economics ranging from fluctuations in market prices, to rising operational costs. While recognising the linkage between social and economic domains, it was beyond the scope of this study to make detailed economic valuations.

Chapter 4: Groundfish fishery desktop case study

4.1 Introduction

The objectives of conducting this desktop analysis as a component of the literature review is to firstly gain a better understanding of one of the most important and dramatic fishery collapses. Secondly, the richness of the literature across ecological, social and management systems, and the benefits of hindsight provide an opportunity to explore how resilience attributes and risk are constructed, deconstructed and/or integrated within an SES. The first section sets the context for the groundfish fishery desktop case study, including a short description of changes, coping strategies, threats and opportunities that influenced the SES. Next, an analysis of the seven resilience principles (Biggs et al., 2015) applied to data that have been coded and collated from key literature articles (ecology, social, and management) is presented. The third section identifies the resilience attributes derived from the application of the resilience principles, followed by a discussion on risk and resilience conceptual relationships. Concluding the chapter are the insights gleaned from this desktop case study analysis.

4.2 Groundfish fishery context

The Atlantic groundfish fishery involves 54 groundfish stocks distributed in an area ranging from Davis Strait to Georges Bank (Figure 14). Groundfish stocks are managed either through the Northwest Atlantic Fisheries Organization (NAFO) for transboundary stocks or by Canada for stocks that are under Canadian jurisdiction[18]. For the NAFO-managed stocks, scientific advice is provided through the NAFO Scientific Council and the total allowable catch (TAC) are negotiated by the various countries at the annual meeting of NAFO Contracting Parties (DFO, 2001). In 2001, for Canadian-managed stocks, the Fisheries Resource Conservation Council (FRCC) provided its recommendations following the release of annual stock status reports by DFO scientists and a broad-based industry consultation process (carried out by the FRCC) on scientific and conservation measures required for each groundfish stock (FRC, 2000-2001). Today, a number of DFO integrated and species-specific management plans are in place that focus both on Atlantic cod, and groundfish in general[19].

---

[18] https://www.dfo-mpo.gc.ca/international/media/bk_nafo-opano-eng.htm

[19] See https://www.dfo-mpo.gc.ca/fisheries-peches/ifmp-gmp/cod-morue/cod-morue-2018-eng.html; www.dfo-mpo.gc.ca/fisheries-peches/decisions/fm-2019-gp/atl-25-eng.html and http://publications.gc.ca/collections/collection_2019/mpo-dfo/Fs144-51-2018-eng.pdf

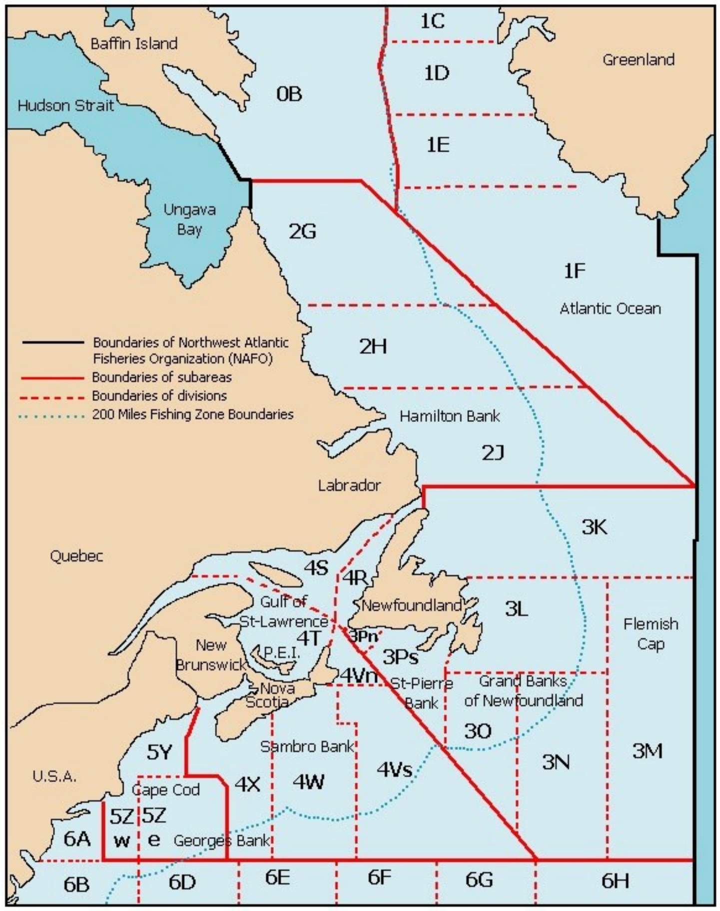


Figure 12: Groundfish management areas in 2001 (source Policy and Economics Branch Gulf Region, Department of Fisheries and Oceans, 2001)

The collapse of the groundfish stocks was a slow creeping crisis that scientists, fishermen, industry and politicians were aware of long before the moratorium was first issued by the DFO in 1992. Red flags had been raised by both scientists and inshore fishermen as to this growing concern, but management reactions were not fast enough to prevent what eventuated into both an ecological systems and social – economic crisis. The FRCC in its 1997 report noted that the fisheries crisis cannot be related to single cause or blamed on single group (i.e. processors, scientists, fisheries managers, politicians and fishermen); it was a failure of the whole fisheries system. Though, as others have pointed out "fisheries are human systems constructed to exploit living resources of a natural ecosystem, whereas the characteristics of the ecosystem both constrain its possible fisheries, and also help to shape the society that a fishery can support" (Hamilton et al., 2004, p 196). A brief timeline of major events occurring in the groundfish fishery are presented in Table 7. Sources used include: Brubaker, 2000; Hamilton & Butler, 2001; Mason, 2002; Halliday & Fanning, 2006; Rose, 2007; Muarry et al., 2008; Bavington, 2009; 2010, and others retrieved from https://www.library.mun.ca/cns/cod/chrono/.

As a cyclic boom and bust fishery, key events have led to the rise and collapse of the fishery. Frank et al., (2005) and others, suggest that four main factors are believed to have led to the collapse of the groundfish fishery prior to 1992. These were: (a) overfishing and the introduction of new technology that allowed processing and fishing boats to spend longer time at sea, trawl larger fishing areas and deeper waters, and the non-selective (e.g. species, age, size) approach of the fishery; (b) the ecological and biological complexity of the fishery (e.g. cod life histories, environmental changes, availability of prey species and other food web linkages); (c) the social and cultural identity of the ground fishery (principal livelihood, investment in the fishery, open ocean attitude), and; (d) government mismanagement following the removal of foreign fishing vessels within the 200 Economic Exclusive Zone (EEZ), that allowed Canadian and US fleets to take their place, while discarding scientific warnings on the total allowable catch (Frank et al., 2005).

Table 7: Major events that have occurred within the groundfish fishery

State	Situation/event	Immediate consequence	Ensuring consequence	Govt. responses	Examples of issues
Prior to the 1960s decade, the commercial industry comprised a large fleet of mainly small vessels that used traps, gillnets and hook/lines Annual catches ranged between 200,000 and 300,000 tonnes.	Between 1960 to 1975, tonnage increased to ~8 million tonnes, by an estimated 200 non-Canadian fleets factory freezer trawlers	1977 Establishment of Canada's EEZ (opportunity to restructure fishery as Canadian fleet did not have the capacity to overfish)	Domestic fleets increased (draggers numbers and sizes), supported by Govt. in their efforts to increase capacity - loans to fishermen to build capacity increased by 400%, Unemployment insurance (UI) reliance	Warning flags from both inshore fishermen and scientists ignored by decision makers (e.g. DFO scientists, and task group on Newfoundland Inshore fisheries, see Harris, 1998)	Mgmt. was weak and stock assessment were over-estimated Economic policy for fisheries – (1980) - Canada based catch limits set not on what the fishery could maintain but also on the "economic needs of coastal fishing communities"
1992 – 2 year moratorium on cod enacted, though a stewardship fishery and recreational fishery continue to operate.	Fishery appeared to be recovering due to strong recruitment and some conservation measures	1998 limited index commercial fishery restricted to inshore opened with a total allowable catch (TAC) of 3,000 metric tonnes	Increase in subsequent years for a cumulative total of 30,000 tonnes (1998-2002) of which 80% was harvested	Establishment of Fisheries Resource Conservation council (including , replacing previous Govt. advisory structure Northern Cod Adjustment and Rehabilitation Program (NCARP), & The Atlantic Groundfish Strategy (TAGS)., in addition to UI	See above (Frank et al., 2005) for issues relating to the collapse Fishing for subsidies (e.g. Brubaker, 2000)
2003 fishery re-closed following the realization that the harvest had resulted in a more severe and rapid impact on the resource than expected.	Minister of DFO announced the formation of the Canada-Newfoundland and Labrador action team on cod recovery – report 2005	Recommendations from the report (2005) accepted by DFO included the recognition of offshore and inshore populations, and reopening of a limited inshore fishery (1year) on a bay to bay bases	Northern cod showing promising signs of recovery since 2012, 2015 quota set at 4,400 tonnes, 2016 10,000tones, and 2017, 13,000 tonnes	2018 quota set at 9,500tonnes but did not include additional removals from the largely unregulated recreational fishery	2017 spawning stock biomass declined by 29 per cent and remains in the critical zone (DFO, 2018).

Among a number of confounding factors, two main drivers are identified: (a) conceptual models on resource management and (b) conflicting management objectives of scientists, resource managers and politicians. A fundamental conceptual model that drove both decision makers, fishermen and companies was drawn from a proposition attributed to Thomas Huxley (1895)[20] indicating that due to the indomitable force of nature, any tendency to over-fish will be met with its natural check long before permanent exhaustion occurs (Kurlansky, 1998). This led to resource managers and users believing that cod stocks were unlimited. Rose (2004) also notes that Huxley added quantifiers regarding the generality of his conclusions and more importantly this proposition was based on the modes of fishing of the 1800s. Unfortunately, these reservations were usually largely ignored/downplayed by both fishermen and managers (Rose, 2004).

One of the reasons for this attitude towards resource management focuses on how the knowledge of species and populations dynamics should be derived. Authors such as Rose (2004) and Bavington (2009) have highlighted the shift in knowledge generation from biologists focused on taxonomic studies to socio-economic driven management. A key driver for this shift was the 200 mile EEZ declaration, when fish within this zone were now recognised as the property of Canada, and were at risk of succumbing to a tragedy of the commons scenario. In line with this transition was the adaptation of mathematical models for stock assessment (i.e. maximum sustained or economic yield) to answer the ecological questions on how much fish were present and how much could be removed. Managers in Ottawa could use scientific modelling of cod populations, fishermen, and the relationships among them, to assess productivity and profitability and as such control fishing without actually being on site (Bavington, 2009). Hence the emphasis on knowledge production shifted from how to find and catch fish, to scientifically certified methods and models designed for measuring and predicting the size of fish stocks and how fishermen would act (Holm, 2001). Other papers and reports have highlighted the issue of “paper fish”, and the reluctance of government to act decisively on the advice of their scientists and inshore fishery. Brubaker (2000) defines paper fish as numbers from a spreadsheet that did not

[20] Thomas Henry Huxley PC PRS HonFRSE FLS (4 May 1825 – 29 June 1895) was an English biologist and anthropologist specialising in comparative anatomy. He is known as "Darwin's Bulldog" for his advocacy of Charles Darwin's theory of evolution (https://en.wikipedia.org/wiki/Thomas_Henry_Huxley) . The full text of the speech in which this proposition was put forward can be found here [https://mathcs.clarku.edu/huxley/SM5/fish.html

realistically reflect the actual stock in the ocean. Hence, it was relatively easier to find “extra numbers” and allocate these to fishermen, as opposed to dealing with demonstrations and protests, and the potential loss of jobs and votes. Shore-based processing plants relied on large industry fleets to bring in enough product to keep them operating. As such, decisions were also made around keeping these plants operating, which required a much higher TAC than was recommended by the scientists.

Parallel to this process, and influenced by these management conceptual models, conflicts among the different objectives of DFO scientists, the policy makers, and their Minster were also taking place. IIes (1980) states that four main questions used to guide the fishery included: biological (how many fish?), social (how many jobs?), economic (how much money?) and political (how many votes?). For example, Crosbie (Minster for Fisheries) in 1989 announced that a politician has to be concerned about protecting both the fish stocks and the livelihoods of the fishermen (Brubaker, 2000). Many authors have suggested that the Minster’s emphasis was more on protecting votes in the form of jobs and money than the fish. Another succinct view of the events leading up to the groundfish fishery crisis is through the concept of Ludwig’s ratchet (Ludwig et al., 1993) in that a series of deteriorating and irreversible steps drove the process:

1. Profit or the promise of profit in the fishery attracted political and economic power that, in the face of uncertainty about resource abundance drove the decision-making process;
2. Science was unable to measure the abundance of fish accurately enough or to predict future states of the fish stocks well enough to demonstrate the negative effects of overexploitation until it was too late;
3. In the face of scientific uncertainty, investment in the fishery expanded to the point that the economic viability of individual fishing units became marginal (commercial extinction);
4. When there was a short-term increase in fish abundance, investment in the fishery expanded. When there was a short-term decrease in fish abundance, disinvestment was slow and industry appealed to government for assistance. Assistance was typically given by the government, ostensibly as a short-term measure. In reality, the assistance tended to become incorporated into the functional economics of the fishery (Brubaker, 2000).

Adding to the above discussion, Murray et al., (2008) critically notes that management's response to Ludwig's ratchet tended to be similar in that "the only way to reverse trends toward overharvesting and wealth accumulation was through large-scale government intervention, such as privatisation to reduce aggregated fishing effort, and/or through the establishment of large marine protected areas" (pp 82).

It is easier now to look back on the crisis and highlight key intervention opportunities that may have helped prevent or mitigate the crisis. Examples include, after the implementation of Canada's EEZ, better management on the numbers and size of the Canadian and US fishing boats that replaced the offshore fleets may have lessened pressure on the fish stock, leaving the 1992 moratorium in place longer than 1998, or not increasing the tonnage between 1998 and when it closed again in 2003. Acts and policies such as Ocean Act (1996) and the Objective Fisheries Policy (2004), which were slowly coming into place, began to take into consideration the wider implications of ecosystem characteristics and their influence on fish stocks, and may have also been regulatory measures which, if passed more promptly, could have helped to mitigate this crisis. Conversely, the silo environment in which these policies operated did not provide much opportunity for open discussion or a collective approach towards addressing the groundfish crisis.

4.2.1 SES changes and coping strategies

SES changes: The most important ecological SES change was the collapse of the groundfish fishery and the subsequent dominance of shrimp, snow crab and lobster populations. Social and economic changes included the loss of livelihoods by at least 40,000 fishermen and fish processors from 1,300 fishing communities which in 2007 amounted to 11% of the overall labour force in Newfoundland (Higgins, 2018). Community populations also decreased, from 568,474 in 1991 to 505,470 in 2006, a drop of 11% over 15 years (Schrank & Roy, 2013). Younger and more educated people (18-24) were more likely to have moved away from Newfoundland 1995-1998 (Palmer & Sinclair, 1997). Various government responses included licences buyback schemes and a quota adjustment program costing an estimated $730 million for Newfoundland alone (Brubaker, 2000). Yet, Woodnow (1998) notes that these approaches generally failed as fishermen were reluctant to give up their licences (10% compared to a target of 50%) as they would then be ineligible for these funding programs and could not participate in the fishery if it were to reopen. Also, there was a greater number of applicants for aid (40,000) compared to a prediction of 27,000 individuals.

SES coping strategies: Many authors (e.g. Woodnow, 1998; Brubaker, 2000) describe the immediate response by fishermen, which was to apply for government assistance through different federal and provincial programs. This in turn created a shift in attitude/conceptual model for many fishermen from a reliance on natural resources to government support systems. As noted by Woodnow (1998) and Brubaker (2000) rather than encouraging fishermen to leave their fishery, these programs allowed many to stay on as subsidies were higher than what they had previously been receiving for their fish. Others moved to the crustacean fisheries, stayed in school longer and/or sought higher education options or left the province for employment opportunities.

Another form of coping was turning to the informal sector (e.g., co-operative labour, subsistence work, unofficial paid work) with a few taking training or business courses and/or starting their own small businesses (Sinclair, 1992). In response to the increase in crustacean populations, DFO increased the allocation of crab and shrimp quotas to inshore fishermen that had previously harvested cod and eased regulations on plant facilities so as to allow them to be refitted for these species (Mather, 2013). Although smaller and less labor intensive than the cod fishery, the value of this industry is higher than it was for cod (Mather, 2013). Another approach taken by the private sector supported by the province was cod aquaculture, taking advantage of the 'egg to plate' model that would allow it easier tracking and marketing opportunities (Bavington, 2009). Yet, due to the complex nature of its ecological, replication of environmental conditions and oversupply in the markets, these ventures were unsuccessful and the last large cod hatchery was closed in 2010 (Mather, 2013). Yet, Moore (2012) notes that simpler cod growouts such as keeping undersized fish in shore pens and feeding them up till they were of market size, continue to survive but with small volumes.

4.2.2 SES threats and opportunities

SES threats: As noted earlier, a result of government funding and subsidies, which allowed fishermen and plant workers to support their families, also established a reliance on this aid, with few fishermen taking up training opportunities or turning in their licences. Thus, the management objective of reducing the fishery by 50% fell short. Newfoundland's communities historically have a heavy reliance on natural resources, with a reluctance by the older generation to move to other locations and/or change occupations. Changes in species populations (prey and predator) and environmental factors such as warming waters may have led to shifts in stock dynamics (e.g. shrimp), which in turn may have reduced employment opportunities and/or economic growth. The relationship between pressures from the industry to open the fisheries and provide employment for union members in the light of slowly recovery of groundfish stocks is also another threat. For example, in 1997 the NAFO sub-division 3Ps cod stock was starting to recover when the quota was set at 10,000 tonnes but due to pressure from the industry, tonnage was increased to 30,000 resulting in another collapse and re-closure of the fishery in 1999, from which it has yet to recover (Davis & Rangeley, 2009). Another issue faced by fishermen was that they received much less individually for their crustacean catches in comparison with the overall market prices. For example, in 2001, fishermen were receiving an income of $25,400, while plant workers earned about $19,701, which also took into account about $10,000 in Employment Insurance (EI) payments (Higgins, 2008). The strong dependency on EI and the need to qualify for the required hours could contribute to people taking bigger risks and/or facing greater stress levels, or other work-related problems (Higgins, 2008).

An additional threat that materialised for inshore fishermen was related to the allocation of shrimp quotas. Prior to the collapse of the cod fishery, the offshore shrimp fleet had been allocated long-term access and increased quotas by the government to support the profitability of the industry (Mather, 2013). From the late 1990's through to mid-2000, due to changing environmental conditions, shrimp populations moved southwards towards the East coast of Newfoundland and with declining stock, there were concerns about its future (Mather, 2013). In response to these changes, DFO cut the quota significantly in 2010 and 2011, which affected inshore fishermen disproportionately as they harvested closer to shore, whereas offshore factory freezer trawlers had the infrastructure to withstand harsher north conditions and were also protected by the ‘first in last out’ policy (Mather, 2013). DFO’s policy of ‘last in first out’ meant that because inshore fishermen were allocated quotas after the offshore fleets, their quotas would be affected first. Mather (2013) notes that the Fish, Food & Allied Workers (FFAW-Unifor) union had objected to this approach citing that this policy contradicts the DFO principle of adjacency, which is where the priority of access should be granted to those who are closest to the fishery resource in question. The DFO approach to managing a resource, based largely on a preference for harvesters with supposed ‘technological efficiency and economic potential’ versus the ‘more traditional and perhaps backward method’ is considered by Mather (2013) as evidence of complex political, economic and technological relations that have a historical context. The reason was that in addition to fishing gear that allowed for huge quantities of catch to be harvested, offshore fleets also had advanced technology on board that provided them with the capacity of processing at sea. Traditional fishermen fished mainly from small boats, relied on manual labor, and bought their catch back to shore for processing.

SES opportunities: For many Atlantic communities, their livelihood is still very much focused on natural resources, encouraging the hope that cod stocks would rebuild. Other industries that provide a source of employment now include oil and gas, mining, and forestry. Starting in 2012, there was some evidence that the cod stocks were recovering leading to a paper by Rowe and Rose (2015) on these results. For example, in 2016 the stock assessment for northern cod was estimated to be around 300,000 tonnes which, although well short of the size of a healthy resource of a million tonnes, is ten times more than what it was in 1992 (Huffman, 2018). Responding to pressure from fishermen, partly because of the decrease in shrimp catches, DFO allowed a quota of up 13,000 tonnes in 2017, which was triple what had been fished in 2015 (Leeder, Globe and Mail, 2018, March 23). The provincial government also funded sustainable fishing gear initiatives to help cod fishermen prepare themselves for the 2018 season (Leeder, Globe and Mail, 2018, March 23). In 2018, DFO stock assessments noted a 30% reduction in the population, which was attributed to natural causes, including starvation due to environmental conditions, and predation by other species, although it can also include bycatch and discarded fish (Withers, April 28, 2018). In June, 2018, DFO reduced the cod quota by 25%, from the 13,000 metric tons allowed in 2017 to 9,500 tons, resulting in protests from the FFAW-Unifor that it went too far, whereas others, such as academics and the Atlantic Groundfish Council (formally known as the Ground Enterprise Allocation Council) stated that it should be lower (Huffman, 2018, June 13). Objections by the FFAW-Unifor to the quota included DFO ignoring the importance of the cod to local economy, reliability of stock and recruitment numbers, and the need for further science and research (Huffman, 2018, June 13).

In a situation parallel to issues within the cod fishery, the shrimp fishery is also facing stock declines. For example, in 2015, the quota was set to about 48,196 tonnes but dropped to about 28,000 tonnes in 2017, and 10,400 tonnes in 2018 due to a decline in fishable biomass from 785,000 tonnes in 2006 to just 104,000 tonnes in 2016 (Roberts, 2017, March 31). Reasons provided by DFO include warming ocean, the growing abundance of predators such as cod, and increased fishing activity (Roberts, 2017, March 31). In response the FFAW-Unifor has emphasised the impact that this will have on approximately 3,000 people, and have asked DFO to reconsider the cuts, the fairness of quota allocations to offshore fleets, and the need for a more integrated approach to the management of the shrimp fishery, as opposed to single stock administration (Roberts, 2017, March 31).

Looking to the future, the younger generation may not be as interested in fishing as an occupation, especially in relation to cod and shrimp given the uncertainty in fluctuating market prices, stock abundance, and management policies. Policies that encourage and promote the shift from coal, gas and oil, to clean technologies and industries are new options that may provide opportunities for young professionals that are wanting to change careers. The presence of Memorial University and the growth in entrepreneurship and technology, especially ocean technology, could be future career opportunities that could support local communities.

4.3 Resilience principles applied to the groundfish fishery case study

This section discusses the seven resilience principles (Biggs et al., 2015) aligned with processes that took place in the groundfish fishery. The purpose of this section is to discuss the resilience principles under the categories of ecological, social and management systems to determine whether having a better understanding of these approaches could have helped alleviate some of the factors that led to the crisis, and/or strengthened coping mechanisms after the fishery collapse.

Principle 1: Maintain diversity and redundancy: *Diversity and redundancy are important for resilience because they provide options for responding to change and disturbance. The diversity of system elements includes multiple species, employment options, management and institutional approaches that provide the bases for innovation, learning and adapting to slower, ongoing changes (Biggs et al., 2015). Functional redundancy refers to the capacity of functionally similar elements to partly or fully substitute for each other (Elmqvist et al., 2003).*

Ecological systems: Rose (2007) documents many major changes in the groundfish fishery, beginning post WWII (1945) when the catch was recorded at levels not seen since the late 1700's, through to 1992, when it collapsed after sustaining 350 years of intensive fishing. The trend in declining groundfish species started with the haddock and redfish followed by grenadier and American plaice, and lastly the Atlantic cod (Rose, 2007). With the collapse of the cod and warmer sea temperatures, capelin, like herring became the dominant pelagic fish in most offshore waters (Rose, 2007). Yet as Rose (2007) notes, much of this fishery produces fish meal used in agriculture and aquaculture industries, and increasingly the salmon farms in Europe. The relatively large abundance of capelin also provided for other species such as whales, seabirds, seals, cod and other fish stocks. For example, the composition of the yield went from the historical exploitation of the upper trophic levels (seals and cod), with minor bait and food fisheries for capelin and herring, to mid-trophic levels in the mid-20th century (cod, haddock, flatfish, redfish), to lower trophic levels and pelagic and demersal planktivores and detritivores (herring, capelin, shrimp, lobster, and crab) in the late 20th century (Bavington, 2009).

Social systems: Harvesting, hunting and processing were for a long time the main occupations available for Newfoundland and Labrador communities. For example, in the 1900's shore fishing was combined with herring and lobster on the south coast, sealing and the Labrador fishery in the north (Rose, 2007). Whereas on the west coast, salmon, herring and lobster fishery were combined with logging, trapping and farming (Rose, 2007). Rose (2007) further describes the cod fishery has having three distinct groups: local Newfoundland inshore fishermen, Canadian draggers and trawlers, and deep-sea foreign fishing vessels. In addition to the harvesters, many of their family members also worked in processing plants, and there was a level of connectivity between what harvesters brought in and the ability of the plant to maintain operational processes

(Rose, 2007). Risks to livelihoods manifested differently between inshore and offshore fishermen. For inshore fishermen, many considered that offshore draggers and larger trawler vessels (outside the EEZ), had an impact on the migration of cod stocks and overall food webs. Although these fishermen were the first to notice a decrease in catch, given the power that the offshore fleet had both within the union and province, these concerns were not taken seriously by government until the draggers also began to experience similar trends (Rose, 2007; Bavington, 2009).

Management systems: Players included NAFO who has a mandate for the seas outside the EEZ, and The International Commission for the Northwest Atlantic Fisheries (ICNAF). ICNAF had previously provided science and regulatory advice on most commercial fish stocks, but with the forming of NAFO, now had little purpose and was disbanded two years later (Rose, 2007). Canadian Atlantic Fisheries Scientific Advisory Committee (CAFSAC) also played a role in reviewing stock assessments produced by both NAFO and ICNAF. FFAW-Unifor represented Newfoundland Fishermen but according to Milich (1999) appeared to be more concerned with the short-term income of its wealthier members rather than the long-term sustainability of livelihoods and the fishery. Another issue was that the fishery had been managed as a single stock, when in fact there was a meta-population of regionally variable, genetically distinct, sub-stocks (Hutchinson, 2008). Using the same management strategy for multiple stocks, which differed in their resilience to exploitation and other environmental and natural factors was one of the major contributing factors to the collapse of the fishery (Hutchinson, 2008).

Principle 2: Manage connectivity*: Connectivity is defined as the manner by which and extent to which resources, species, or social actors disperse, migrate, or interact across ecological and social systems (Bodin & Prell, 2011). Connectivity in SES facilitates the exchange of material or information and affects the spread of disturbances and facilitates recovery after a disturbance Biggs et al., 2015).*

Ecological systems: Connectivity is important for resilience as it connects spawning and feeding grounds but it can also be a risk factor in the form of habitat loss from destructive fishing practices, which in turn impacts recruitment. For example, cod spawning habitats outside the

EEZ were decimated by draggers and foreign trawlers prior to the collapse of the stock, which was further escalated by the intensity of the Newfoundland's domestic fisheries (Hamilton et al., 2004). Other examples of conductivity are manifested at different trophic levels and food webs in response to environmental or natural factors. The development of a crustacean based fisheries (shrimp, snow crab, and lobster) is thought to have been caused by changes in oceanographic climates and a reduction in predators, specifically cod (Bavington, 2009, 2010). Connectivity is also associated with spatial and temporal changes in density and mass (Hutchings, 1996). For example, the recruitment of different species and across different age cohorts (specifically cod, but also other species that have late reproduction cycles), emphasizes the time lag between stock abundance and the numbers within actual reproductive age groups.

Social systems: Overfishing and interactions with hostile climatic conditions and other natural factors drove the changes that led to the collapse, and as the ecosystem was being altered, human population declined due to outmigration (Hamilton et al., 2004). Despite the conflicts between inshore and offshore fishermen, both groups had family members who worked at the same plants that were supplied by these two fisheries. As such, there was an underlying connectivity to keep the plants supplied and maintain good working relationships between both groups. The 1994-1998 Atlantic Groundfish Fishery Strategy (TAGS) [21] program kept many fishermen and their families still connected to the fishery even after it had closed, thus creating a system that was largely being maintained by government funding. Brubaker (2000) and Huffman (2018) note that the federal government had already spent over 4 billion dollars on Atlantic groundfish programs through the 1992-1993 Northern Cod Adjustment and Rehabilitation Program (NCARP), and continued to spend through TAGS, which had initially been set up to support retraining, license buyback, and early retirement elements. At its peak, almost 40,000 people were supported by the system, which exceeded the estimated 26,500 people eligible for the program (Brubaker, 2000). With an initial $550 million assistance package in 1998, which was later increased to $730 million due to protests from the fishermen, TAGS continued to sustain the notion of fishery profitability, even in the absence of fish (Brubaker, 2000). From a resilience perspective, although many did stay associated with the fishery, there was also a mass outmigration of people leaving to work in the Alberta oil fields. This coping mechanism

[21] https://www.cdli.ca/cod/tags1.htm

however, disconnected them from their families and way of life, thus changing the social landscape that had been built around the cod fishery (Hamilton et al., 2004).

Management systems: The demand for wild seafood is increasingly dependent upon a natural capital base that is rapidly diminishing (Davies & Rangeley, 2009). Yet the many players and conflicting management objectives did little to build connectivity among different assessment groups (e.g. DFO, NAFO, CAFSAC), fishermen, unions, and industry. Much has been written about the quality and sharing of data among different management groups and within groups themselves. In addition to the uncertainty of the data (see Hutchings et al., 1997; Charles, 1998), bigger risks centered on how information was shared and used by managers to support decisions that may have favored one group over the other. Authors such as Charles (1997), Neis et al., (1999), Brubaker (2000), and Bavington (2009) have highlighted that science information was a social construct as it was heavily influenced by economic and political decisions that undermined conservation efforts. In addition, the centralized management (in Ottawa) coupled with a downsizing of budgets and research capabilities considerably decreased the ability of local institutions to gather realistic data *in situ* (Harris, 1990). Hence management decisions were based on DFO science, which was also subjected to ministerial and economic influences.

Principle 3: Manage slow variables and fast feedbacks. *SES consist of variables that change and interact on a range of timescales (Holling & Gunderson, 2002). Slow variables determine the underlying structure of SES, whereas the dynamics of the system typically arise from interactions and feedbacks between fast variables that respond to the conditions created by the slow variables (Biggs et al., 2015).*

Ecological systems: Slow and fast variables and resulting feedback loops are represented in changes observed in population dynamics, feeding relationships, food chains, and ocean climates. The survival of larval fish, and their contribution to population growth (temporal dimensions), is strongly driven by ocean climate, which in turn influence the distribution of nutrients, concentration of plankton, and the retention of larvae within specific areas to provide an optimal environment (Bakun, 1996). The 1992 cod fishery moratorium reflected the threshold shift from an ocean system dominated by cod and other top predator groundfish to one where lower trophic level invertebrates abounded (Hamilton & Butler, 2001). The shift between these two regimes (fish to crustaceans) appears to have taken place relatively quickly during the early 1990s (Bavington, 2009, 2010) but may have also been largely underway well before the official recognition of the crisis (Hamilton & Butler, 2001).

Social systems: Slow variables and fast feedback interactions taking place in the ecological system also influence the social system to either cope, adapt or transform in response to these changes. For example, the shift from groundfish to a crustacean-based fishery would also change the socioeconomic characteristics (e.g. gear type, fishing areas, and expenses) of the former fishery (Hamilton & Butler, 2001). In addition to fishermen adapting to new fisheries, other changes were also taking place within the communities, including outmigration, older and declining populations, higher unemployment rates, and a reliance on government aid (Hamilton et al., 2004). Although the crisis accelerated trends that had been present prior to the event, it did not discontinue the cycle, which might have been a reflection of the underpinning dominant attitudes among fishermen, industry, and management agencies (Hamilton et al., 2004)

Management systems: Social pressure (by voters on elected officials) and political objectives (e.g. maintaining employment opportunities) have often delayed management actions (Shertzer & Prager, 2007). In 1989, the CAFSAC confirmed earlier warnings that DFO's northern cod assessments had, since 1977, been overestimated, leading to the TAC being set at unsustainable levels (Brubaker, 2000). Despite this and other previous warnings from the Task group on Newfoundland Inshore Fisheries to reduce the 1998 quota from 266,000 tonnes to 125,000, the DFO increased it to 235,000, which was 88% higher than what had been recommended (Brubaker, 2000). The reason was that if stock estimates declined, the recommended target would mean large adjustments for the industry, whereas by taking this approach mangers could phase in catch reductions rather than impose tough measures all at once (Brubaker, 2000). Conflicts between conservation objectives such as scientists warning that the TAC is too high, and economic development such as government not wanting to put people out of work, is a trend that is continually repeated. In addition to the groundfish fishery, other fisheries failures have occurred with periods of slow fish population growth, driven by overfishing, and changes in ecosystems or climate, leading to fast feedback responses in both the social and management systems (Planque et al. 2010; Eero et al. 2011).

Principle 4: Foster complex adaptive systems thinking. *Properties of CAS and their implications for the management of SES include the possibility of emergent macroscale SES behavior that cannot be predicted from individual system components (Biggs et al., 2015). Understanding CAS requires a particular conceptual model that interprets the SES in a holistic manner, including the importance of trade-offs, slow variables, feedback loops, and systems uncertainty (Pahl-Wostl, 2009).*

Ecological systems: Principles 1-3 have highlighted some of the reasons as to why it is important to achieve this 4th principle. For example, the unparalleled reductions in cod abundance and the unexpectedly low rates of recovery, highlight the limited understanding of fisheries sciences in the context of fish behaviour, habitat ecology, and evolution (Hutchings & Reynolds, 2004). Charles (1998) emphasises that uncertainties in the fisheries reflect random fluctuations, parameter estimates, and states of nature, and the lack of knowledge about the nature of the fishery system. Conversely, Rose et al. (2008) and Walters and Maguire (1996) suggest that there are lessons to be learned by management, especially as it relates to variations of biomass at spawning sites, timing, size (fecundity increases exponentially with size), age, and the complex mating rituals at these aggregation sites. deYoung and Rose (1993) also provide examples of how CAS was not taken into consideration when stock assessments were conducted. Firstly, the northern cod was treated as a unit stock, although it comprised distinct populations, with different migratory paths, which contributed differences to what was being seen in inshore and offshore fisheries (Harris, 1990), resulting in an overestimation of biomass (deYoung and Rose 1993). Secondly, variables such as recruitment, and natural mortality were treated as constants, when in fact there were variations that were not being considered, which also led to an overestimation of biomass (Myers &Hutchings 1994; Finlayson 1994).

Social systems: Given the complexity of ecological systems and disconnect within social groups and among managers and scientists, further compounded by rigid management structures, this may be one of the hardest principles to achieve. For instance, the focus upon the offshore fisheries landings by scientists as the main source for data collection, (easier to collect, fewer people to interact with) did not reflect the differences between inshore and offshore populations (Neis 1992). As such, the data collected and applied to the models were already flawed (Hutchings, 1996). With the failure to recognise different sub-populations of fish and hampered by the reluctance to put into place hard conservation measures, there was little opportunity and time for management agencies to respond effectively to feedback from the ecological system. The response by resource managers' to maintain funding support programs provided short-term relief to communities but led to another issue, since rather than reducing the capacity of the fishery, people still remained and continued to collect these benefits.

Management systems: Management practices were (and still are today, in most part) focused on single species stock assessments. Harris (1990) discusses the case of the Grand Banks, which was both inside and outside the EEZ, and for most species a single stock was now subjected to two sets of rules (NAFO and DFO). This led to considerable confusion and further added to the uncertainty of stock assessments, coupled by the lack of knowledge of different sub-populations within the region (Harris, 1990). There is still no clear consensus among the industry, resource managers and scientists as to the cause of the collapse, although there is some acceptance that overfishing (guided by policy maker's interpretation of the scientist advice, which was flawed), and environmental changes both contributed to the crisis (Schran & Roy, 2008). Conceptual models have also been shown to underpin the attitudes towards scientific data and what validates credible information (Charles, 1995, McCay & Finlayson, 1999). For example, initially, fishermen and management officials would not believe that the groundfish fishery could collapse and when it did happen there was a strong sense that science and technology would be able to solve these problems. Despite an understanding by scientists of cod recruitment and population dynamics in the later years, governments' were reluctant to make key decisions based upon this new knowledge as their priority was to maintain jobs in this sector (Hutchings, 1996; Brubaker, 2000).

Drawing from the interactive governance theory, governing shared resources requires a comprehension of the relationship between both the natural components of the ecosystem, the users and other stakeholders (Fanning, 2007). Adapting from Jentoft's (2000) limits of governability, in fostering the capacity for complex adaptive system thinking (i.e. diversity, complexity, dynamism and vulnerability), requires that the roles of the governing system (e.g. contextualising, coordinating, learning and safeguarding) at multiple levels (provincial, national, international) will need to align with the system to be governed. Furthermore, it is not enough that the two systems are aligned, but there should also be a comprehensive understanding of issues and coordination of responses conducted at multiple levels, but also across disciplines (science, social science, economics, policy analysists) to ensure that appropriate forms of governance (i.e. self-governing, co-governance, hierarchical) are identified in a timely manner.

Principle 5: Encourage learning. *Learning is defined as the process of modifying existing or acquiring new knowledge, behaviours, skills, values or preferences. This principle is based on the assumptions that knowledge is always incomplete, and that uncertainty, change, and surprise are inevitable in complex SES (Biggs et al., 2015). Learning can take place at the individual level and through social interactions (Reed et al., 2010).*

Social systems: Fishers have detailed knowledge of their resources, their environment, and their fishing practices that is rarely systematically collected (Neis et al., 1999). Others have noted and highlighted the value of local and traditional knowledge and its contribution to the development of conservation and management practices (Murray et al., 2006). For example, Neis et al., (1996) describe how fishermen's knowledge about stock structure, changes in catchability, information on abundance, and impacts of reopening the capelin fishery, if captured in a systematic approach, could contribute to official stock assessments. Fish harvests knowledge is dynamic and coevolves with fishing practices that extend beyond the individual, household, and community, to include management, technologies, and marine ecological conditions (Murray et al., 2006). When fisheries science and local knowledge are combined, it provides a more holistic view of the SES, emphasising the important contributions that fishers can make to new science and management, especially at the local scale (Murray et al., 2006). Neis et al., (1999) have also documented the experience of local fishers in relation to the cod collapse and note their extensive knowledge of specific names of cod stock in relation to seasonal movements, use and availability of gear types and location of spawning areas. The authors present detailed findings on how this information can be used to broaden the basis for interpreting quantitative surveys used in fisheries assessment (Neis et al. 1999).

The sentinel fishery program was one of a few collaborative programs between DFO and fishermen. According to their website[22], the primary objective of the program was to develop time series of abundance indices to be used in the assessment process of cod stocks. The northern Gulf of St. Lawrence sentinel fishery program was established in 1994 through the recommendations of the FRCC. This program was the first on the Atlantic coast to incorporate abundance indices into stock abundance assessment analyses. Participating fishermen received training on sampling protocols at Memorial University in St. John's or at the Centre spécialisé des pêches de Grande-Rivière, from DFO and project coordinators. To minimize risks in data collection, and to encourage annual participation of the fishermen, efforts were made to recruit the same fishermen annually. The SafeCatch project also contributed findings relating to fish harvesters occupational health and fishing vessel safety.

Management systems: Hutchings & Reynolds, (2004) suggest that much learning is required to prevent population collapses and there is a need to consider the conservation of marine fisheries seriously. Early fisheries research tended to focus on exploring new resources, fishing methods and processing technologies, but gradually moved towards the exploitation of the fisheries as international fishing effort expanded in the 1960s, resulting in a pattern of providing short-term advice on catch limits (Halliday & Fanning, 2006). Mather (2013) and others have raised questions relating to the role of science in resource management, and the need for investments in provincial fisheries science capacity. Yet it is not only the production of knowledge that builds resilience but also the ability to speak freely and be critical about facts for or against the dominant paradigm (McCay & Finlayson, 1995, Brubaker, 2000). For example, scientists may have known the truth but were not heard or allowed to speak because others within their departments were also charged with making fisheries policy, and as such had reasons to favor more generous assessments (McCay & Finlayson, 1995). Other reasons include the defensive behavior of bureaucracies not wanting to admit they had made mistakes, and the disconnect both within the fisheries agencies (scientist and policy makers), but also with the fishing industry,

[22] https://ogsl.ca/en/oceanography/sentinel-fisheries/about

which may have further marginalised and delegitimized information from the inshore fishery (McCay & Finlayson, 1995).

Prior to joining the Canadian Confederation (March 31, 1949), Newfoundland had a small but able fisheries research presence, led by the Newfoundland Fisheries Research Board which was founded in 1936, and focused mainly on marine fisheries ecology (Bavington, 2009). The extension of the EEZ in 1977, led to a rapid expansion of the fisheries research and management capacities of the newly-formed DFO (Bavington, 2009). During the late 1980s and early 1990s, there was also a growth in DFO involvement with Memorial University faculty showing interest in marine research on cod. The Northern Cod Research Program, which resulted from the Harris Panel report (1990) and the Ocean Production Enhancement Network (a Centre of Excellence in Fisheries Oceanography located at Dalhousie University), brought new resources to deal with issues relating to Newfoundland cod ecosystems. This level of research was not sustained, and in the mid-1990s there were severe cutbacks, including the disbandment of research groups, scientists leaving DFO or retiring, and budget cuts (Bavington, 2009). Furthermore, the integration of former fisheries vessels with the Coast Guard reduced the availability of these vessels for science programs as search and rescue was often given a higher priority (Sandeman, 2002).

In addition to the sentinel fishery program, another program prior to the establishment of NAFO was the ICNAF initiative to institute a Northwest Atlantic standardized bottom-trawl survey program using research vessels. These surveys provided a platform for broad-scale ecosystem monitoring, the significance became increasingly important after the fishery closed, and as the management of uses of the ocean emerged as a focus of interest with the 1997 introduction of Canada's Oceans Act (Halliday & Fanning, 2006). Walters & Maguire, (1996), though have noted that the high cost of information for accurate stock assessments may require alternative measures such as large scale closures to act as refuges (which could be rotational) that would directly restrict the proportion of fish available to harvest at a specific time.

Principle 6: Broaden participation. *Participation refers to the active engagement of relevant stakeholders in the management and governance process (Stringer et al., 2006). The resilience* *literature generally considers participation that focuses on stakeholders with an active interest in the management of ES, or with relevant local, traditional and scientific knowledge (Olsson et al., 2004).*

Social systems: Inshore fishermen were limited in their ability to participate in decision-making. As noted by Mason, (2002) and Rose (2007) although inshore fishermen used less destructive fishing methods and caught fewer fish, decision makers tended to have a biased approach favouring the voices of offshore fishermen. For example, members of the Newfoundland Inshore Fishermen's Association (NIFA) were first to note that cod stocks were declining and questioned government on their stock assessments. Going so far as to commission their own assessment report (Keats et al, 1986) based on DFO figures, they took the government to court based on the information collected but were still ignored (Rose, 2007). Efforts to address these issues were only made once the offshore fishery reported that there were no longer able to catch fish (Rose, 2007; Bavington, 2009). The NIFA was also concerned with the FFAW-Unifor acceptance of the provincial government's suggestion that the basis for sharing cod stocks in the future should be the historical allocation between the inshore artisanal sector and the offshore draggers (Milich, 1999). Offshore draggers paid larger dues to the union and had greater political clout within the provincial government resulting in their views being more often considered over inshore fishermen (Milich, 1999). Given the size difference of the catch between these two groups this approach put inshore fishermen at a significant disadvantage.

Management systems: Much has been written about the quality and sharing of data across different management groups and within groups themselves. In the addition to the uncertainty of the data (see Hutchings et al., 1997; Charles, 1998), bigger risks centered on how information was shared and used by resource managers to support decisions that may have favored one group over the other. Another issue was that the flow of information that procced along a decision-making chain among the scientists, advisory boards and the Fisheries Minster was often disjointed, with important details filtered out and new ones added to support certain agendas (Wappel, 2005). Authors such as Charles (1997), Neis et al., (1999), Brubaker, (2000), and Bavington (2009) have highlighted that science information is a social construct as it is heavily influenced by economic and political decisions that undermined conservation efforts. For example, during different hearings advisory committees were often presented with evidence that emphasised the profound lack of trust existing among fishermen and scientists and fisheries managers (Wappel, 2005, Simms, 2017).

Conflicts between scientists and managers as to the best options to present to policy makers, who in turn were being driven by economic and political pressures to avoid an employment crisis, was a significant issue (Charles, 1997, Brubaker, 2000). Following the cod collapse there was a lack of confidence in the CAFSAC, who were responsible for providing governmental advice to the industry (Halliday & Fanning, 2006). In 1993, the Minister of Fisheries & Oceans created the FRCC that included scientists, academics, leaders of industry groups, and other experts outside of DFO (McCay & Finlayson, 1995, Charles, 1997). Removing the final authority for resource assessments and recommending quotas from the Science Branch of DFO to the FRCC led to quicker and more decisive decision making, and increased legitimacy, in comparison to when DFO was in charge under the old system (McCay & Finlayson, 1995). Building on the success of the FRCC, Charles (1997) has also suggested that in addition to community quotas and conservation harvesting plans, a form of co-management with a focus on coastal community engagement could be a productive way forward.

Co-management is often cited as form of initiating polycentric governance (e.g. Jentoft & McCay, 1995; Charles, 2007; Berkes, 2009; Pinkerton, 2011). Fanning (2007) assessment of a community-based management pilot study within the Scotia Fundy area highlighted both successes and challenges of this initiative. This study demonstrated the benefits of providing users closest to the resource the opportunity to manage their allocated quotas (micro level), while the government maintained legislative oversight at the macro level (Fanning, 2007). Fanning (2007) noted challenges with this experiment that included the need for ongoing monitoring and evaluation of the process to ensure that co-management efforts were meeting the expectations of all parties (Fanning, 2007).

The divisions between inshore and offshore fishermen in Newfoundland, and between provinces (mostly Nova Scotia) for access to the fishing grounds, indicates that participation would not have been equal between the different parties. Another influencing factor was the efforts to increase the efficiency of the home fleets in response to Article 62 in the Law of the Sea Convention (Holland, 2002). Driven by DFO's desire to build a modern fishing fleet, both provinces invested heavily in developing their provincial fleets, aligned with government subsidies that provided support for processing plants to keep employment-generating facilities open (Holland, 2002).

Researchers (e.g. McCay & Finlayson, 1995; Mason, 2002; Bavington, 2009) have asked the question as to whether the crisis could have been avoided as many of the earlier flags had been raised, and risk factors could have been managed. According to Bavington (2009) the answer is no because the state had too much power as it favoured economic and political goals as opposed to the conservation of the resource. Learning from this experience, Bavington (2009), Mason, (2002), and others call for a more interdisciplinary approach that includes participation and collaboration amongst environmentalists, scientists, sociologists, political analysts, government managers, and people who live and are affected by management decisions.

Principle 7: Promote polycentric governance. *Polycentricity refers to a governance system with multiple governing authorities at differing scales, thus matching problems with appropriate scale (Ostrom, 2005). Polycentricity contributes to the resilience of ES by providing a governance structure that facilitates other key resilience-enhancing principles, especially redundancy (P1), connectivity (P2), learning and experimentation (P5), and participation (P6) (Biggs et al., 2015).*

Management systems: Halliday and Fanning (2006) describe fisheries science on the Atlantic coast, beginning around 1898 with the Fisheries Research Board of Canada. Yet an issue with scientific fisheries management is that it continues to maintain its legitimacy at national and international policy levels, while wild fish species continue to decline rapidly (Bavington, 2009). One of the reasons is that fisheries management rarely considers the entire fishery system (social, economic and ecological objectives) in an integrated way (Hanna, 2008). Bavington, (2009) (2002) also notes that the precautionary approach debate has provided some scientists with much scope for career enhancement through the production of scientific papers. As such, the focus on resolving scientific issues has been diverted attention away from involving the industry and managers in developing frameworks for taking action (Bavington, 2009, 2002).

An attempt to broaden governance was the establishment of the FRCC in 1992, which comprised 15 individuals appointed by the Fisheries Minister, and included representation from the fishing industry, universities, province and federal government fisheries staff as ex-officio members (Charles, 1998). The role of FRCC, prior to its closure in 2011 (due to funding cuts) was to provide independent and public advice on Atlantic fisheries to the Minister, such as recommendations on the closure of additional groundfish fisheries, lowering of TAC and exploring marine protected areas options (Charles, 1998). Building on the success of the FRCC, Charles (1997) has also suggested that in addition to community quotas and conservation harvesting plans, a form of co-management with a focus on coastal community engagement could be a productive way forward. An earlier attempt towards a co-management approach initiated by DFO was not helpful in that, rather than encourage and support coastal community engagement, the agency focused on the sector, pitting inshore and offshore sections of the industry against each other (McCay & Finlayson, 1995).

In 2003, the federal government established the Canada-Newfoundland and Labrador Action Team for Cod Recovery, followed by the 2006 Strategy for the Recovery and Management of Cod Stocks in Newfoundland and Labrador: A Federal-Provincial Approach and Northern Cod Science and Fisheries Stewardship Initiative (NCSFSI) established to help build better relationships between the industry and government. For example, the Strategy calls for a focus on long-term rebuilding considerations that will require commitment and collaboration from government, industry, fishing communities, Aboriginal groups and other interested stakeholders (DFO, 2006).

Milich (1998) suggests that because living marine resources belong to complex adaptive systems, they are best managed by decentralized management approaches as opposed to the conventional, scientific, and top-down approaches. McCay & Finlayson (1995) also concur and suggest that unfortunately it may take larger and more ecological - social crises to destabilize the current management systems. Still, ingredients such as greater participation of stakeholders in knowledge creation and management decision making, and an ecosystem-based fisheries approach and policies may help to slow the predictable outcome (McCay & Finlayson, 1995). Yet, there is still a need to match the system to be governed with the governing system (Fanning, 2002) as not all stakeholders have the resources and/or authority to make decisions in a time of crisis. As noted earlier despite many provincial, national and international agencies involvement, in addition to numerous local actors, covering different spatial and jurisdictional spaces, the coordination and information sharing process greatly limited the ability to prevent the collapse. At the end of the day, economic and political goals were prioritised over conservation measures.

Insights drawing from the alignment of the resilience principles and the literature

As noted in the earlier chapters, these seven resilience principles are not new, for example diversity, redundancy, connectivity, and the interactions between slow variables and fast feedback loops have long been important concepts in biology and ecology. Complex adaptive thinking is often associated with resilience scholars, and also has its roots in earlier systems theory work. Learning, participation and polycentric governance have been developed across many disciplines including the social sciences, community development, management and governance. As such, the legitimacy of these principles has been well-established prior to being incorporated into resilience and SESs thinking. In their presentation of cases studies that describe each principle, Biggs et al., (2015) suggest that the application of all these principles within a SES at the same time is not necessary. Yet, it could be useful as a checklist to guide a risk and resilience approach that explores how the interaction of these two concepts might support or create challenges to proactive or mitigate actions that address threats within and across different components in a SES.

4.4 Resilience characteristics

Tables 8a - b provide a summary of attributes that have positively or negatively affected the resilience of this SES. For example, the diversity of the groundfish population was that it was able to sustain intensive fishing pressure for over 350 years, however, compounding ecological factors and environmental factors, and mismanagement led to a reduction in ecological and livelihoods diversity. Similarly, there were many different players involved in the management system and attempts were made to match issues with the relevant spatial scale of the fishery.

However, the ineffective cross-scale coordination across the different levels may have limited governance efficiency. Production plants were dependent on having enough fish to process and make a profit, with both levels of government providing subsidies to increase the Canadian fishing and processing capabilities after the declaration of the EEZ. Following the collapse of the fishery, the connectivity of having family members follow into the fishery declined. Yet, many fishermen continued to draw benefits long after the fishery was closed.

Table 8a: Resilience attributes drawn from resilience principles 1-3

Principles	Ecological systems	Social systems	Governance systems
Principle 1: Maintain diversity and redundancy	• Species diversity • Redundancy across different species of groundfish	• Livelihoods diversity • Redundancy based on natural resources (land, sea, formal and informal sectors)	• Diversity of decision makers (International, federal, provincial) • Industry players (inshore & offshore)
Principle 2: Manage connectivity	• Fish population recruitment • Spawning habitats and population growth • Trophic levels and food chains • Environmental and natural factors influencing recruitment and biomass	• Harvesters and processing plants (livelihoods) • Recruitment into the fishery (traditional fisheries vs other occupations /education) • Collapse of fishery and declining populations due to outmigration • Government investment (industry and TAGS) • Technology advancements and fishing efficiency	• Subsidies and building of national/provincial fishing fleets following the deceleration of the EEZ • Prioritization of the offshore industry (higher economic value/strong union/more cohesive) • Incorrect stock assessments and the impact on management decisions
Principle 3: Manage slow variables and feedbacks	• Shifts dominate prey species and trophic level dynamics • Fish population recruitment • Environmental and habitat changes	• Technology changes (impact on the environment) • Shifting to other fisheries post collapse • Reliance on government aid	• Scientists and policy makers (power relations) centered on economic /political goals vs conservation objectives

Principle 3 relies on both a good understanding of Principles 1 and 2, but also the authority and resources to recommend and implement changes in a timely manner. There is a vicious cycle linking advanced technology with bank debts (needed to obtain the technology and increase fishing efficiency) and the need to fish harder to pay off these expenses. Changes in political environments (slow variable), and the timeframe for new policies to be implemented were also not aligned with fast feedbacks occurring across the ecological system, which was related to conflicting goals of conservation and social/economic development, and data errors and misinterpretation. Yet, social changes generated a much faster response through the financial aid packages and programs.

Table 8b describes the resilience attributes coded from the literature and described in the previous section. Here the focus is on the social and management systems, and their activities and governance practises on the ecological system (see Figure 1). Fostering complex adaptive thinking first starts with the conceptual models (influenced by values) that are embraced by resource users, scientists, and policy makers. When these models do not align or are counterproductive to being able to understand and respond to slow and fast variables and feedback loops, these eventually lead to a collapsed system. For example, the focus of fisheries science changed from learning about the fish/fishery through documentation and field studies to becoming a system managed by numbers and assumed predictions of fishermen's behaviour by a centralised management system. The cod fishery collapse is one of the most documented and researched events in fisheries history. Hence, much of the learning by natural and social scientists learning took place after the event. Yet, influenced by power dynamics, conflicting objectives and conceptual models, effective implementation of this learning was hindered and not timely.

Table 8b: Resilience attributes drawn from principles 4-7

Principle	Social systems	Management systems
Principle 4: Foster complex adaptive thinking	• Fishermen and processors conceptual models (e.g. groundfish continual abundance, wastage of low quality fish) • Alternative assessment reports and insights provided by inshore fishermen • Reliance on natural resources prior to collapse, and on financial government aid post event	• Single species assessments and failure to integrate data from other sources • Conceptual models of policy makers and scientists about the resource • Reliance on financial and technical solutions • International conventions and agreements, confusion re responsibility
Principle 5: Encourage learning	• Local and traditional knowledge that coevolves with the fishery • Sentinel fishery program	• Shift from representing the species e.g. exploring and documenting new species, identifying new resources and technology to quantitatively measuring abundance modeling to predict ecological and social behaviour • Centralisation of scientific learning from local research stations to Ottawa (DFO) • Collaboration with international institutions (e.g. ICNAF) to provide broader ecosystem based assessments

Table 8b: Resilience attributes drawn from principles 4-7 cont.

Principle	Social systems	Management systems
Principle 6: Broaden Participation	• Inshore fishermen ability to effectively contribute their knowledge to the decision-making process (Govt.) • Power of the unions vs fishermen's associations e.g. NIFA vs FFAW	• Data collection sources (off-shore vs inshore fishermen) • Establishment and disbandment of the FRCC • Competition with other provinces e.g. Nova Scotia
Principle 7. Promote polycentric governance	• Understanding issues at different spatial and temporal scales (inshore vs offshore, migration, population recruitment) • Conceptual model by management of traditional inshore fisheries vs professional offshore industrialised fleets • Establishment of different committees and strategies e.g. FRCC, CNFLAT and Recovery and management of cod stocks strategy • Implementation of changes to effectively address issues at cross-cutting scales	

The centralisation of learning centers, clashes between traditional knowledge and scientific research (including the prioritisation of natural over social science), compromised by data uncertainty hindered effective learning systems. Competition among different provinces and between the inshore and offshore sectors influenced who was able to contribute to management processes. Inshore fishermen were limited in their ability to participate in management processes, as most of the power was held by the offshore fishing industry. Positive learning programs such as the Sentinel program and broader ecosystem surveys declined due to funding cuts and limited resources. The FRCC was an opportunity to bring other stakeholders to the table, thus widening the participation process. Although this Committee made some significant recommendations that were accepted by government, it was disbanded in 2011 due to funding cuts. Since this disbandment, other programs that had been established in the lead-up to 2011 and after provided some opportunities for inshore fishermen and others to contribute and provide feedback to management. Unions such as the FFAW-Unifor provided some opportunities for fishermen but it appears there is still a lot of distrust among inshore fishermen, large corporations (offshore fleets and processors) and management.

4.5 Risk and resilience conceptual relationships

In its simplest form, one approach to mapping out the relationship between risk and resilience concepts may be explored via the connections among people/environment, things/events, outcomes, and responses. Biggs et al., (2015) principles provide a framework to explore the different elements that influence individual principles and the overall SES. It should be noted though that these principles will be interpreted differently across and within stakeholder groups, and there may be no consensus as to the importance, prioritisation or assessment status of these principles. Similarly, the interpretation of risk (and who is at risk and why) will differ across and among stakeholder groups. Still, incorporating a risk assessment approach/discussion as part of a resilience management strategy may help to identify (a) risks to the SES if these principles are not met, and (b) assess the potential risks and consequences of implemented coping actions/responses over immediate and long-term temporal scales.

Drawing from the literature, Figure 13 provides a hypothetical flow diagram of how the resilience principles could contribute to improving the groundfish SES. This approach follows the works of Boholm, (1998, 2003), which describes risk as a cognitive frame that produces contexts which link an object of risk (a source of potential harm), an objective at risk (a potential target of harm) and an evaluation (implicit or explicit) of human (or environmental) consequences. It should also be noted that as this case study was drawn from secondary literature, there was not an opportunity to explore the integration of descriptive/factual and normative elements though field data (Boholm, 2003). It is acknowledged though that risks are highly contextual, influenced by personal and afar experiences, and collective narratives (Boholm, 2003).

Starting from the left and moving in a clock-wise circle, risk drivers (**Box 1**) prior to 1992 (which have been described in the previous sections of this chapter) include overfishing, conflicting management objectives, data uncertainty, natural and environmental factors, and mismanagement, all impacting on the groundfish fishery SES (**Box 2** object at risk). Drawing from Table 8a-b, a subjective assessment approach using a scale of 1-5 is applied to each principle (**Box 3**) and assessed (**Box 4**) on how well each one was achieved using a five point Likert scale (Table 9). The scale ranges from 1 very poorly, 2 poor, 3 satisfactory, 4 good, and 5 very good.

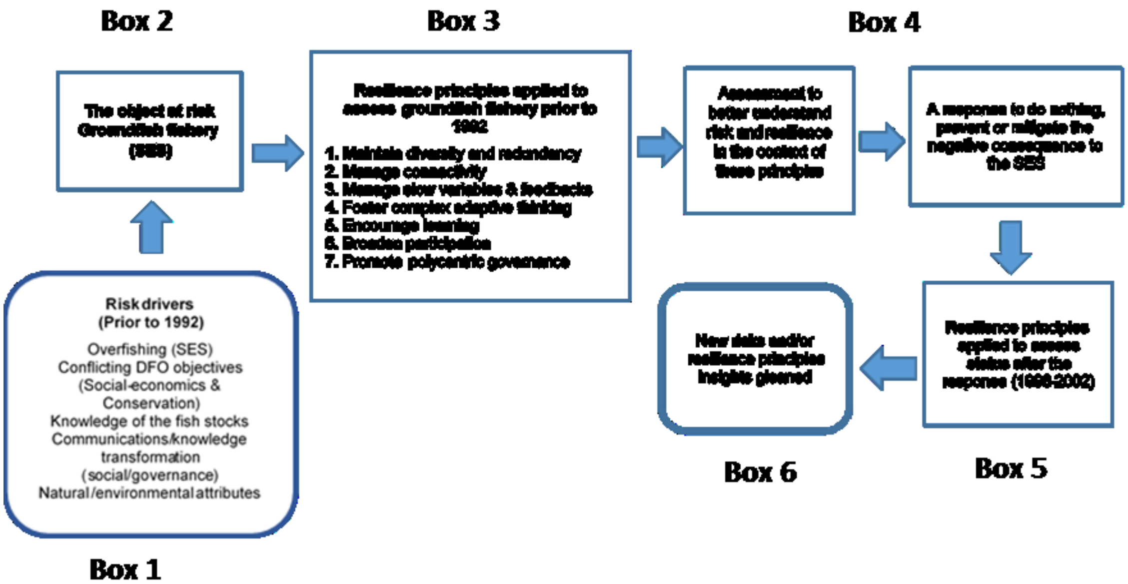


Figure 13: Understanding the groundfish fishery through the resilience principles lens

Table 9: Example of resilience principles most at risk
(Drawing from the literature analysis, a bolded **X** represents my perspective on both the status of these principles and a light X indicates a shift after 1992).

Principle	1	2	3	4	5
P1 Maintain diversity & redundancy	X				
P2. Manage connectivity	X/X				
P3. Slow and fast variables and feedback loops	X	X			
P4. Foster complex adaptive system thinking	X	X			
P5. Promote learning	X		X		
P6. Encourage participation	X	X			
P7. Polycentric governance	X	X			

A systematic second round of applying the resilience principles (**Box 6**) has not been done in this example as this was not the original focus of the thesis. However, drawing from the earlier discussion of the principles, and the summary of changes, coping strategies, threats and opportunities a few examples that could apply to **Box 6** and **Box 7** are presented. **X** represents my perspective on the status of these principles and X indicates a shift after 1992 (i.e. **Box 6**). Given the history of the fishery, it could be assumed that by 1992, all principle objectives were at a high risk of not being achieved. **Principle 1** diversity, still remains at high risk (**X**) as the cod fishery has not recovered.

Principle 2: management's understanding of ecological connectivity (**X**), management understanding and reaction to social/economic connectivity impacts (**X**) post event. Prior to the event ecological connectively might be considered as a 2 or 3, as would have been the connectivity between, for example processing plants and harvesters, political pressure and voters/unions, and the implementation of the EEZ and building the capacity of domestic fishing fleets. The ability to manage connectivity among different social, economic, technological, and political elements was low, resulting in the distribution of different risks disportionately among fishermen, depending on their income, reliance on the fishery and/or degree of debt. Post-1992, the ongoing dialogue, for example on quota allocations for shrimp among inshore, offshore, and government agencies continues. There has been some recovery of cod stocks, yet the mental model of wanting to immediately increase quota allocations by inshore fishermen is still there. Although, initially submitting to pressure from the industry, DFO has been faster to cut quotas this time around. Environmental factors are being tracked more proactively, including warming waters and the impact on shrimp and cod migratory patterns or shifts in predator-prey interactions (recovering cod and capelin or cod and shrimp).

Principle 3: Slow variables and fast feedbacks are part of the SES cycle. Having a better understanding of a SES does not translate into effective (or proactive) management. Hence it is not enough to be aware of these risks, it is also having the power to act in a timely manner to make the necessary changes to prevent, mitigate or adapt to slow and fast variables and feedback loops. Prior to the event (**X**) management's reaction to ecological variables and feedback was low, though faster in the context of social/economic impacts. As such, the only mitigating responses available were to close the fishery and providing financial aid to the fishermen (**Box 5**). Post event (**X**) there appears to be a better understanding of the ecological system in terms of connectivity and diversity, but less so among the interconnections with the other three dimensions (social, economic and political). Social and economic variables suggest that communities are still very heavily reliant on natural resources (fisheries, tourism, mining, oil & gas), which could present risks to their resilience, given current environmental and demographic changes. For example, the growth of ocean technology and younger generations coming into the workforce could provide employment opportunities related to fisheries improvements, marketing/business, oceans education and/or marine conservation/research fields.

Principle 4: Complex thinking (X) slightly improved post-event once different sources and approaches to data collection and analysis were applied to ecological data, but remained disconnected in the context of social and political dimensions. Species diversity (other than the cod and groundfish) may have improved post-event, although it is more probable that it may have just been a replacement processes within different food chains (e.g. groundfish being replaced by crustaceans).

Principle 5: Promote learning can be interpreted in a number of ways depending on the knowledge source, objective of study or discipline, for example traditional knowledge, social or natural science, and who conducted the learning and for what reason(s). Prior to the event (**X**) risks associated with this principle were largely around data uncertainty, but also the process of selecting and applying specific elements of this information to support explicit management objective(s). The withdrawal of funding support for field-based surveys and programs that encompassed both species populations and habitats greatly limits the ability of users and decision makers to better understand Principles 1-3. Consequently, with an imperfect understanding of Principles 1 and 2, coupled with restricted participation, limited acceptance of different forms of knowing, and ad hoc cross-scale coordination, creates risks to the formation of enabling complex adaptive thinking environments

Post event (X), a plethora of research papers, reports, and documentaries have been produced across multiple disciplines. There has also been a slight shift in government's openness and willingness to incorporate different sources of knowledge to inform their decision making processes through their Cod Recovery Strategy. Memorial University also continues to play a key role in ocean and fisheries research.

Principle 6: Prior to the event (**X**), inshore fishermen would have had less input into the decision making processes as the offshore sector were considered more reliable by government. In addition to having access to participate, another risk factor would be the ability of inshore fishermen to make successful recommendations to management processes and changes that it made to their position in the fishery. Post-event (X), unions still have a strong say at the decision table but are still fragmented between offshore and inshore sectors. The disbandment of the

FRCC reduced the ability of fishermen, industry, processors and academics to provide feedback and recommendations to managing agencies. Yet there is still a forum through mechanisms identified through the Cod Recovery Strategy and the Standing Committee on Fisheries and Oceans.

Principle 7: From the perspective of government agencies, polycentric governance prior to 1992 (**X**) consisted of a number of international, national, and provincial agencies. One of the risks was that policies and regulations were often conflicting and confusing, resulting in changes and disbandment of organizations and resources. As noted earlier, on paper an effort to align jurisdictional boundaries with relevant management agencies was apparent, yet the ability to enforce specific rules and regulations within these areas may have been limited. At the local scale, inshore fishermen were the first to describe apparent errors in stock assessments by government agencies but were largely ignored until the offshore (who carried more credibility with DFO) highlighted this issue. Post-1992 (**X**) included the FRCC and the Cod Recovery Strategy (including funding for research), which indicates a slightly more open attitude by government agencies. Co-management is often promoted as a form of polycentric governance, yet despite there being entities that could be considered "relevant stakeholders" (e.g. inshore, offshore, processors, government), within these groups individuals hold multiple and often conflicting views, which change depending on external and internal influences (personal vs afar experiences). Government agencies also hold different mandates, which may conflict both within agencies (e.g. DFO's conservation and economic development objectives) and with other departments.

4.6 Insights about risk and resilience concepts

4.6.1 Specified resilience and risk management

Specified resilience refers to "resilience of what to what/whom", which can also be parallel with the "risk of what to what/whom". In this context, one of the connecting bridges between risk and resilience concepts in a SES can be considered through the lens of trade-offs between social and ecological systems. For example, in the context of negotiating trade-offs among the various users of ecosystem services relating to the cod fishery, at a macro level, one option was between conserving the ecological system (i.e. building a resilient cod stock) versus developing a resilient social system (sustaining jobs both in the fishing and processing components). Scientists were aware of the risks to cod stocks if TACs continued to be maintained at high levels prior to the collapse and after the fishery was briefly opened in 1998. As more value was placed on maintaining the resilience of the communities through jobs in the fishery and processing plants, these warnings were ignored. The high degree of uncertainty around these models led to decisions being made to "fit the purpose". Rather than consider the worst scenario and plan proactively, management took these concerns and transformed them into their own interpretation i.e. because there is uncertainty, we will need more proof before making hard decisions, which would affect thousands of jobs. Taking this approach meant ignoring the precautionary advice and recommendations on the status of the stock (even though there were initial errors), which in turn put the ecological system (relating to principles 1-3) at risk, in an effort to build the resilience of the social component.

At a micro level, economic and political objectives guided the options taken to sustain the industry, including protecting federal and provincial financial investments that had been provided to large corporations. As an example, for processing plants, which were owned by large corporations, the ability to sustain their workforce required having enough high quality fish to make a profit. This in turn led to unsustainable practices of discarding low quality fish (economic vs ecological value) either at sea or at the processing plant. Here, the resilience of the corporations (including investments) was being built by sustaining its workforce through practices that created risks to the resource, and reduced its resilience. Eventually, this approach flipped when the resource was pushed over its threshold, resulting in a collapse of both the ecological and social interconnected system. This is a simplified example as there were many other forces at play. For example, international market influences became an external driver that fueled much of the behavior of both fishermen and political processes, highlighting the connectivity between market forces and political influences. Whereas at the national level, Canada was building its domestic fishing fleets, protecting its resources and management, industry and fishermen were guided by a mental model that suggested fish stocks would always be abundant.

Maintaining the specified resilience of a fishing community (and their social-cultural identity) in response to a closed fishery (due to reduced species diversity and/or low recruitment) has often led to governments providing subsidises to fishermen to compensate for their lost livelihood/identity. Yet, maintaining these subsidies over a long period may lead to their ongoing reliance on government assistance. Another coping mechanism is to shift to another livelihood, but this could also just shift the problem to a different fishery. If the fishery is within the same area drawing from the current ecosystem supporting and regulating services, it may still be at risk if the underlying drivers that caused the issue (e.g. knowledge of the species, addressing pressure from the industry/politics, mismanagement) in the first instance have not been addressed. Shifting interest or focus to resolve a problem is well-documented. For example, where seawalls have been built to stop shore erosion at one site, has often escalated problems in another location due to the disruption of natural process of sand deposition along the shoreline.

4.6.2 General resilience

General resilience refers to being prepared for unexpected shocks and living with changes. Both specified and general resilience are important for reducing risks to SES components. With specified resilience, a risk management approach can be taken to identify and proactively put into place measures that may prevent or mitigate threats from an explicit hazard or event. Yet, this approach raises a couple of issues, for example, what might be a threat to one party (inshore fishermen– last in first out policy), could be an opportunity for another (offshore industry). Another consideration in this example is that both inshore and offshore fishermen draw from an interconnected ecosystem that is dynamic and evolves around slow variables and fast feedbacks. Building general resilience into a SES (through these seven principles) may help prevent or better mitigate risks and threats to the overall system as opposed to just addressing one part of the system. Conversely, understanding the risks and elements that enhance specified resilience provides a grounded framework to build general resilience, which could act as a buffer for unexpected threats and risks to the overall SES.

In the case of the cod fishery, the high degree of connectivity among ecological systems and process, coupled with the reliance by the social system on provisioning service, data uncertainty and value around knowledge generation, and the disconnect between different levels of managers and users, all led to the overall breakdown of the SES's resilience. "The coasts under stress" project (Ommer, 2007) and others have highlighted the resilience of the Newfoundland community following the collapse of the stocks. Yet there is still a very heavy reliance by coastal communities on natural resources and the desire to maintain a traditional lifestyle, although changes to ecological systems may not support this lifestyle. From an ecological perspective, although there have been some small increases in the inshore cod stocks, the commercial fishery is still closed, but there is some allowance for limited fishing in some management areas, and the acknowledgement of bycatch. Although stocks did show some signs of recovery from 2012 to 2015, even reopening a limited fishery was too soon, and with large quotas (pressure from the inshore sector), it resulted in populations declining and a cut in quotas (2018). It is interesting to note that fishermen, based on the quotas that were issued in 2017 were preparing for a bigger quota in 2018 with government support, only to find out that quotas for that year had been significantly reduced. Applying a general resilience perspective, having already experienced the first collapse (or living in its legacy) finding other alternatives that were not fully reliant on management decisions or ecological fluctuations may have better prepared inshore fishermen for this quota reduction.

From a management perspective with the diverse and numerous agencies, policies and legislations involved in a fishery SES, it could be helpful to assess if any these approaches overlap or cause conflicts that might create risks, either to another specific element of a SES or with another policy. For example, Stoll et al., (2016) describes the evolution of the licensing system in Maine and how the current approach has restricted the ability of both fishermen and the state to respond to changing environmental circumstances. Three key findings are described in that study which include, a decrease in: (a) livelihood diversification results in economic instability, (b) mobility and flexibility within the fisheries leads to less compliance as fishermen avoid cumbersome rules and regulations , and (c) engagement undermines local ecological knowledge (Stoll et al., 2016). By quantifying the decline in fisheries access in Maine over a twenty-five year period, the authors demonstrate how adaptability in a fisheries context can reduce the resilience of fishermen (specific resilience) and the broader SES (general resilience).

Groundfish fishery studies indicate that many important interventions were made by communities and governance systems to cope with ongoing political, social and ecological changes. Coping strategies included (a) increased subsidies/actions to build domestic fleets and plants to take advantage of the EEZ and keep communities connected to the fishery even after it was no longer viable; (b) shifting to other fisheries (lobster, snow crab and shrimp); (c) initiating a cod aquaculture program (which has since closed); and (d) exploring ways to finance cod[23]. As this latter coping attempt was a pilot project, there is still little information on the outcomes of this initiative (Mather, 2013). Yet as seen in the years following the collapse many of the coping strategies implemented then have in fact enhanced or created new risks to the SES. Applying a general resilience approach that takes into consideration both vertical and horizontal scales, and across temporal frames will help strengthen the ability of the SES to respond to unexpected risks and events.

4.7 Summary

The groundfish fishery case study is a significant historic and international event that provides the opportunity for fisheries managers, industry, fishermen, academics and other interested parties to learn from. In the lead up to 1992 and post collapse, important changes included declining groundfish stocks, loss of jobs (harvesters and processers) and the reorganisation of management resources to address this crisis. Coping strategies included (a) increasing subsidies/actions to firstly build domestic fleets and plants to take advantage of the EEZ and later to keep communities connected to the fishery even after it was no longer viable; (b) inshore fishermen shifting to other fisheries (lobster, snow crab and shrimp); and (c) initiating a cod aquaculture program (which has since closed). Yet many of the coping strategies may have enhanced and/or created new risks that only became evident at a later date (e.g. reliance on benefits and EI). Current threats (from 2012 onwards) include changes in environmental factors, such as ocean warming (and its impact on species migration and recruitment), reliance on natural resources for livelihoods, and pressure on management agencies to reopen and/or increase quotas

[23] The limits of market based approaches and the economic potential of fish resources e form the foundation for the WWF's new approach to fish stock recovery (Mather, 2013). Developing a financial instrument, defined as a "Financial Institution for the Recovery of Marine Ecosystems' (FIRME)" will entail funding through the redirection of wasteful state subsidies to harvesters and fishing companies and the attraction of private sector investors interested in buying in to what is essentially a futures markets for fish (Rangeley & Davies, 2012).

for species that may still be recovering. Opportunities include exploring other fields that could still be related to fisheries and the ocean sector. For example, changes in demographics could encourage a transition for youth from following in traditional fishing occupations to other areas such as ocean technology and conservation.

The analysis of the seven resilience principles (Biggs et al., 2015) using data from the literature provided the basics to explore potential relationships between risk and resilience concepts. Resilience attributes are identified and, depending on the perspective, can either enhance resilience or create risks to a specific component of the SES. Collectively, these provide the foundations to start exploring the interactions between risk and resilience concepts. One practical approach is to assess how well the objectives of the resilience principles are achieved in two time frames (prior to the event, 1992 and post event, up to 2018). Based on this subjective assessment all principles scored very poorly prior to 1992, but there were small improvements post-event. Encourage learning (principle 5) scored the highest post event due to the plethora of research articles and reports that were produced. However, the application of changes based on this new knowledge, especially in the management context, still faces challenges due to political and economic pressures. The main message here is that components of risk and resilience are dynamic, and what might be one person's risk may be another's opportunity to build their resilience. Furthermore, risks and resilience attributes change over time, and what once was a coping strategy for one event can lead to unexpected risks to the same entity/individual in the future if SES conditions change.

Understanding the roles of specified and general resilience provides another opportunity to conceptually explore interactions between these two concepts. Specified resilience (what to what/whom) parallels risk management as they both have a similar application structure and understanding of what is at risk and or requires resilience. General resilience focuses on unexpected shocks to the system. Building on the foundations of specified risk and resilience assessments, a general resilience approach could provide the SES with the means to buffer or mitigate unexpected risks and threats. Here the focus would be on applying complex thinking to better identify and manage for slow variables and fast feedback loops, which involves maintaining diversity and understanding connectivity. Applying complex thinking (Stockholm

Resilience Center[24], n.d.) requires learning through its many forms of knowledge sources, the ability to apply that knowledge in a timely manner to the decision making process, and to maintain forums that allow for participation in management decisions by participants that have the resources and experience at different spatial and temporal scales.

The approach taken in this study provided a subjective assessment on how well the objectives of the resilience principles were met. Perspectives change based on personal and afar experiences, and individuals wear many hats (e.g. inshore fishermen are business owners, unionists, community members, fishermen associations etc.). Hence, the interpretation of what is a risk (or resilient) can change over short and long time frames, and in response to different issues/opportunities and perceived crisis. Thus, not everyone would agree that these principles are the most important to them. As a broad guide, these principles provide a quick snap-shot to better understand what/who is being made resilient and by what, and the risks that might be associated with the process for making something resilient and/or the consequences of not anticipating a specific risks or preparing for an unexpected event. This process can be made stronger though by understanding what the specific risks are to different stakeholders and how resilient are they to unexpected events.

[24] https://www.stockholmresilience.org/research/research-streames/complex-adaptive-systems.html

Chapter 5: Setting the context - Southwest New Brunswick Case Study

5.1 Introduction

The purpose of this chapter is to provide context for the Southwest New Brunswick case study. Examples drawn from the interviews are described in Chapters 6 and 7, with the analysis and discussion presented in Chapters 8 and 9. This chapter begins with a brief description of the case study area including an overview of the traditional fisheries and salmon aquaculture industry. The next sections describe the governance context, followed by examples of coastal and marine research, conservation and education awareness initiatives and organisations. Profiles of the participants are then presented in the last section of this chapter.

5.2 Setting the context

The Bay of Fundy has supported a diversity of productive fisheries, well before European settlement (Coon, 1999). For example, the northwestern coastal regions of this area are believed to have been inhabited by the Passamaquoddy Nation several thousand years ago, while the Saint John River valley north of the bay became the domain of the Maliseet Nation (Erickson, 1978). The Mi'kmaq also ventured into this area calling it "Mĕnagwĕs - where they collect the dead seals" (Erickson, 1978). Currently there are approximately 300 known Passamaquoddy people residing within their traditional territory, yet they are not recognised by the Canadian government, although they are acknowledged as Indigenous Peoples by the United States[25]. The Schoodic Band of Passamaquoddy, led by Chief Hugh Akagi elected in 1998, continues to fight for recognition by Canada, with support by groups such as the New Brunswick Quakers[26] .

The tidal currents in the Bay of Fundy are fast, exceeding 10 knots (5 m/s, or 18 km/hr) at peak surface speed (Desplanque & Mossman, 2004). The Quoddy region in the outer Bay of Fundy includes important breeding, spawning, nursing, feeding, foraging, resting and staging areas for many marine species, including birds, invertebrates, fish, and mammals. Approximately 160 billion tonnes of seawater flow into the Bay on 12-13-hour intervals bringing large nutrient upwelling from off Grand Manan and Brier Island, which in turn fuel the production of phytoplankton creating vast summer feeding grounds for fish from the Gulf and beyond (Coon,

[25] http://kukukwes.com/2017/10/19/passamaquoddy-nation-moving-closer-to-status-in-canada/
[26] https://qonaskamkuk.com/peskotomuhkati-nation/peskotomuhkati-persistence/

1999). In the inner Bay area (e.g. Minas and Chignecto Basins), large tide-washed salt marshes, and mud flats covered with algae also supply nutrients for other important feeding grounds. Vertical tidal ranges can be over 16 meters, with the horizontal range exposing vast areas of ocean floor up to 5 kilometers (Desplanque & Mossman, 2004).

The southwest area of New Brunswick has historically depended on marine resources, including significant fisheries for herring, groundfish (e.g. cod, pollock, haddock), anadromous fish (e.g. salmon, gaspereau, alewife), invertebrates (lobster, scallop, clams, urchin) and seaweeds (dulce, rockweed) (Lotze & Milewski 2002). Historically, the diversity of the inshore fisheries has allowed fishermen to move from one fishery to another without having to depend totally on one fishery (Recchia per. com, 2012). Gardner & MacAskill (2010) note that the fishing industry (which is primarily seasonal fisheries) in the Bay of Fundy includes approximately 600 mainly independent fishing vessels, who employ over 1,500 (skippers and crew). As such, fishing is a key activity for income and employment in this area. According to Gardner & MacAskill, (2010), the main fishery is Lobster (*Homarus americanus*), which accounts for about 80% of landed catch, but other fisheries also include Herring (family Clupeidae) and Scallop (*Placopecten magellanicus*).

5.3 Traditional fisheries

The next three segments provide a brief overview of traditional fisheries sector and salmon aquaculture industry. Historically herring and scallop dominated the fisheries but are now largely replaced by lobster, with salmon aquaculture being the most important coastal based industry.

5.3.1 Lobster fishery

Lobster fishing has been one of the economic mainstays of dozens of coastal mainland and island communities in this region, especially after the collapse of the Groundfish fishery in 1992 (Walters, 2007, Wiber et al., 2012). As noted by Walters (2007), fishermen tend to shift fishing effort amongst Lobster, Groundfish and other species, depending on the season, abundance and market value. For Lobster fishing, fishermen normally employed two forms of trapping strategies. In shallow waters where setting is precise and retrieval fairly easy, traps were set in sequence, either individually or in pairs with each buoyed to the surface (Walters, 2007). In deeper waters (because of the difficulty in retrieving traps), fishermen typically deploy 'trawls', which are sets of 3 to 25 traps spaced apart and joined together by a rope with buoys at each end of the trap line (Walters, 2007). Fishing vessels are normally 41ft. long and as a coastal fishery, under 45ft, as required by regulations[27] Figure 14a & 14b describe the tonnage (lobster landings) and value (ma) from 1990 to 2017.

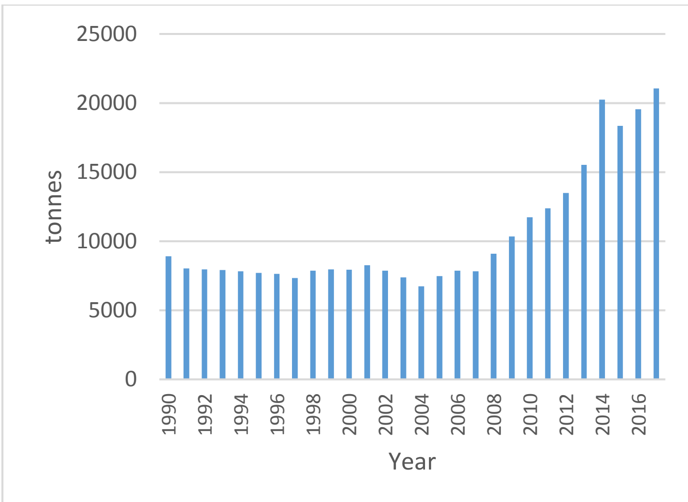


Figure 14a: Lobster metric tonnes, live weight

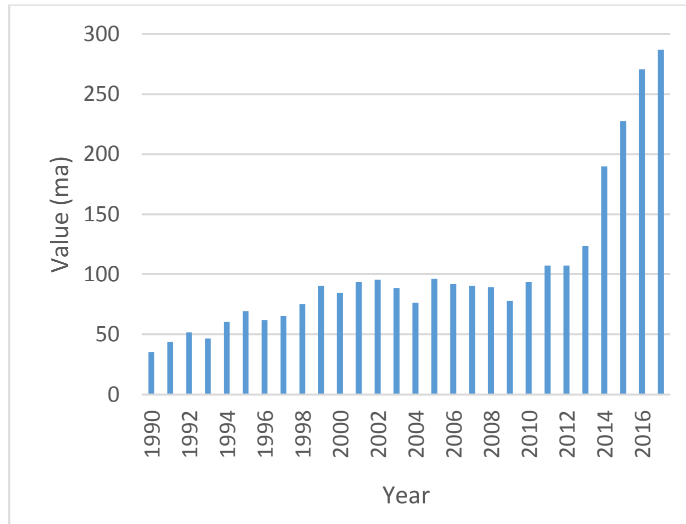


Figure 14b: Lobster value ($million)

Source: (Statistics, n.d. DFO-Ottawa, Ontario K1A 0E6[28])

Lobster licenses are allocated based on government-designated, License Fishing Areas (LFAs), which restrict the spatial areas in which individual fishermen are permitted to set traps. In 2017, LFA 36 included 177 licence holders, restricted to 300 traps, with two fishing seasons, fall and spring[29] . Yet, Walters (2007) notes that fishermen tended to fish within more limited areas based on their knowledge about the location, proximity to home port, and informal agreements with other fishermen over the use of the area. Figure 15 shows the location of LFA 36, and nearby areas.

[27] https://www.dfo-mpo.gc.ca/reports-rapports/regs/licences-permis/maritimes/com-fish-lic-pol-permis-peche-com-eng.htm
[28] http://www.dfo-mpo.gc.ca/stats/commercial/land-debarq/sea-maritimes/s2009av-eng.htm
[29] https://www.dfo-mpo.gc.ca/decisions/fm-2017-gp/atl-20-eng.htm

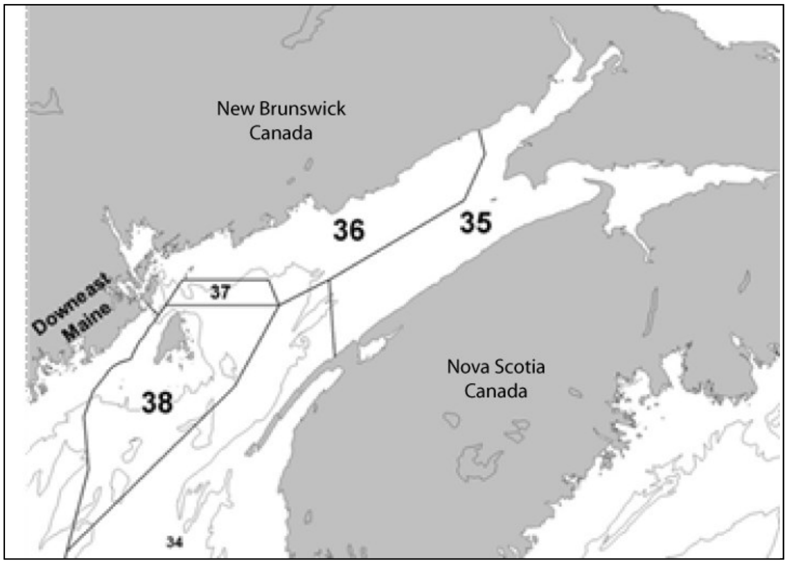


Figure 15: LFA 36 and other nearby lobster fishing management areas
(Source: Canadian Science Advisory Secretariat Maritimes Region Science Response, 2018)

The inshore lobster fishery is managed by "input control," in that a limit is placed on fishing efforts[30]. Conservation measures include (a) limits on licences and number of traps, (b) limited and staggered fishing seasons (lobster fishing is generally prohibited between July and September to protect the summer moults), (c) protection of egg-bearing females (which is believed to have been initiated by the fisherman, whereby a small v-shaped notch is cut in the female's tail prior to release to ensure it will be released in the future, even when not bearing to ensure the reproductive cycle continues), (d) minimum lobster size (72 mm starting in 2013 to increase the likelihood of reaching full adult maturity), (e) maximum size (or a closed window size as an alternative measure to protect large lobsters that proportionally produce more eggs), (f) trap designs (e.g. biodegradable panels) that allow undersize lobsters to escape or gear that when lost at sea will not continue catching lobsters and other species, and (g) ongoing monitoring and enforcement of fishing regulations and licence conditions.

As the total number of licenses is capped, this limits new entry to only those who can acquire pre-existing licenses, which are either passed down to younger generations or sold. Data provided through the submission of logbooks is the primary method through which catch, effort,

[30] https://www.dfo-mpo.gc.ca/fisheries-peches/sustainable-durable/fisheries-peches/lobster-homard-eng.html

landings, value, by-catch, species at risk, and positional information is collected for this fishery. Logbooks must be submitted to a certified Dockside Monitoring Company (DMC) recognized by DFO Maritimes Region[31]

5.3.2 Scallop fishery

The inshore fishery in the Canadian portion of the Gulf of Maine region includes the Bay of Fundy and Scallop Fishing Area 29 west of 65° 30’ (DFO, 2010). Vessels in the inshore scallop fleet typically range from 30’ – 65’, with Digby and New Bedford style dredges being the primary gear types (Canadian Science Advisory Secretariat Science Advisory (CSASSA) Report (2012/2010)). As noted in their report, the responsibility of Atlantic sea scallop management lies with DFO. The Bay of Fundy is fished by three separate scallop fishing fleets: Full Bay, Mid Bay, and Upper Bay (CSASSA, 2012/2010). The vessels in this fleet range between 45’ and 65’ length. As of 2014, the Mid Bay fleet comprises of 206 licences with the majority based in New Brunswick ports and the remainder from Nova Scotia ports at the head of the Bay of Fundy and in the Digby area (CSASSA, 2012/2010). Most vessels in this fleet range from 30’ to 45’ length overall and usually form part of a multi-species licensed inshore enterprise. The upper bay fleet comprises of 16 licences, all on vessels primarily less than 45’ length overall and, like the Mid Bay, it is usually part of a multi-species inshore enterprise (CSASSA, 2012/2010). All licences in this fleet are based in Nova Scotia and New Brunswick ports at the head of the Bay of Fundy. The Full Bay fleet fishes operates under individual transfer quotas (ITQs), and has a 1 October to 30 September fishing season; while the mid and upper Bay fleets fish a competitive quota with a 1 January to 31 December season (Nasmith et al., 2013). The Full Bay fleet has been the main source of inshore scallop landings during the period from 1985 to 2013[32]. As noted by DFO, in southwestern New Brunswick, the value of the 2012 inshore scallop fishery was $3.4 million

5.3.3 Herring weir fishery

The Gulf of Maine Research Institute[33] describes herring weirs is an adaptation of fishing practices that indigenous fishermen used and consist of a fence of long stakes driven into the

---

[31] https://www.dfo-mpo.gc.ca/fisheries-peches/ifmp-gmp/maritimes/inshore-lobster-2011-eng.html#toc7
[32] https://dfo-mpo.gc.ca/fisheries-peches/ifmp-gmp/scallop-petoncle/scallop-petoncle2015-sec2-3-eng.html
[33] http://www.gma.org/herring/harvest_and_processing/weirs/default.asp

ground with nets arranged in a circle or heart shape. At night, schools of herring bump into the lead line or fence and are directed towards the coastline to enter the weir through its open mouth. Boats and human resources remove the trapped herring to larger boats (herring carriers), which then bring the catch to nearby processing plants. Historically, these weirs and stop seines provided the bulk of the juvenile herring for the many packing plants within the Bay of Fundy but today, the abundance of coastal schools of juvenile herring are much reduced (Gulf of Maine Research Institute website[34]). The weir fishery is a non-vessel, non-core fishery and is not subject to any catch limits, but is restricted by resource and site availability as well as market. A Core Enterprise is defined as a fishing unit composed of a fish harvester (head of enterprise), registered vessel(s) and the licences he holds, which has been designated as such in 1996 under approved criteria[35]

In the fall of 2002, the Fundy Weir Fishermen Association, in partnership with the New Brunswick Department of Agriculture, Fisheries and Aquaculture, Connors Brothers Ltd., Grand Manan Fishermen's Association and DFO, initiated a herring tagging study focusing on herring from the weir fishery. The purpose of this program was to investigate stock structure, fish migration and movement patterns (Mouland et al., 2003). Since the start of this project, a total of 77,957 herring have been tagged and 2,742 tags recovered. Most recoveries have been from close to the site of application but there have also been some recoveries from fish caught on Scots Bay and German Bank, off coastal Nova Scotia and the USA, and from mixed aggregations off the Long Island Shore (Waters & Clark, 2005). In 2017, herring exports amounted to $65 million, with The Dominican Republic, United States and Haiti being the most important markets for exports (Government of New Brunswick, 2017).

5.4 Salmon aquaculture

Coastal communities in SWNB have been coexisting and accommodating the salmon aquaculture industry for the last 30 years following the collapse of the groundfish fishery (Walters, 2007). Beginning with one commercial site in 1978 the industry is now the largest

[34] http://www.gma.org/herring/harvest_and_processing/weirs/default.asp
[35] https://www.dfo-mpo.gc.ca/reports-rapports/regs/licences-permis/maritimes/com-fish-lic-pol-permis-peche-com-eng.htm

single food commodity in New Brunswick in terms of sales, earning an estimated value of $117.3 ma in 2013, rising to $227.843 ma in 2017 (NB Agriculture, Aquaculture and Fisheries, 2017). Figure 16a-b indicate the production (tonnes) and value (CAD) of farmed salmon from 1991 to 2017. Data was unavailable for 2006, 2015 and 2016 (Statistics Canada. Table 32-10-0107-01, n.d.)

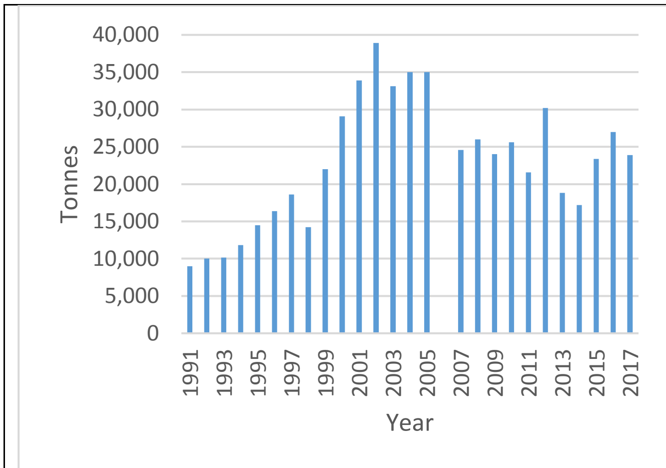


Figure 16a: Salmon metric tonnes, head on/gutted

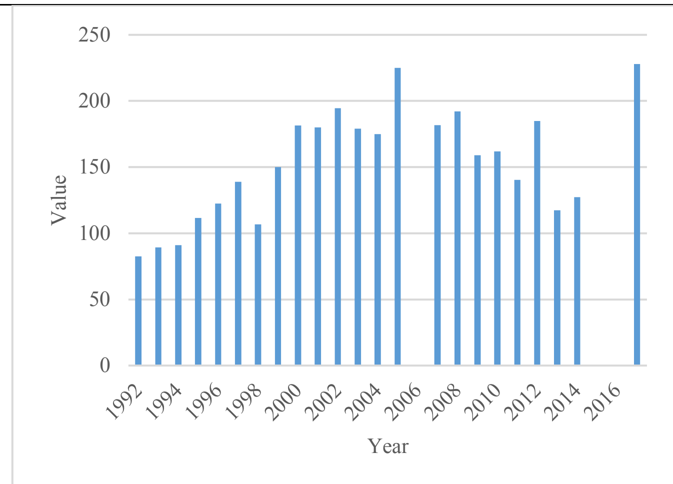


Figure 16b: Salmon value (ma)

Source: (Statistics Canada. Table 32-10-0107-01, n.d.)

Chang et al., 2014) provides a good overview of salmon aquaculture development in SWNB. Other studies have focused on fishermen's perspectives and knowledge production (Wiber et al., 2012), growth of the industry and interactions between fishermen and aquaculture industry (e.g. Stewart, 2001; Walters 2007, Harvey & Mileweski, 2007; Barnett, 2016; Rehn et al. 2017, Grant et al., 2019), and risks to the industry (e.g. McClure et al., 2005).

The first successful salmon farm in Atlantic Canada was on Deer Island in 1979 (harvest of 6 metric tons), and the results of a joint project among the Canadian federal government, the New Brunswick provincial government, and the private sector (Sutterlin et al., 1981). The salmon aquaculture industry focuses mainly on grow-out farms. Farmers purchase young fish (smolts) from regional salmon hatcheries, and grow these into market-sized, adult fish (typically 4–5 kg), which usually takes 18–24 months. At sea, fish are reared in net cages that are suspended by floating collars and anchored to the seabed by mooring lines (Chang et al., 2014).

The initial success of these first farms (indicating suitable environmental conditions for the production of salmon) and high international market prices for farmed salmon, coupled with supportive government policies and subsidies, led to a rapid investment from mainly multinational companies and an increase in farms (Walters, 2007; Chang et al., 2014). For example, Chang et al. (2014) notes that in 1980 there were two farms with an average of 5,600 fish per farm, in 1995 there were 66 farms, producing 160,000 tonnes per farm, and in 2012 there were 45 farms producing 370,000 tonnes per farm. As a result of disease problems, the implementation of single-year class farming within a bay management area framework, and economic factors led to the consolidation of ownership of these 45 farms to five companies, with one company operating 60% of the farms (Chang et al., 2014).

Salmon farmers hold long-term leases issued by the provincial government providing secure access to specified (mapped) areas of waters and sea bottom (Walters, 2007). Applying for a lease requires the farmer to identify suitable sites that are no closer than 1km to existing sites and they cannot impinge on herring weir sites, which are often in the same preferred area (Walters, 2007). As such, many herring weir fishermen converted long-held weir leases into salmon farm leases, either for their own farms, or more commonly were leased to an aquaculture company (Marshall, 2001). As there is a limited time period on these leases (~10 years), fishermen were required to either sell or cede full control of the lease to the company once the deadline had passed (Walters, 2007).

The management of aquaculture leases is conducted at the provincial level. Chang et.al, (2014), notes that initially new site proposals were evaluated on a site-by-site bases, with no consideration of potential cumulative effects of multiple farms in the same bay, apart from the recommended minimum separation distance among farms. Fish health problems, including an outbreak of sea lice in the mid-1990's and infectious salmon anemia (ISA) required the implementation of industry-wide bay scale management practices; most notable was the allocation of 10 sea louse management zones where chemical treatments could be coordinated (Chang et. al., 2014).

In 2000 the Bay of Fundy Marine Aquaculture Site Policy was revised to better focus on the regulation and development of the industry, including preventing the expansion in areas that were overcrowded and allowing for growth in less developed areas (New Brunswick Department of Agriculture, Fisheries and Aquaculture, 2000). The policy produced a framework for 22 Aquaculture Bay Management Areas (ABMA), and established guidelines on the rotation and class structure of the stock. The policy also set farm boundaries based on a combination of factors, including oceanographic, fish health, and business considerations, and designated large controlled growth and exclusion areas where new proposals would not be accepted (Chang, et al., 2014). Although these procedures helped to control ISA, another outbreak occurred in the mid 2000's attributed to the number of small ABMA's and the lack of mandatory fallowing between year classes, resulting in another revision of the ABMA framework in 2005. This new revision allowed for fewer but larger ABMAs, and a mandatory fallowing of 3 years for farms (Chang et al., 2014).

Salmon aquaculture has generated considerable employment and economic prosperity in New Brunswick. The industry's rapid expansion has also generated controversy in many of these same communities (Stephenson 1990; Millar & Aiken 1995; Marshall 2001). New salmon farm sites often compete for space with traditional fishing of lobster, herring and scallop (Walters, 2007). Furthermore, chemical treatments for salmon diseases can pose a risk to the health and quality of harvested benthic invertebrates, such as lobster (Milewski 2001; Haya et al. 2001; Waddy et al. 2007).

Details about these salmon farm impacts on the lobster fishery have been noted both in the news (e.g. CBC News, posted April 26, 2013[36]), and through research (Wiber et al., 2012). Kelly Cove Salmon, a division of Cooke Aquaculture is one of the main salmon companies in the areas where this study was conducted. Most of the production from the farms goes to the local processing industry, and onward to Canada and export markets, mainly in the US (Gardner & MacAskill, 2010). In 2013, Kelly Cove Salmon was fined $500,000 by the New Brunswick courts after pleading guilty to two charges in connection with the deaths of hundreds of lobsters

[36] https://www.cbc.ca/news/canada/new-brunswick/aquaculture-company-on-the-hook-for-500k-for-pesticide-use-1.1317105

in the Bay of Fundy from an illegal cypermethrin-based pesticide used in 2009 - 2010 (CBC News, April 26, 2013). At the time of writing, this specific pesticide issue had been resolved.

Interesting enough, a later article by CBC (posted Mar 20, 2017) noted another potential 'environmental disaster' from a sea lice outbreak that was averted in the summer of 2016. Over 250,000 salmon died and another 284,000 were pre-emptively killed to contain the spread (CBC, posted Mar 20, 2017[37]). These farms were owned by the Gray Group which subsequently went into receivership, and documents obtained by the receiver Ernst & Young reported fears that tons of rotting salmon could have washed up on the shoreline at Saint Andrews during the tourist season that summer, which would have had a very negative impact on the tourism industry. Furthermore, despite one of these sites being visible from Saint Andrews, neither the Mayor nor the public were aware of this threat. Gray Group's assets were later acquired by Newfoundland-based Northern Harvest. In 2018, the Norwegian company Marine Harvest, one of the world's biggest players in the salmon aquaculture business made a share purchase agreement to take over this company's nine sea-farm sites and a processing plant in St. George (Smith, Jan, 2018[38]). Yet, in May of that year, Northern Harvest was also charged with the use of pesticides under Section 15 of the New Brunswick Pesticides Control Act (Smith, May, 2018).

5.5 Governance context

Government departments with major roles in this area include federal and provincial (Table 10). DFO is the main authority for implementing regulations under the Fisheries Act, the Coastal Fisheries Protection Act (1985), and other fisheries-related legislation. The Federal Fisheries Act (1985) provides DFO with the authority and mechanisms to manage fisheries and implement measures. Management plans for the inshore fishery are developed by DFO and include consultation with the fishing industry[39].Along with a lead role in fisheries management, the DFO maintains responsibilities for federal fishing and recreational harbors, and for the provision of hydrographic and fish inspection services. The Aquaculture Activities Regulations[40] (AAR) clarify conditions under which aquaculture operators may install, operate, maintain or remove an

[37] https://www.cbc.ca/news/canada/new-brunswick/sea-lice-outbreak-fundy-1.4030118
[3838] https://www.cbc.ca/news/canada/new-brunswick/salmon-aquaculture-sea-lice-1.4493244
[39] https://www.dfo-mpo.gc.ca/reports-rapports/regs/afpr-rppa/framework-cadre-eng.htm
[40] https://www.dfo-mpo.gc.ca/aquaculture/management-gestion/aar-raa-eng.htm

aquaculture facility, or undertake measures to treat their fish for disease and parasites, as well as deposit organic matter, under sections 35 and 36 of the Fisheries Act[41].

Table 10: Examples of Government departments with major roles in this section

Federal	Provincial
Fisheries and Oceans (DFO)	Fisheries, Agriculture and Aquaculture
Transport Canada (TC)	Tourism, Heritage and Culture
Canadian Food Inspection Agency (CFIA)	Energy and Resource Development
Environment Canada (EC)	Environment and Local Government

Within New Brunswick, the implementation of a number of relevant policies falls under the umbrella of the Minister of Agriculture, Aquaculture and Fisheries, including the Agreement on Inter-jurisdictional Cooperation with Respect to Fisheries and Aquaculture (1999), the Marine Aquaculture Site Allocation Policy for the East Coast of New Brunswick, 2008. Legislation under this portfolio also includes: The Aquaculture Act, May 13, 2011, Fisheries and Aquaculture Development Act 2009, Inshore Fisheries Representation Act, 2011, Seafood Industry Improvement Fund Act, 2016, and Seafood Processing Act, 2006. The Clean Environment Act (O.C. 82-588), which also includes water quality (O.C. 82-588) and environment impact assessment (O.C. 87-558) and the Clean Water Act (O.C. 2001-488) fall under the Minister for Environment and Local Government.

When this research was being conducted in 2012 the study area was also undergoing an integrated coastal planning process, which began in the early 90's, and was started partly by local community groups including the St. Croix Estuary Project, and Eastern Charlotte Waterways. This initiative was reenergised in 2004 by DFO and the provincial Department of Agriculture, Aquaculture and Fisheries (Southwest New Brunswick Marine Resource Planning Committee, 2005). The purpose of this planning process was to develop a Southwest New Brunswick Marine Resources Plan to guide decisions on the use of marine space and activities. A proposed plan was submitted in 2009 (Southwest New Brunswick Marine Resource Planning Committee, 2009), and an advisory committee comprising fishermen, first nation representatives,

[41] https://laws-lois.justice.gc.ca/eng/acts/f-14/

DFO, provincial departments, NGOs and academics was established in 2011 (Southwest New Brunswick Marine Resource Planning Committee, 2011).

5.6 Examples of Southwest New Brunswick stakeholders and initiatives

5.6.1 Community fisherman associations

Fisherman's associations operating in this area include the Grand Manan Fishermen's Association (http://www.gmfa.nb.ca/about-us.html), and the Fundy North Fisherman's Association (http://www.fundynorth.org/). The Grand Manan Fishermen's Association was formed in 1981 with a motto of "Professional Fishermen Working Together" (Grand Manan Fishermen's Association[42]). Services to its members as described on their website include: a marine service centre, wharf winches, waste oil disposal depots, a 4-wheel drive tractor and fuel pontoons allowing for 24-hour fuel access to the Fundy fleet. Other benefits include representation on many fisheries and harbor authority councils, fleet insurance programs with Fairway insurance, and reduced rates for fuel and lubricants from Irving Oil. The day to day business of the Association is managed by a Board of Directors, comprising seven directors representing each village on the island, led by executive officers including president, vice-president, treasurer, and secretary (http://gmfa.nb.ca/).

FNFA is a community-based organisation located in Saint Andrews and represents small-scale commercial fishermen from St. Martin area to St. Stephen, including the communities of Deer Island, Campobello Island and fishermen who work the Saint John and Magaguadavic River Systems. Their members are primarily engaged in lobster, scallop, herring, groundfish, shad, gaspereau and freshwater eel fisheries[43]. The vision of FNFA is to support fishermen, promote healthy fisheries, and encourage viable fishing communities in Southwestern New Brunswick. Working with researchers from DFO and UNB, a number of projects have been conducted by the Association including aquaculture impacts on traditional fisheries, ghost gear retrieval, lobster stocks, and mapping oil spills in the Saint John harbor. The day to day management is conducted by an Executive director and two staff, who are guided by a board of Directors, with a president and vice president.

[42] http://gmfa.nb.ca/
[43] https://www.fundynorth.org/

5.6.2 *Conservation, education and awareness institutions and organizations*

Notable non-government organisations include the Conservation Council of New Brunswick (https://www.conservationcouncil.ca/), the Atlantic Salmon Federation (http://www.asf.ca/main.html), ACAP Saint John (http://www.acapsj.org/), and Eastern Charlotte Waterways Inc. (http://www.ecwinc.org/).

In 1969 the Conservation Council of New Brunswick (CCNB)[44] was formed as a provincial wide non-profit organisation to create awareness of environmental problems and support advances of practical solutions through research, education and interventions. Important milestones of the CCNB include the 1994 "Turning the Tide" report that marked the first comprehensive analysis of the health of the Bay's ecosystem, identifying major point sources of pollution and firmly putting the problem on the radar of policy-makers, fishermen, and citizens. Another initiative was the 2003 Fundy Baykeeper (a member of the Waterkeeper Alliance) with a focus on conducting on-the-water research and monitoring in the Bay of Fundy, including the removal of large debris from the water and coastline, and working with community members and fisheries groups to promote a healthy marine environment. One of the most significant results of the Turing the Tide report and work of the marine program was the cleanup of sewage in the Saint John Harbour, a decades-long campaign led by CCNB (s described on their website).

The Atlantic Salmon Federation[45] mandate focuses on the conservation, protection and restoration of wild Atlantic salmon and the ecosystems on which their wellbeing and survival depend. As noted on their website[46], programs focus on aquaculture, low marine survival wild salmon, freshwater recreational fisheries, dam and fish passages, watershed habitats and water quality, Greenland interceptor fishery (protecting off-shore Atlantic salmon feeding grounds), and indigenous fisheries.

Established in 1992, ACAP Saint John[47] conducts in-school environmental education programs, summer camps, ecological inventories, water quality monitoring programs, habitat restorations,

[44] https://www.conservationcouncil.ca/
[45] https://www.asf.ca/
[46] http://www.asf.ca/main.html
[47] http://www.acapsj.org/

watercourse restorations, wetland enhancements, contaminated site remediation, and works with residents in community cleanup initiatives. The Eastern Charlotte Waterways Inc.[48] began in 1993, and focuses on projects that integrate common social, economic and environmental concerns, to maintain community wellbeing through sound environmental health.

5.6.3 Coastal and ocean research

Both DFO and provincial departments conduct and support ocean and coastal research. Founded in 1908, the St. Andrews Biological Station is Atlantic Canada's oldest permanent marine research facility[49]. Research in support of DFO's departmental mandate to manage, regulate and support human activities covers a number of areas, including: aquaculture, biodiversity, climate change, coastal oceanography, fisheries and species at risk. DFO's Centre for Aquatic Animal Health Research and Diagnostics[50] (CAAHRD) supports the mandate of the National Aquatic Animal Health Program, which is to protect Canada's aquatic resources by preventing the introduction or spread of infectious diseases in wild or farmed aquatic animals, such as finfish, molluscs and crustaceans. At the provincial level, the provincial Fish Health Laboratory[51] provides diagnostic testing and screening for the different disease agents affecting aquatic animals.

Other marine research is conducted by institutions such as the Huntsman Marine Science Centre and UNB. The Huntsman Centre[52] based in Saint Andrews is a private, not-for-profit research and education facility whose mission is inspiring stewardship through the engagement of the community in the discovery of the oceans. UNB offers courses in Marine Biology[53], including summer intensive programs in collaboration with the Huntsman Marine Science Centre. Notable research being conducted by UNB include the conservation of coastal marine invertebrates (e.g. Rémy Rochette Lab[54]), and Dr. Wiber's[55] work with communities, fishermen's groups and researchers, including an Ethnographic study of risk assessment in coastal management. Other

[48] http://www.ecwinc.org/
[49] https://www.cbc.ca/news/canada/new-brunswick/marine-biology-st-andrews-oceanography-1.3370824
[50] https://www.dfo-mpo.gc.ca/science/coe-cde/caahrd-cesaard/index-eng.html
[51] https://www2.gnb.ca/content/gnb/en/services/services_renderer.16116.Provincial_Fish_Health_Laboratory.html
[52] https://www.huntsmanmarine.ca/
[53] https://www.unb.ca/fredericton/science/depts/biology/undergraduates/marineblock.html
[54] https://www.unb.ca/saintjohn/sase/dept/bio-sciences/labs/rochettelab/index.html
[55] https://www.unb.ca/faculty-staff/directory/arts-fr-anthropology/wiber-melanie.html

partnerships that conducted work in the Bay of Fundy included the Coastal CURA project[56] and the Canadian Fisheries Research Network[57] (CFRN). An important virtual cross-jurisdictional institution is the BoFEP[58], which includes researchers and government representatives from Nova Scotia, New Brunswick, and Maine.

5.7 Participants Profile

The section presents the profile of the participants. Although the gender-neutral term "fisher" is more inclusive, both SWNB participants and the literature (see Branch & Kleibernote 2015) use the term fishermen, when referring to their occupation. As such, I will use the term fishermen for both women and men when referring to the SWNB case study.

As most fishermen are engaged in a multispecies inshore fishery and hold multiple licenses, it is difficult to estimate the total population of all commercial license holders in the inshore sector in this area (Wiber et al. 2012). A more accurate estimate for the total universe of relevant fishermen in the study area could be based on the lobster licenses for Lobster Fishing Area (LFA) 36, which approximate about 176, of which the FNFA has an estimated 75 members, including crewmembers that are not license holders (Wiber et al. 2012).

Tables 11 a-c provide an overview of the participants' demographics, including role, age, gender, years in the fishery/industry and species fished/processing (past and current). The tables are divided into the three areas, comprising of the two islands (Campobello and Deer islands), and the mainland (Upper Bay). The first column of each table notes the assigned codes that have been used to reference quotes from the participants in Chapters 6 and 7.

---

56 http://www.coastalcura.ca/
57 http://www.cfrn-rcrp.ca/CFRN-RCRP
58 http://www.bofep.org/wpbofep/

Table 11a: Campobello Island: Participants profile

Code	Role/ Occupation	Age	Gender	Years in the fishery /industry	Species involved with	Species previously involved with
CI_01	captain, started as crew	51-60	male	40	lobster, halibut	tuna, purse seined for herring
CI_02	sea-urchin diver, scallop & lobster fishermen, buyer / processor	31-40	male	17	scallop and lobster	sea urchins
CI_03	buyer/ processor	31-40	female	8	lobsters, scallops, clams, ground fish, urchins, baitfish	
CI_04	weir fisherman	41-50	male	29	herring	urchins, purse seining for herring
CI_05	buyer/ accountant	Above 60	male	10	lobster	
Cl_06	captain, fisherman	31-40	male	15	scallop	herring, lobster
CI_07	captain, fisherman	31-40	male	17	lobster, scallop, herring	

Dependency on the fishery: Five participants (CI_01, 02, 03, 04, and 07) relied 100% on fisheries for their livelihoods. Participant CI_05 had a 75% dependency, with 25% being obtained through Employment Insurance (EI). Participant (CI_06) also had a 75% dependence, as his wife's income helped support their family of three.

Education levels: CI_02, CI_04, CI_06 & CI 07 had high school levels (mainly grade 10) and some community college certification. CI_03 & CI_05 had bachelor degrees (CI_03 in science). Both CI_06 and CI_07 mentioned new government regulations, which required them to take medical and radio courses or update their certification.

Table 11b: Deer Island: Participants profile

Code	Role/Occupation	Age	Gender	Years in the fishery /industry	Species involved with	Species previously involved with
DI_01	Previously fished with husband, current licence holder and captain	41-50	female	15	lobster	herring weir (with husband)
DI_02	licence holder and captain	41-50	male	15	lobster	scallops
DI_03	captain - scallop dragger	51-60	male	54	lobster, scallop	herring carrier, scallop
DI_04	fisherman	Over 60	male	47	herring, lobster	scallop
DI_05	previous fishing company co-director	41-50	female	7		lobster, scallop, clams, bait
DI_06	fisherman	41-50	male	45	herring (weir) lobster, scallop	groundfish licence- but never fished
DI_07	researcher	41-50	female	29		
DI_08	dock-side monitor	41-50	female	30	all species except lobster, maintains log-books	lobster and sea-urchin (deck hand/ stern)

Dependency on the fishery: Five participants (DI_02, DI_03, DI_04, DI_06 & DI_08) relied 100% on the fishery. DI_01 dependency was 95%, with 5% being obtained through EI. DI_07 only had a 25% dependency as she also worked as a researcher. DI_04 had also previously worked in infrastructure. DI 05 was no longer involved in the fishery (in the past relied on the industry 100%), and now worked in the tourism industry.

Education levels: Five participants had high school levels (DI_1, DI_2, DI_3, DI_4, & DI_6), with four having obtained Grade 12. Two participants (DI_05 & DI 08) had community college certification (DI 05 had a business administration diploma), and one participant (DI_07) had a doctorate degree (with a focus on Deer Island fisheries).

Table 11c: Upper Bay: Participants profile

Code	Role/ Occupation	Age	Gender	Years in the fishery /industry	Species involved with	Species previously involved with
UB_01	captain, fisherman	Over 60	male	59	lobster, herring	salmon, groundfish, scallops, clams and periwinkles
UB_02	buyer/processer	41-50	male	35	lobster, mussels, clams, scallop, groundfish	lobster, mussels, clams, scallop, groundfish
UB_03	captain, fisherman	41-50	male	32	lobster and scallop	groundfish, herring (but not since the mid 80's)
UB_04	captain, fisherman	51-60	male	40	lobster	groundfish
UB_05	captain, fisherman	41-50	male	29	lobster, shad/ gaspereau	
UB_06	captain, fisherman	Over 60	male	38	scallop and lobster	herring (weir), groundfish
UB_07	captain, fisherman	41-50	male	27	lobster	scallop
UB_08	captain, fisherman	41-50	male	59	lobster, shad/ gaspereau	Salmon, ground fish, scallops, dug clams and periwinkles
UB_09	captain, fisherman	41-50	male	35	lobster, scallop	lobster, mussels, clams, scallop, groundfish
UB_10	captain, fisherman	51-60	male	32	lobster, scallop	ground fish, herring (but not since the mid 80's)
UB_11	captain, fisherman	51-60	male	40	lobster	groundfish

Dependency on the fishery: With the exception of UB_01 and UB_08, all other participants had a 100% reliance on the fisheries. UB_01, had a 75% reliance, 25% coming from working at the Saint John dock in winter, whereas UB _08 also 25% of their income coming from real estate and from work on the waterfront. Two of the participants (UB_04 & UB_05) mentioned doing small jobs when not fishing, UB_03 noted that his wife worked in the health industry, which contributed to the family income. UB_09 wife was also a fisheries buyer and helped with the business. UB_10 left the fishery for the lumber industry for a while but has since returned.

Education levels: Seven of the participants **(**UB_03, UB_04, UB_07, UB_08, UB_09, UB_10 & UB_11) had high school levels (ranging from Grade 7 to 12). Two had post-graduate education (UB_01 and UB_06), and UB_06 had a masters in mathematics. UB 02, UB_05, UB_08 had community college certificates. UB_03 also had additional skills training and certification required for captaincy.

Table 11d provides a summary of the family involvement in the fishery and/or salmon aquaculture. The data suggest that for these respondents, most entered the fishery through family connections but many did not think younger family members would be fishermen. For example, DI_03 and DI_06 currently had sons that fished with them, whereas, CI_01, CI_04 and UB_09, thought that they might have family members continue the fishing tradition when they were older but were not sure. UB_04 stated that he would prefer if his son did not follow into the fishery.

Table 11d: Family involvement in the fishery

Code	Family involved in the fishery (past and current)
CI_01	Nephew
CI_03	Grandfather, brother in aquaculture - Cookes
CI_04	Sons still to young
CI_05	Brother was a deck crew-purse seiner
Cl_06	Crew - father owned purse seiner, brother-in-law
CI_07	Uncles still fish lobster, grandfather, retired
DI_01	Niece is also a fisherman
DI_02	Wife helps out
DI_03	Daughter works on consignments, wife used to work in plant
DI_04	Brother
DI_05	Husband fisherman and buyer, father - herring carrier captain
DI_06	Always fished with family
UB_01	Son fishes for lobster, done so for 20 years, and also scallops
UB_02	family always been in the business (fishing and as buyers)
UB_03	Father moved from Grand Manan. son-in-law, and son in fishery
UB_04	Son started fishing with him a couple of years ago
UB_05	Father used to fish until he was 82 years old
UB_06	Father used to fish and grandmother had shares in weir
UB_08	Father was in the fishery, (herring weir, shad/gaspereau)
UB_09	Father was a fisherman, wife is a buyer
UB_10	Started fishing with a cousin
UB_11	Grandfather fished

5.8 Summary

The purpose of the chapter was to set the context for the SWNB case study. Currently, the most important fisheries for participants included lobster, herring (weirs), and scallops. In addition to these fisheries, other historical fisheries included the groundfish fishery and herring (purse seining). The growth of the salmon industry was also discussed. A number of federal and provincial government agencies and departments have jurisdiction and work in collaboration with municipalities. Not-for-profit organisations, fishermen associations and academic organisations contribute to conservation, education, and research (which also includes government initiatives and ongoing research and fisheries assessment programs). The last section presents an overview of the participants' demographic profiles, with additional information regarding species fished (past and present), years fishing, education level and family involvement (past and present) in the fishery. The profiles also contain codes that will be aligned with specific quotes that are presented as data in the next two chapters (Chapter 6 and 7).

Chapter 6: Environmental, social, economic, technology, and management changes and coping strategies

6.1 Introduction

The purpose of this chapter is to present examples of what participants said in response to questions relating to changes within the five domains (environmental, social, economic, technology and management). Participants were also asked to describe how they coped with these changes. Changes and coping strategies categories are grouped according to themes and sub-themes based on the importance (i.e. saturation/frequency) of a specific topic. Saturation refers to commonly discussed topics, and their frequency. For each of the domains, changes are first discussed, followed by coping strategies.

6.2 General observations

When asked about the history of Southwestern New Brunswick, informants noted that in the past, people fished multiple species and community life was very much centered on fishing and related occupations. For example, one respondent noted: *Most western part of the bay was the wild salmon fishery and other fisheries, lobster, long line for cod, few scallops, and weirs used to catch fish when there was fish everywhere* (UB_06). For participants, this all changed with the onset of the most notable event reflecting social - ecological changes, that being the decline and collapse of the groundfish fishery: *We saw it first many, many years ago in Newfoundland and it's just been a gradual decline all over since that time* (CI_05). Reflecting on these changes, one participant further described his experience: *Well when I left here to go to Ontario in 1970, we had a pretty thriving fishing community, but I came back here now about nine years ago, ten years ago and we've seen a decline in the fishery to where now our only viable fishery to speak of is the lobster fishery* (CI_05). With the end of the groundfish fishery, many fishermen shifted to lobsters: *You would never starve if you fished groundfish, but if you want to make money then fish lobster traps* (UB_06).

Commenting on the shifting status of species and the reputation of the fishermen, one respondent said: *Codfish, haddock, Pollock are things of the past. My grandfather fished these. Lobster was something that you did in-between. Now it is king* (CI_07). A similar perspective was expressed by another respondent: *A lobster fisherman/the lobster fishery went from being something you did, but it wasn't king, right? In the eighties, herring was king. So, for many people lobster was something you did until the weirs got fishing, to bring in a little income and you did it in the fall. But in the late eighties to now, lobster has become king. So, the social changes are that lobster fishermen, now [have] status in the community* (DI_05). Yet, one fishermen noted: *Lobster is king, but there is only so much local demand for lobster, as fishermen were making about $5/lb at the wharf* (UB_08).

Reflecting on the connectivity between inshore fishing and community identity, many participants considered that with the exception of lobster, the other fisheries were declining: *Before, we had at least 50 clam licences on Campobello, now only six or seven [harvesters] dig* (CI_02 & CI_03). A similar observation was made in the context of hand-liners and gillnet fishermen: *Numbers of hand-liners has gone [down] and back about seven, eight, maybe nine years ago we had about two or three gillnet fishers on Campobello, and today we don't have [any]* (CI_05). Reflecting further, this participant remembered that: *In 1976 when I graduated, there were about 16 herring purse-seiners [but] now only one [is] left* (CI_01). This participant also used to see tuna fleets at the breakwaters: *there would be 25 or 30 boats, tuna men in them* (CI_01). Similarly, another respondent described past opportunities from fisheries: *20 plus 25 seiners in Head Harbor and they all employed between five and seven men. So, you know it's about 75 and 90 men, making a living every summer, and this was a really economic thing for the island and at the same time there were the ground fish and a lot of herring, so yeah this used to be a really booming place* (CI_04).

In the scallop fishery, the most notable reported social-ecological change was the decrease in the fishing fleets: S*ame scallops around, but back then there were bigger fleets fishing, and with more boats* (DI_03). The reduction of the scallop fleet led to other community changes: *With the introduction of the scallop fishery quota (1996/97), people left the fishery for jobs out west, which then led to the decrease in community population* (UB_03). Some moved to another fishery: *I was previously involved in the scallop fishery and now just focus on lobster because my helping hand is getting another part-time job at the nuclear power plant as it is more reliable wage wise* (UB_07).

Participants also mentioned the role of industries and how these sectors had influenced the community inshore fishing identity. For example, one participant said: *One of the big changes that kind of struck me was when we first started in here it was like 90 percent wild product and probably ten percent aquaculture, and now I would guess it would be probably 60/40 or more maybe, even 50/50 wild to farm raised. People seem to be spending a lot more money now on aquaculture than before* (UB_02). This participant also described the changes in fishing activity around Saint John: *I mean Saint John at one time, you know in the Saint John River, the gaspereau industry was huge, and they smoked the gaspereau, and a lot of it was shipped to the Caribbean, and there was an awful lot of that fishery activity*. Another participant thought that a lot of the change had to do with the growth of other industries in the area: *Since 1970, it's just been slow growth but in the last year or in the last 10 years it's been significant with the LNG and expansion of the refinery and now its expansion of the cruise ships* (UB_05).

Looking back on their fisheries legacy some of the participants reflected on the cyclical nature of the environment. For example, for both the scallop and herring fisheries, one respondent said: *It's cyclical. You know you have a couple of good years in a row, then you might have three four bad years in a row…that's been the way of fisheries* (CI_04). Another respondent described the situation, saying: *I'm a true believer that everything runs in cycles; so, the fisheries build up and then they dissipate and they build up and then they dissipate, just the circle of life* (DI_01).

6.3 Environmental changes and coping strategies

The three most frequently mentioned environmental changes related to: (a) weather and environmental factors, (b) inshore fisheries and other species, and (c) marine and land based pollution. Environmental changes were observed as being subtle (e.g. thicker fog, stronger tides) and very obvious (e.g. more seals in the area). Describing their observations, one participant said: *Very subtle that you have to stop and think* (UB_03). Another participant also noted that: *Although I'm not out on the water as much but I have noticed changes, oh it feels different; it's hard to put words around it cos a fisherman, he's able to fish because of how things feel* (UB_01).

6.3.1 Environmental changes

Weather and environmental factors

Describing flooding and wind events one respondent said: *Last fall when we had that flood down in at Bonny River, might be thirty miles from where we are here now, and up here we had seventy-five millimeters of rain fell and down there they had a hundred and seventy-five and that type of flood has never happened before* (UB_01). Another participant mentioned: *More wind in the fall/early spring, weather systems in the last years a lot longer, has blown north -east for almost a week* (UB_08). Whereas a third respondent stated *I think a lot more east wind in spring, whereas in the past it has been more south west wind in the spring* (UB_09). Similarly, a fisherman from Campobello Island described conditions as being: *We have like more violent storms, I've been fishing; lobster fishing since I was 18 years old and now last fall (2011 or 2012?) may have been the worse fall for storms that I have seen, also get a lot more wind than you used to, but it does not seem to have any effect on the fish species* (CI_01).

Warmer water temperatures and overall seasonal changes observed by participants included: *We had a warming spell in the late like 2000s you know mid-2000 to mid-2001 but seems to be going the other way now; like take the weather we've had the past few months…sort of like three weeks last summer we ran above average but for 18 months prior to that we were below average temperature wise* (CI_04). Reflecting back on previous winters, another participant commented: *Years ago, they used to skate across from Deer Island to Grand Manan, St. Andrews, when I was a kid, I could remember they used to tow barrages from St. John up to St. Andrews right and they would break the ice a little bit that was in the early 70s, just thin ice, but in 1902 or 1904 or 1912 you could skate across* (DI_02).

Other examples include one fishermen who said that: *The temperature has gone up a little bit and the water seems to warm up faster this time here* (CI_04) and *Water temperature don't go down as much as it used to like in the winter time it stays up, compared to ten years ago* (UB_03). A suggested reason for these changes was: *We haven't had any snow or really winter, we haven't had any winter really, so that's got to help the water temperature from cooling down, because you don't have it snowing all the time* (DI_02).

Weather changes were also described as being cyclic. For example: *It is getting warmer but we have had this type of weather on a cyclic basis right, but the intensity of it, I can't remember* (DI_08).

Inshore fisheries and other species

<u>Groundfish fishery</u>

The groundfish fishery was the most discussed topic in the context of environmental changes. Participants provided both past and present examples to describe their experiences. Prior to the 1992 groundfish fishery moratorium participants described the fishery as: *I've seen them come ashore; I've seen people wade in the water with pitchforks and shovels and throw the fish ashore, Pollock, cod those were at the times a grown man could catch a fish and hold it by the gills and have it stand up and have his picture taken with it and the tail would be like this on the ground, it'd be that big, right?* (DI_08) and *Ground fishery used to be the main fishery but it is gone now, right now even for Pollock* (CI_02 & CI_03).

Other comments described the increase in seal numbers, with two interrelated explanations for this abundance. One participant said that the: *Huge increase in the seal population, was because there are no natural predators in the bay* (UB_08). Whereas another participant noted that *with the ground fish gone, we now have a seal population that when I was like young and like 14 or 15, when seeing a seal it was odd and now they're everywhere; so well I think this happened because we do not have a bounty on them* (CI_01).

Describing the difficulties of finding groundfish now, comments included: *If you want any groundfish now you pretty much have to go gillnetting down off of Nova Scotia to get them* (CI_05), and: *You need to go far e.g. Yarmouth for only 10,000 pounds and they are going cheap, and after expenses not much left* (CI_02 & CI_03). Signifying the rarity of seeing any groundfish, this participant also noted: *Now if you caught a Pollock around here or a haddock you'd have to be written up in the newspaper because it would be an event or a cod, that's how much that has changed* (DI_08).

Another fisherman said: *We used to get really large schools of the young Pollock up insides the* *docks and stuff, and that's been a few years since we've seen that I don't know exactly what happened if something changed they don't want to come here or the big Pollock stops spawning or exactly why but it's been a while since we've seen them* (CI_04). Supporting this comment, this respondent noted: *Two years ago is when I last saw Pollock, whereas in the late 80s and 90s, Pollock was the main species caught* (UB_06).

Similar to pollock, changes were also noted in the halibut migration patterns, which was thought to be due to changes in weather conditions: *We haven't really noticed anything in the halibut, they were a little later coming last year (2010) but that I think was water temperature* (CI_02 & CI_03). Another fisherman noted: *There was no more flounder and due to the lack of other ground fish, I need to run trawls long line much further off-shore* (UB_06), thus also indicating reasons for an increase in fuel and boat maintenance expenses.

<u>Lobster</u>

Lobster was the second most frequently mentioned species, with comments focusing on size and abundance changes. For example, one participant said: *Everything, except probably scallop, lobsters in the last few years, haddock definitely, cod fish, all that inshore fish that first came in, they have all grown smaller, yes, gradually and gradually, and, it's been, going on [for] a decade, but they didn't seem to all go altogether at the same time, like you would notice in a three year span* (UB_02). This participant further described his experience as: *I worked with Armco when I was about 15, at that time up the bay, the lobsters were giant, they were all like 80 percent of the lobster brought in were jumbo, and now in that same area today, which would be 30 years later, the average size would be probably be only one or two [pounds]*. This participant also noted: *There used to be a lot of fairly big female lobsters, and now it's very, very hard to find, a female over say, three pounds, it's almost like looking for needle in a haystack* (UB_02).

Although the lobsters seemed to be getting smaller, there appeared to be more around. For example, this fisherman observed: *More lobster around, but smaller lobsters that's good, because that means in the future there is going to be more to be able to sell* (DI_02). Reasons provided by participants to explain these observations included: *There is more catch now than when first started fishing as lobster traps have improved and so has gear and boats* (CI_02 &

CI_03). Reflecting further, another participant said: *When I fished in the sixties, of course we weren't fishing the gear we're fishing today or as much gear as we're fishing today, but even the traps never had the lobsters in them that you have today* (DI_10).

There was some uncertainty as to why this was happening. In addition to new technology, other suggestions referred to the reduction in the groundfish population. For example, these fishermen said: *Seen a big increase in lobster catch, but perhaps that's due to the decline of the ground fish, but no one is really sure as to why* (CI_04), and: *You know, as far as lobsters go, there has been a big increase in those in the last eight or ten years. Now you talk to older people who are not from here or other places around and a lot of them say, it could be due to the collapse of the groundfish like the cod, but there never was probably a big cod fish area, and it maybe that a lot of the eggs or I don't know if it is spawn or it is being able to mature whereas before the ground fish and other predators would eat [them], but I don't know that myself* (DI_04).

Reflecting specifically on predation, another fisherman said: *There is a lot more lobster now than ever it was as there is no groundfish. Cod used to eat the lobster, now there are no predators* (UB_09). Another participant noted: *It has definitely improved, because there is no ground fish, so no cod fish to eat the juveniles. We are the major predator now* (CI_01). One participant also thought it was a combination of factors: *Lobster stocks increase due to the collapse of the cod fishery, but conservation measure has also increased numbers* (UB_08). The conservation measures in this case included V-notching and the implementation of minimum and maximum sizes for lobster, all initiatives that the fishermen had proposed to DFO.

Participants also discussed the influence of seasonal changes on when and where they catch lobsters. For example: *This spring is a little slow, but I am sure it will come good later* (CI_02 & CI_03), and: *Lobsters for some reason or another have been increasing, yeah it is good and I don't know how or what it means but they have the last few years, not in all places; but wherever they do come, it seems to be heavy to what it was a few years ago* (DI_10).
Another participant mentioned the quality of the lobsters being caught, and related this to changes in weather and environmental conditions. For example: *Yeah, I find the lobsters are a lot softer now, you know, to what I can remember, even when I first started fishing, in 1988 and I*

didn't find them as soft then as I do now, just seems to be the water temperature, it's getting hotter (DI_10).

Herring

Reflecting on past experiences, participants spoke about changes mostly in the context of herring weirs. For example, participants from Upper Bay noted that there was a: *Lack of herring in Dipper harbor, used to be able to drive for bait (light in the water, would attract the herring), last weirs being built here in 2011, would see herring while fish draggers were around, now not a thing* (UB_06); *No herring now, Sheldon's Point (Reid and Freenery) [is the] last weir* (UB_08), and *I've noticed it, I recorded it and talked to other fishermen and they were experiencing the same thing with the herring, we don't see herring* (UB_01).

A fisherman who had not been involved in the herring fishery, but heard about it from his father said: *Well, here herring, that's gone and my dad was always talking about that herring and how much came through her*e. The same participant also linked the herring to whales being seen with the herring: *But I know they had whales at that time and this may have been because they were following the herring* (UB_05). An island fisherman also noted similar changes relating to the mainland: *When I first started running herring, always herring in Saint Andrews and Passamaquoddy, and there was always herring there and quite a lot of weirs, and I don't know whether it has to do with environmental change or slowdown in the fishery that's all gone, that's the thing of the past* (DI_03). Another fisherman from the Islands considered herring as being cyclic and there was potential for good catches in future years: *The herring seemed to be you know strong like the past two years there was a really big year class of herrings spawning and they were everywhere they were from here to New Hampshire to Halifax it was a really big year class to take them while to catch someone's up, so, that's a good sign* (CI_04).

This island participant noted that visual impact of clear cutting along the coast was a factor: *I noticed a lot of clear cutting along the edges of banks [so] it's not as dark as it once was. [Cut] the stuff that opens up places that used to be dark and long, and because my fishing (weir herring) the darker the better right and the fish don't seem to act the same, because of the extra light that is added (*CI_04). Explaining further, the fisherman said: *I see that as especially along* *the coast because everybody wants to see the water and they work hard for the money and they want to retire and see the water, but at someone else's expense sometimes (*CI_04).

Scallop

Besides lobster, scallops seemed to be the only species that fishermen thought were doing better in most areas but they also noted the cyclic nature of the fishery and that it was hard work. For example: *Scallop stocks seem to be increasing, scallops are everywhere* (UB_03); *Scallop catches are increasing and decreasing every 5 year cycle, seems better now* (CI_06); *Scalloping a cycle, six or seven bad years then good years, last two years has been phenomenal scallop years, and the price has been pretty good this year, $8.50 boat price and we have not seen that since 2005. The price was down to $5.00 last year, but scalloping is hard work* (CI_02 & CI_03); and *I've seen that go up and down, but I think they had a fairly good fishery this year, but scallops are so labor intensive* (CI_01). A fisherman who had previously been heavily involved in the fishery emphasised: *You could etch out a paycheck from a scallop fishery in the past but these days, not so much* (CI_05).

Reasons that participants gave for these changes included: *Some people think that actually a scallop will thrive more on fishing* (UB_02); *Scallops seem resilient, you can fish them hard but they come back* (CI_01); and: *It almost seems that scallops show that trend if they are a fished and if they are like regulated as of what they're allowed to come out, that they seem to sustain themselves* (UB_02). This fisherman also had similar observations in relation to soft clams: *Soft shell clam, you know, if continuously harvested, seem to help make the clams grow and stuff*. (UB_02). Other reasons provided by respondents included: *They say that was because of the tsunami in Japan, which killed off the prime growing grounds for the small scallops, where they cultivate them over there* (CI_02 & CI_03); *Perhaps different areas to fish and number of boats that go fishing have decreased, most fishermen fish Mid-bay scallop ITQ* (CI_06); and: *I think the quota is working and the fishery will be sustainable if we can keep a reasonable quota* (CI_02 & CI_03).

Wild Salmon

Participants, mainly from Upper Bay commented on the loss of the wild salmon fishery. One participant, reflecting on the low number of Island participants, commented on this topic: *There never was a wild salmon fishery around Campobello, I think the native people were fishing then for food but as far as commercially fishing I don't recall anybody to my knowledge on Campobello that ever commercially fished wild salmon* (CI_04).

For Upper Bay respondents, most comments reflected on the fishery being closed/gone. For example: *No more wild salmon fishery, used to be a fishery about Pt. Lepreau* (UB_03); and: *Salmon, that's gone, the salmon was here in the 70s* (UB_05). Although this participant was not involved in this fishery, he mentioned that: *I did my grandfather's old record book, from when he started fishing salmon in 1940 through to 1968, and everyday all the salmon that come, but first time they closed it was in 1968 and then they opened it again in 1985 and '86 and a few fishermen were given tags before it was closed again* (UB_09). Another respondent said: *There used to be so much salmon going up the St. Croix River that they couldn't even give them away because they were so plentiful and then I don't know if it was because of the sawdust or what but let's say because of the pollution, the salmon run declined or dropped, but they have started to come back a bit in the St. Croix River* (DI_08).

Reflecting on possible reasons for the loss of the wild salmon fishery, participants mentioned: *The lack of conservation practices* (UB_08); and: *Dams in the river and net fisheries killed that fishery and I don't think the salmon will come back because there are too many changes in the river systems and because of aquaculture* (UB_09). Sport fishermen were also thought to have had an impact on wild salmon: *Well, they said the stocks were low, but it was mostly on sports fishermen, they wanted more salmon catch for themselves and it was a lot of politics involved with that because that's a big thing you know, taking the politicians on sport fishermen in the river* (UB_07). Continuing this discussion, the participant mused about the impact of the Greenland fishery: *The stocks might decline for a lot, but everything is a cycle. And they said a lot of the salmon, the line of salmon need to go to the Greenland, up around Greenland. And they had a big salmon fishery for years and years and they just were ripping, like factory trawlers and never stop like this fishery* *shut off for 20 years and they were still hauling them out there and never stopped. And [those salmon] are the same ones that migrated here* (UB_07).

The collapse of the blueback herring fishery was also mentioned in the context of the wild salmon. *They used to be a big fishery in the winter, but after that spraying took place, I think they got sprayed and dammed off. They sprayed something along the trans-Canada highway that washed in the water and killed about everything that was alive there, including the blueback herring and then the greenback herring, and they just gone along with most of the salmon* (CI_04).

<u>Other species</u>

Describing changes in the composition and quantity of other species, one participant said: *There are no birds, no seaweed drifts, used to be a habitat for monk fish, which were targeted in the 90's US market. First [there was] a decrease in jelly fish, now an increase* (UB_03). This participant referred to the connectivity among different levels/chains in the food web and habitats: *So, the nurseries are in-shore, and you go in the rock pools, you can see the little larvae of some kind, you know, I can't identify [them] till they get a certain size. I do a lot of urchin fishing and we went places like in kelp beds and you could really see one-inch long lobsters and spawning, so it is important to protect these areas* (CI_04).

Another participant mentioned a study conducted by a scientist [from Maine] in the fall of 2011: *The amount of plankton in the water has been substantially reduced in the Bay of Fundy. There's been a big drop, and well the northern right whale feeds on that and then we see the northern right whale start to wash up on the beach through starvation. It's gonna take something drastic like that to get people motivated to do something about this* (CI_05). This participant also mentioned concerns about the use of pesticides for controlling sea lice and diseases in the salmon aquaculture, and the impact this might be having on other species in the area.

Whales: Participants observations included: *Not a high density of whales around here, a few sharks like 15 years or more ago but, they were like they were pretty good sized ones* (UB_03); and: *No whales in this part of the bay, more around Deer Island and the Wolves* (UB_08). One participant in referring to offshore areas suggested: *Water is not firing as it once did as there are* *no plankton blooms, it has been years since I last saw this* (UB_06). This observation was also supported by an Island respondent who added there are: *More humpbacks in the area because they are chasing plankton* (CI_07).

Shrimp: All comments regarding shrimp were from Island participants. One of the comments reflected on the cyclic nature of the fishery: *2009 was phenomenal shrimp year, haven't seen that for about 20 years, hopefully it will not be another 20 years before it comes back, but it was not good this winter 2011, but also really a cold winter* (CI_02 & CI_03). Another participant made a similar reference but also included the Maine shrimp fishery: *We're seeing you know a lot of feed, a lot of small shrimp. Maine just had record landings in the shrimps this year. They shut their season down early because the landing was so good, so that's all positive* (CI_04). This participant also made the connection between shrimp and being prey for other species: *We had shrimp you know, which are indicators of the health of your area and there were bands of shrimp on your beaches, and your squid would come after the shrimp, and the herring and then the groundfish would come after it, yeah the whole food chain* (DI_08).

Sea urchins: Two comments, both from island participants referred to the sea urchin fishery, and made reference to the salmon farms. For example: *The use of antibiotics by the salmon industry resulted in the sea urchin fishery being really hammered, the eggs are smaller, but now it seems that the value is better on the other side of the market, don't need as many but the quality of the roe has gone way down* (CI_02 & CI_03). Another participant noted: *The urchin fishery is declining so it continues to be a weak fishery, especially here in this particular area, whereas Grand Manan has a bit of different story because they follow a different conservation policy* (CI_05).

Seabirds: Reflecting on changes in seabird populations and composition, one participant said: *We have a lot of bald eagles which we didn't have when I was growing up, and they are here now because of the salmon sites, which discard their smelts and it drew the eagles* (DI_08). Whereas an Upper Bay participant mentioned: *See garnets here now, didn't see them here before but in the last couple of years they have been here (Garmin Hamlet to see them), but they are here for some reason but don't know why* (UB_03)

Squid: This is another species that seems to be seen sporadically: *I guess, there were squid around here for a couple of years and they just disappeared, it's been quite a while ago now, 15 years ago, like they never were here and they just came and there was lots of them when they did come. Then they just disappeared again so I don't know if they caught them up or, but there really wasn't much market for them, but we used to use [them] for the trawler stuff* (UB_03)

Tuna: The abundance of tuna the previous year (2011?) was a notable event: *Last year most tuna, I've ever seen in my life in the channel, not as rule, but last year you could look out for three or four miles and tuna were just coming out of water, jumping everywhere, it was really quite incredible and I have never witnessed that before* (CI_04).

Marine and land-based pollution

Describing land based pollution changes, a couple of the participants said: *They always blamed back then all the pulp mills and all the sawdust that was in the St. Croix River, and in fact there still are areas up above the causeway going toward St. Stephen and Bayside that you could still see on the beaches and when the tide's down you could still see the sawdust from a hundred years ago* (DI_08); and: *In the past a lot of pollution from the pulp and paper factories, but this has been cleaned up over the years, perhaps due to fines over the last 10 years* (UB_08).

One of the biggest changes relating to marine pollution was that they were seeing more plastics in the water and on beaches: *When I first was fishing, no one had plastic bags and stuff, almost 15, 20 years ago when I was a kid. You'd never see plastic in the water [and] when you walk. [I] walk a fair amount on the beach and you never knew of the plastic bags or plastic bottles of some type. Now it's just plastic pollutio*n (CI_01).

Debris from abandoned and existing salmon farms had also been increasing: *I noticed a lot of salmon cage debris, like a lot of that's broken cages, lot of plastic on beaches that wasn't around you know 20 years ago*. (CI_04). As noted earlier, impacts on the urchin fishery were also being attributed to antibiotics and chemical pollution from these farms.

6.3.2 Coping with environmental changes

This section describes the coping strategies that participants used to deal with these changes. For weather and environmental factors, and changes in inshore fisheries and other species, participants: (a) adapted fishing practices, and (b) left the fishery for other fisheries or employment opportunities. Dealing with oil spills, some participants were relying on industrial and government management plans. Participants also seemed to be more self-aware about recycling and how they could contribute to reducing plastics within the marine environment. A few fishermen noted the uncertainty in the fishery, and the opportunity to learn from the groundfish fishery collapse. For example, one fishermen noted: *Nothing is steady in the fishing business, nobody would have believed the ground fish would ever end. We need to learn from that experience and look after what is left, especially the lobster as something could hit those fisheries, disease/chemicals and they could go the same way* (DI_03).

Adapting fishing practices

Fishermen adapted their fishing practices to changing weather patterns by going further offshore, although this also increased their expenses, including fuel, navigational gear, and bigger boats: *I went deeper this past fall because I have a bigger boat, but otherwise I put a lot more inshore, and fish offshore, deeper water later [in the season], when it's milder out* (DI_01); and: *Through some consultation and mostly just changing the way you fish, go around areas, fish somewhere else* (UB_05).

Leaving the fishery for other fisheries/employment opportunities

The main coping mechanism for dealing with the decrease in the herring and the ground fish was to leave the area or move to another fishery: *Our community here on Campobello, I mean I don't know what the population is now, but when I graduated it was 14000 and I think now about 7 to 900,000 and it's falling fast, so in the past there would be eight or 10 big graduating classes from high school but when you go back let's say five years maybe only two would still be here* (CI_01); and: *When the cod fishery collapsed, we moved to full time scalloping* (UB_03).

For those choosing to remain in the fishery, the possibility of better fishing years based on their experience and belief in the cyclic nature of the fisheries, provided hope, but always with some caution: *Seeing a lot more small lobsters so looks promising for the future* (CI_07); and: *There are a lot of changes, but nothing coming back. I could say the lobster fishery seems to be holding strong and that could be maybe because there is not any cod fish deep not sure why, but [lobster is] getting a lot of fishing pressure* (CI_04).

Recycling and oil management plans

Changes in fishermen's practices towards dealing with marine pollution included recycling, and addressing oil waste and spills: *Many small and simple things, from men taking home their recycled pop cans to community comments if somebody pumped the bilge and there was oil going into the water. I think this has all improved for sure* (DI_05). Similarly, another participant said: *Yeah, our oil waste management is good, I mean we have places to put our oil and stuff, and I find the environment seems to be more protected now than it was years ago* (DI_10).

Dealing with marine pollution from fishing boats, one fisherman said: *Nothing goes off my boat in the water, unless it's bait. I have a garbage can on my boat and they don't throw anything overboard cos if you do, you're going after it, but I think people are starting to pay more attention and there's bit more respect for other users* (DI_01). When addressing chemical pollution from salmon farms, one participant suggested: *Fishermen can lobby to stop the use of treating salmon with harmful chemicals, using different chemicals and methods [such as the] well boat, so that the chemicals are contained* (CI_06).

On the possibility of an oil spill, participants suggested that existing regulations and disaster plans were in place to help them cope if a major event was to occur: *Oil spills, like the refinery in Canaport have got plans set up, disaster plans if that were to happen* (DI_10); and: *Oil industry is pretty heavy regulated, there are even exclusions on around that tanker half a mile so* (UB_07). Yet there was some uncertainty as to how well these plans would work: *Recovery oil plan in place, but very difficult to recovery oil in five or three knot currents* (UB_08).

Compensation from the company or government if an oil spill was to occur was also discussed but there were conflicting views as to what this would mean: *Oh, the good thing about oil spills is you can get compensated but your equipment's still all sink up. I don't think there are any government* *regulations for compensation, so you're just done* (UB_09); and: *Although there will compensation, the environment/habitats will take a very big fall, and the oil and gas industry needs to be accountable* (UB_08).

6.4 Social changes and coping strategies

6.4.1 Social changes

The most frequently mentioned social changes related to: (a) Community composition, including native fishermen and international workers; (b) Inshore fisheries; (c) Growth of the aquaculture industry; and (d) Community cooperation and attitude. A few fishermen were trying to get out of the fishery as there was no one in their family to take over, either because there were other jobs available or the start-up costs were too high. For example, one fishermen said: *When a fisherman retires he normally likes to sells his license or passes it on to a family member, but I think around here most people are probably trying get out of the fishery, because in this area, there is actually other work that people can do* (UB_07). Another participant said: *When my son was little and I asked him are you gonna be a fisherman, and he would say no I'm getting a real job, but he made good money when he was fishing and was able to pay for his own school and didn't have any loans, now he is making a hundred and twenty thousand a year in Alberta* (UB_11).

Community composition

Many participants observed that their communities were getting older as the younger generation left for education or other employment opportunities. For example: *I see what seems to be a lot of the older people here, the younger people are going job seeking, and although there is quite a lot of work here, you know with our fishery, it is mainly seasonal work* (DI_10). Similarly, responses were also provided by island participants: *We're finding that the demographics in these small communities are changing, it's changing rapidly with young people having to move out of the small communities, move away if they want to have gainful employment* (CI_05). Reflecting on the change to community identity and structure, one participant noted that: *Many older people [left] in the community, only a handful of your kids, lots of houses up for sale, and many of the houses are faded, but in the past were well kept*. (UB_06).

Native fishermen

A few participants mentioned the inclusion/activities of native fishermen as an important change that had some impact on competition/cooperation among fishing communities: *When the native were introduced into the fishery, which would have been probably the most part within the last decade, that had a lot of, I won't say negative impact but, that affected I think the mindset of the individual fisherman and how they would have to survive, and obviously an industry that was getting harder and harder for them to live off* (UB_02). Other comments noted that non-native fishermen were captaining these boats and that these fishermen were not keeping the dock areas tidy and clean: *Fishermen from Campobello have sold their licensees to Saint Mary's First Nation, but captains are non-natives, and these boats are using SJH as home port but[its] not their boats so [they] don't take care of the infrastructure like the owner-operator boats* (UB_08).

Supporting this statement, another fisherman said: *There should be a native aboard that boat fishing for lobster, but they don't, they hire white men to fish their boats and if you can't catch enough lobsters to make a go for the band you're gone and they'll get somebody else, so it's a high level turnover and because they are being paid twenty-five percent to go operate the boat, they're only interested in catching lobster; they're not interested in cleaning up the wharf or you know upkeep on the boat or anything because the natives have to pay for it so they just run them and that kind of stuff irks me to no end* (UB_11). Commenting further, this participant described a meeting with the Saint John Port Authority: *At a meeting with the Saint John Port Authority [he] sort of indicated that the natives gotta go and he wouldn't come out and say that but that's the sense that I got. We're not doing [damage] because you're in there gaspereau fishing. We want those native boats out of our harbour because they leave such a mess, they don't clean up. [But the authorities] can't point the finger and say, you can stay but you have to go* (UB_11).

International and national workers

Processing plants such as Paturel on Deer Island (currently closed due to a fire in 2018[59]) rely on a seasonal fishery, and so hire international and national workers for positions that local people are not willing to fill. One informant noted: *One big change in the island in the last year or year*

[59] Boston-based East Coast Seafood Inc. owns Paturel, and has plans to rebuild following a second fire that forced it to close in March 2018 https://www.cbc.ca/news/canada/new-brunswick/deer-island-fire-department-1.4556988

and a half has been a number of Filipino workers that come to the island to work in that lobster processing factory (DI_04.) Expanding further, this same participant said: *I have heard it is high [maybe] 60, but I am not sure, so, that's a big change like, that's 10% of the island [population] overall*.

Inshore fisheries

The most notable social changes were related to the composition and identity/status attributed to being a fisherman, as this was often not considered prestigious work. Reflecting on his experience, one participant said: *Fishermen are not viewed the way now as they were 20 years ago. [They were] initially considered rustic fishermen in late 90's, early 2000's, but now seen as making alot of money and perhaps considered as being greedy* (UB_03). Along similar lines, others shared that: *For the longest time, a fisherman was just a poor fishermen and now [some] have alot of money, and there were brand new vehicles sitting on the wharf* (CI_02 & CI_03). Conversely, one fisherman's perspective was: *People get into the seafood business and they automatically think they're gonna be wealthy. That's a misconception regardless if they buy a lobster boat* (DI_05).

Remembering their childhood experiences and connections to different fisheries, one participant noted: *I remember as a youngster in summer time if I didn't have anything to do or wanted to make five cents, there was always something, I could go bait a trawl, or I could go help someone seine a weir, or I could go dig some clams and that's all gone. The clamming was never really good but it was always something that could get you by* (CI_04). Similarly, another fisherman said: *if there was a job, like if things are slack, I mean, you would go work at one of the lobster ponds or try to find a job with someone else, just basically most would do anything that was fishing related* (DI_04).

A few participants noted that not many young people wanted to fish now: *There are less people buying into the fishery, it's an expensive business to buy and do it, [whereas] I was sort of taking over my father's license over the years* (DI_02); and: *No young people getting into the fishery industry, as there is a problem with banks not being willing to finance loans* (UB_08). Reflecting on the past, others remembered that: *30 years ago, you would hand you licence to your son, but* *now there are not a lot of sons getting into the fishery because (a) you can't retire like this anymore because the cost of living has gone up so much and (b) everyone wants to sell, because they need money* (CI_02 & CI_03).

Many of the participants were able to get into the fishery (scallop, lobster, herring) because their father, husband or relative were already involved: *It's pretty well just the same families that just keep going down the line, like father and son, or brothers or something like that. There is not really any new people here it's just they're all from right here. The fish is out of here, the same community* (UB_03). Other participants commented: *When my grandfather got out of this, he sold his boat and licence to participant (CI_01); and: that's how he got into it, he is his nephew* (CI_02 & CI_03); and: *Well when my husband passed, I went to fisheries and they gave me two choices; fish it or sell it, and so I fished* (DI_01).

A few of the participants said that although they had children who had gone fishing with them, they also hoped that they would find other jobs or stay in school: *I have two children, a boy and girl - one is 14 and one is 17 but would hope that they do not get into the fishery but stay/go to school* (DI_02). Another fisherman made reference to the perceived stigma of fishing: *Although my son fished with me for five years, he is now in Alberta, went to school out there for two years he didn't want to tell the people he went to school with that he was fisherman* (UB_11).
Many of the younger generation were also just starting their own families: *I think starting out and he has got a young family, and when he has got an income coming from woodlots, whereas in the weirs there was never a guaranteed income every week, and he liked the guarantee of the incomes* (DI_04). Similarly, another participant said: *My young fellow he likes going out fishing, but he hasn't any kids* [*so he does not have that responsibility yet]* (DI_02). There was one exception where, one participant wished that her children would engage with the fisheries: *I'm so disappointed in my boys because they're in the IT industry, they're in faster paced living and altogether different than this type of life* (DI_08).

Another possible reason why the younger generation did not want to fish was attributed to their attitude/drive towards work. For example: *Nowadays young people don't have much drive to do stuff and on the boats you got to keep busy you know. It's just a different generation I guess, they* *are computer people* (DI_02); and: *If they don't all follow any interest at the start, it's sort of hard to get someone to like it, you have to like, because some days is not always good* (DI_04). Expanding further, this participant added: *The young people nowadays growing up, they like to have some time to themselves and they fear to do the weirs especially when they are in the summer time. When you [fish] seven days a week really and most young people like to have the weekends off, and they like to have a paycheck every Thursday or Friday (DI_04)*. Comparing the attitude between past and current generations, a couple of participants noted: *Younger generation is changing, my grandparents raised me and I learned to work the way that they did. Lots of young people do not want to work in the fishery because it is hard work* (CI_02 & CI_03).

Growth of the aquaculture industry

Comments referred mainly to changes within the salmon aquaculture industry, but other species were also mentioned: *Our main ones would obviously be farm raised, mussels and salmon, farm raised Atlantic salmon although we dabble in other stuff but, they would be the main ones* (UB_02). For most island participants but also a few Upper Bay fishermen, the growth of the aquaculture industry (numbers and sizes) was a big social change within their community. Initially many farms had started out as means for an alternative/fill the gaps livelihood, especially after the collapse of the groundfish fishery. Community attitudes towards aquaculture changed when locally owned farms were amalgamated by large corporations such as Cooke, leading to a rapid growth of the industry: *Aquaculture is taking over the wild fish fishery and it has been since I've been in the marketing end of it. I think when we first started probably it was eighty-five percent wild product and fifteen percent aquaculture but now it would be far greater, maybe not half but it would certainly have increased* (UB_02).

Other comments included: *Aquaculture used to be owned by small independent farmers, now owned by three large companies, and government sides with aquaculture because of the money they have invested* (CI_07); and: *Aquaculture sites were small, when it just started, they were like local when they had the experimental site in Lords Cov*e (DI_05); and: *Aquaculture was not always on a big scale - probably mid 80s- early 90's, when I was younger, it couldn't be any more than 25 years, but small scale ended probably in the late 90s, some of them are still around* *but not many* (CI_01). Describing her experience with the aquaculture industry, one participant explained: *We've seen that in aquaculture industry when there used to be a lot of small family owned businesses in the aquaculture business and at that time our island flourished because [of those] people. The people lived there and they supplied jobs to the locals there and you could just see the community prosper. But the minute that those salmon sites sold off to the big corporate then the only money that was coming there was once in a while they would supply something for a breakfast program at school. But there was no money staying here, they wouldn't gas up their car nor buy a pack of chips at the store* (DI_05).

The socio-economic value of these locally owned farms was reflected by the many small processing plants that supported these initiatives: *Processing plants especially in our area, South Western New Brunswick, there was probably 25 or 30 processing, licenses, and now there is three or four active in the area but, since then a lot of the small community based operations have died and leading like into the bigger plants for sure, but, that seems to be in the way of economics in the world* (UB_02). Furthermore, these family owned farms also supported local industries, and there seemed to be more community cooperation among those who worked/owned these small farms and members of the family/community who fished: *Used to be a full time welding shop and boat shop that supported these small fish farms, and fishermen would also go there for assistance, but now that does not happen* (CI_02 & CI_03).

In addition to government support and ideal environmental conditions for farms (sheltered bays, nutrient rich waters, and natural flushing by the tides), the growth of the industry was also attributed to corporate greed: *I think a little greedy, they tried to grow too many fish in too small of an area, that led to crowding and disease* (UB_01); and: *Aquaculture salmon farms were small scale, mom and pop, but then larger corporations could see money in it, and more companies invested more money until now I believe there is only three or four companies that own the whole thing now and that's along with multi-million dollars' worth of government subsidies* (CI_04). This sentiment was also expressed by others, noting that current issues within the aquaculture industry did not happen at this scale in the past: *The size and number of stock was probably about 100/110 cages, with 25 - 300 fish, and they never lost a fish to ISA or had problems with sea lice that required food stuff and medication. Now there are big cages, and a* *well boat there 6 months a year, so with mass production (100,000 to 200,000 in a cage) means more money for the province, but has huge issues for the aquaculture industry in terms of dealing with diseases and sea lice* (CI_02 & CI_03).

Reflecting on overall social changes to the community, one fishermen observed that the: *Shift in wild fisheries to aquaculture products means the face of the communities is also changing. Those who would've fished, the traditional fishers, and those who now do only aquaculture* (UB_02). This participant also said: *It's changing, you know the face of seafood for sure because it's a different seafood, like a wild salmon and farm raised salmon are totally, totally different from one another and that would be the same with everything whether it be lobster, scallop, cod, haddock, like it'll change*.

Community cooperation and attitude

Changes in community cooperation and attitude were mentioned by quite a few participants. Reflecting on the past, one participant said: *When you walked up the street, people had their windows open and there might be a woman come out and say "Oh, come on in dear and have some Cookeies", now when you walk around everybody has got their shades drawn, doors are going to be locked. I don't know if that that sense of community went away with the fishing or if it's just modern life* (CI_04). Similarly, another participant mentioned that: *This changeover happened gradual; it certainly didn't go like all over a year or two. But I think it just kept getting worse, yeah like from the late seventies to the mid-eighties things were kind [of] more cooperative and then I think probably the mid-eighties people started catching a lot of lobster and they were making more money, and things started to get very competitive* (UB_02).

Describing changes in his fishing harbor, one participant said: *I think the people, you know, [each] harbor they would all [be] working together [to load/unload] and now they are very mandated for themselves. That's probably the biggest change that I've seen now* (UB_02). Changes in fishing practices were also noted: *There used to be such a thing way back when if you fished in Mispec or you fished in Black River or Saint Martin or Dipper Harbor, there was a gentlemen's agreement where you fished, now they're called transient fishermen; they travel through the whole district,* *fishing with no regard to the guy that fishes here or there and the prime example is Saint John Harbor* (UB_11).

One of the most mentioned reasons for this change in community cooperation was the issue of competition between fishermen and buyers in the face of rising expenses and fluctuating market prices: *I think because everybody is feeling the squeeze, which starts from the big buyers up top* (UB_07); and: *More competitive than ever, not as friendly as it was years ago, when fishing was both pleasure and business* (CI_07). In the case of companies there also seemed to be less willingness to help others out: *In the past, say we sold our product to another buyer and there was a loss, the loss was shared, as there was an agreement worked out and everyone shared, whereas now it's like a dog-eat-dog world; everyone you know is out for themselves* (UB_02). Explaining further, the participant said: *The end result doesn't seem to be working because, you know the harvesters are not making what they need to survive and the bigger companies claim that they don't make enough to justify paying more so it just doesn't seem to be efficient* (UB_02).

6.4.2 Coping with social changes

This section presents examples of how participants coped with these social changes. Communities on Deer Island generally welcomed international and new workers by providing social events and opening community services to them. There were quite a few suggestions on how best to address the changes in family members not wanting/expected to follow in the inshore fisheries. Shifting attitudes towards work values sometime led to licenses being sold to outsiders, if there was no immediate family member to take over. Similar to dealing with environmental changes, fishermen also adapted fishing practices to reflect spatial closures and lobbied to have government reconsider the subsidies provided to the aquaculture industry. With shifting attitudes towards community cooperation, participants suggested that people needed to be friendly and continue to maintain an Island identity. As seen with environmental changes, a couple of participants also suggested taking things as they come and dealing with things as best they could: *I believe that everything will stay as it is and people will get by* (CI_07); and: *I think we just take everything day by day because everything is uncertain. You can't plan when you don't know what's going to be thrown at you, I guess we react* (CI_01).

Community composition

New workers appeared to be welcomed by the community and accommodations made to help them adapt to their new environment as they helped fill an important gap in the workforce. For example, one participant said: *Well mostly its people who have lived here leaving and immigrants coming in to work. I think they're trying to get to know the local community, but most of them work out at Paturel and they work long, hard hours, very controlled, but we've set up for the school to be opened in the evenings for basketball and ball hockey so that they can feel more welcome, and some also attend the local church* (DI_01). This participant also noted large corporations like Paturel did not support (spend) much within the local communities: *They bring people in and they may buy a bag of chips and may buy a few groceries or can of gas, but they're not bringing any real value*. Other industries that used international and national workers included the aquaculture and sardine industries. For example, this fisherman noted: *The aquaculture industry has hired and the sardine plant, Vietnamese first I think at the sardine factory then its Romanians at the aquaculture plant* (DI_05).

Maintaining inshore fisheries

There was quite a bit of discussion on how best to cope with the shifting phenomena of family members no longer wanting (or expected) to follow a fishing life style. For example, this fisherman noted: *There are more people selling their licenses now and moving out of the fishery. It's gonna be a generational shift* (UB_01). Other participants said that an attitude influenced how one approached fishing: *If you have family in the fishery then your attitude is different and you are more likely to stay. But buying your way into the fishery is an investment, and you have your goal as a financial gain* (UB_03); and: *I believe there is that attitude, I mean, to a certain extent, live for the day and forget what is going on tomorrow, but not everyone is that way, you are always going to have that group [who is] going to be feeling like, easy come, easy go, but you also have to tell young people, like my son, well we better save for a rainy day or prepare, no matter what* (DI_04).

Recognising the changing needs of the younger generation, one participant commented: *Attitude now is towards having a better life with family. I have encouraged my son to do something else and I think people would like their children to have a better life* (DI_03); and: *Well you could* *convince everybody to slow down and smell the roses and it's not all about money, but that's not usually the case, especially with young people when they want to advance a career and have families and build homes. They want [to] make money and they want [to] make it quick and that seems to be the way now* (DI_05). On the other hand, one fisherman said intergenerational learning (and the benefits of better boats and gear) was important for coping with social-ecological changes: *I guess its part of an evolutionary process. I learned to fish from my father who fished back then with a small boat and they fished as hard as they could and whatever they could because if they didn't, the fish could go away, the weather could get bad or the price would go to hell. But now even if the price goes to hell we can fish in that boat that we have there now in weather that's fairly comfortable that would send my father ashore* (UB_01).

Addressing the growth of the aquaculture industry

Dealing with the growth in aquaculture, one fisherman reported: *We just have to fish a little different area that's all, but everyone would be squeezed into a smaller area and probably be more expenses to go out for fishing or something like that* (UB_09). Taking another perspective one respondent noted: *One way to stop aquaculture growth is to dry the money up, that's provincial and federal, the federal government dumps money over to state, who in turn subsides large aquaculture companies* (CI_01).

Maintaining community cooperation

Being able to get along with people was important for achieving community cooperation: *You got to be friendly with people if you're going to get things to work, you know what I mean, people around, you got to be friendly, and listen to the people* (DI_03). The low crime rate also helped build community: *Fortunately, we do have a real low crime rate on the island, especially violent crime is really low, almost non-existent, which is really good, and that's a great place to raise the family except for the economic challenges* (CI_04).

Maintaining an island identity was very important to one participant: *I mean that's something that you can't lose is this island identity; it's extremely important and people move in and out and we need to find a way to maintain or sustain that island identity* (DI_08). Yet, she also mentioned that: *for Deer Island because this is also a cyclic thing, the young people moving away and then* *when we had the local salmon farms, we had a lot of people come back, and a lot of people stayed and helped build, and now the salmon has gone the way of all new industries, mostly under one big company so you've got them moving away again, but I really wonder if Deer Island might be considered/heading towards a retirement community now*. Another participant observed: *I think there are less people, but the people around are having lots of kids* (DI_02).

6.5 Economic changes and coping strategies

6.5.1 Economic changes

The biggest overall social-economic change impacting fishermen and communities was the financial pressures of staying in the fishery: *I think the biggest social change now is the financial pressure for the individual enterprises to succeed at their harvest. It's like any business, they have to adapt payments, expense payments and make their money. It's obviously far greater pressure now than it was a few decades ago and it almost looks like it'll continue this way* (UB_02). In this context, the most frequently mentioned economic changes related to: (a) increasing fuel prices and other expenses, (b) fluctuating Canadian dollar and market prices, and (c) factors affecting employment flexibility.

Increasing fuel prices and other expenses

With a fall in market prices, fishermen also saw an increase in fuel and other expenses. For example: *Economically, the increase in fuel prices was the biggest change. Scallop prices have basically stayed the same, 90's was the heyday, and fuel was low. This boat here is seven years old now and when I fueled it up and I put in the water it was $0.39 a litter. Now it's over a $1 here in seven years.* (UB_03); and: *Everything has increased, 300% increase in fuel cost, insurance has gone up, overheads have gone up* (UB_09); and: *Oh fuel is a big thing now and I would say just about everything's gone up, boats and everything, but the price of fish has gone down* (DI_10).

There were also notable changes in bait costs and user fees: *$20 for little pound block of bait. We buy that frozen bait. Sometimes we get fresh bait that comes in the plant down there but most of time in the fall we're buying frozen bait [which] costs me $300 to go around my traps once for* *bai*t (UB_03). User fees were another concern: *User fees have increased, so has fuel prices, gradually since 2008* (CI_01).

<u>Start-up costs</u>

A significant economic change for small scale processors and inshore fishermen has been the increasing start-up costs to get into this industry: *It costs too much to get into the fishery and processing as the province has made it such, that to buy products you need licences and facilities that requires code, whereas 10 years ago people could buy anything that they wanted* (CI_02 & CI_03). This made it especially hard for family members to follow in the fishery or processing business: *My son could not afford to get into the fishery, I think I paid $4500 for my lobster license back then but now it's close to $100,000* (UB_03). Similarly, in the scallop fishery: *Boat licences cost $300,000 minimum, $2,600,000 for boat licence and boat (scallop), the core status was $100,000 before boat and licence* (CI_02 & CI_03). Emphasising these points, one fishermen said that: *At 32 years old, he was the youngest fishermen. But now its too much to get into the fishery, $300,000-400,000, lots of people would love to go, but it is a very big investment* (CI_06).

Fluctuating Canadian dollar and market prices

The fluctuating Canadian dollar and its impact (including other international drivers) on markets prices was a continual ongoing issue for fisherman: *Well, right now the Canadian dollar is high and that's bad for us* (UB_09); and: *Yeah lobster prices have gone down. We went from $6 to $3.25, $3. 50. When I fished with my father 40 years ago he would get $3.50 for them* (UB_03). Another fisherman was concerned about being able to pay his bills or set aside money for a rainy day based on what he was getting for his lobster: *Really the price we're getting for lobsters right now is not enough, because that's when you run into trouble big time cos if you have to replace an engine you're looking at 15, 25, 30 thousand dollars and you know you're not getting that out of the fishery every day so and these things do happen but if you're getting your six dollar a pound lobsters you can put something aside for that, no matter how you look at it, bankers don't like to lend to fishermen* (UB_01).

Lobster fishery

The most important economic changes observed in the lobster fishery was a decrease in market prices for their catch, although there was some debate among fishermen, with a few who thought the prices were stabilising, whereas others noted that they were still getting the same price they had in the past. All participants agreed that fishing expenses had increased: *Lobster prices have decreased, at one time, over 2 days I got $13/lb, but other good times it would be around $6.75/lb*. (CI_01); and: *I have seen them up to $7 over here and I have seen them down like $3. And it fluctuates. Like last fall, I got around $5 or something like that and the lobsters were abundant. This spring if they are scarce, probably the price maybe back up to $6. I don't say it will, but it is all going to depend on the supply and demand for it* (DI_04); and: *You take the price of lobsters now compared to twenty years ago, we're getting the twenty-year-ago price. Yet to trap twenty years ago didn't cost me a hundred and fifty dollars; it probably cost me seventy-five, a crate of bait twenty years ago was six dollars, a barrel of fuel was nine, now a crate of bait is sixty-five and a barrel of fuel, two hundred and fifty dollars, from nine dollars, everything has gone up except the price of lobster; it's gone down. In 1991 we got five dollars a pound and now we're getting four-twenty-five* (UB_11). Similar situations have also occurred in the scallop fishery: *Last winter we had a real good price but 10 years ago we were getting $10 a pound, last winter we get $9 a pound, the winter before we got $5.75 to $6.95. That's a quite change* (DI_03).

Comments from lobster fishermen who thought that the process had stabilised included: *Well I think people are better off today*, t*he price of lobster has not come up much today but the volume has come* (DI_03); and: *Right now they're pretty much stabilized. I mean this year we started the spring fishery with a price higher than it was last spring and the fall lobster fishery was comparable to the fall fishery last year, which was comparable to the fall fishery from the previous year* (CI_05).

Participants also described the 9/11 event as being a particular influencer on market prices: *We saw prices drop after 9/11, and the reason for that is because I think people just stopped spending, I think the mindset was they just stopped spending* (CI_05); and: *My theory is that lobster prices seemed to start to downturn about the time of 9/11 and it never seemed to be able* *to completely recover from that* (UB_02). Other fishermen noted: *Lobster catches have maintained over the last decade; but lobster prices have decreased after 9/11* (CI_02 & CI_03).

<u>Herring fishery</u>

Commenting on the impact of the herring fishery decline, one fisherman thought that overall: *Things have not changed too much [because] lobster balances out the herring. Used to be about 20-30 purse seiners in the past, and that was mainly locally owned, but the main change has been the increase in fuel prices* (CI_07). Given the current situation, one participant thought it not worth fishing herring anymore: *No money running herring now* (DI_03). On a more positive note, one fisherman thought that the herring prices had gone up a little: *The herring have gone up, I believe a little bit, not a lot, really, but that's changed* (DI_04).

With the decline of herring came the reduction in processing plants: *We used to have a sardine plant down in Wilson's Beach, and they closed that 20 years ago. It employed a lot of the women, and they just said it wasn't economically viable anymore and that affected a lot of families who got by on that plant* (CI_04). The same participant also described situations where large companies bought out smaller plants: *There was sardine factories all along on the coast and on the shore here and then of course Connors Brothers come through and they bought out everybody, and they operated until they had their cycle* (CI_04).

Employment flexibility

Others mentioned that in the past people were able to move around doing different jobs throughout the year, which has now changed: *Yes, there is not as much year-round work as it was when I was 10 years old. Everything was booming then, but as you get older, 30 years, a lot of stuff seems to change so [it is not possible to do this anymore]* (DI_02). A similar comment was made by another participant who said: *Small industries [which have allowed people to take on different contracts] have passed. One time you could drive out this road from the airport and you could look into that guy's dooryard – there'd be a truck sitting there, a gravel truck, pulp truck you know and you would just go up maybe past two or three more houses, there'd be another pulp truck or a gravel truck, every other dooryard there was a pulp truck or a gravel truck, they're all gone, just couldn't compete with the bigger companies* (DI_10).

During the heyday of the herring and groundfish fisheries, processing plants around the Bay provided work for both men and women in the community: *Now, I know a lot of the men years ago will be working and they are fishing probably in the weirs or fishing lobster and their wives would probably work in the sardine cannery* (DI_04). With the closure of these plants, and relocation of other facilities, this made it harder for Island people to continue to work/remain in the industry: *The cannery has gone [to] over there [to Black's Harbour]. And the women that used to work there, when they moved all that operation to Blacks Harbor, for the first few years there would be a number of women would still work there but it is just phased out now. I think there is only about two or three from the island go there and they have got to travel in the ferry with the young kids and all* (DI_04). Two people are now needed to bring an income into the home, with more choosing work outside of the fishery sector: *Most income in the past came from one person; now two people are supporting the family, and unlike in the past the second job is more likely to be outside the fishery* (UB_06).

6.5.2 Coping with economic changes

This section presents examples of participant's responses to coping with economic changes. Dealing with increasing fuel prices and other expenses, many participants provided examples of where people they knew fished harder and or differently. Others become more creative and experimented with different approaches to reduce costs, and/or tried to anticipate the market. If participants were able to get their licences from other family members this helped them to cope with the high cost of getting in to the fishery. For those that were not able to get into the fishery and/or the start-up costs were too high, they moved to other industries, including other fisheries, aquaculture and/or tourism. The seasonal nature of some of these occupations allowed them to relocate to where the opportunities were, while remaining in their community. As noted in other sections, a few participants believed that they just needed to deal with economic changes as part of life: *You need to play with the cards that you are dealt with. For example, [I] will haul in all the traps in one trip (fall) to reduce fuel* (UB_03); or: *You got no control over that, I just take it as it comes you know, but I do try and put something aside for weaker years, if you have a good year I'm going to put a little bit away. I have seen people coming into fishing and have a good year and the next year they were out of there, right, so, you want to try to save some, because there isn't going to be a lot sometimes, and I think that's the biggest thing, you know how to* *pinch your pennies* (DI_04). Another fisherman related his experience as being a matter of practise: *If you wanna make a living at it, you can make a living. When I first started into the fisheries I remember my young fellow and I went fishing the first time with the gear, [and] he come up with four scallops and they were flipped out, but I said, 'oh we'll get better at it you know', and we did* (DI_10).

Fishing harder and/or differently

To pay for new and additional electronics, gear and boats, fishermen tended to fish harder: *When the lobster fishery started people were hauling by hand, made some money then went and bought bigger boats. Now we have to fish more and all year around to be able to pay for those big boats; big investments need a lot of product*. (UB_06). Another participant also noted: *People invest in their gear now because there are bigger boats, but [you] also need to fish harder to break even* (CI_07).

According to one participant, within the herring industry (weir and seine), doing something differently allowed her father to cope with fluctuations in the stock: *I can remember my dad having his sixty-one-foot herring carrier and he used to chase the seines. And of course our local economy was all about the weirs, so when they'd have a bad year and the seiners would catch fish, my dad would be successful. [In some ways] it was terrible because you could see like everybody around was struggling and dad because he was doing something a little bit different was succeeding, but that was in the early seventies* (DI_05).

Experimenting and being creative

Not all expenses have continued to increase: *Electronics prices have come down. You can buy the best GPS going now for $1700 or $1800 but about 10 years ago this would have been about 4 grand* (CI_01). In coping with other expenses, fishermen needed to become very creative: *You know people are very innovative; they find way to cut costs, you know as best they can* (UB_01). Another approach was to establish a sideline, fisheries-related business: *Traps are about $100.00 a piece now at most places, which is why I have a trap shop, and build my own, for $48.00 - $49 apiece. Some I sell, for 75.00 and make 25.00 profits. Small companies do not have too much overhead compared to larger companies and this helps them cope with economic changes*

(CI_02 & CI_03). One fisherman set up his own retail business with his wife as a co-partner: *What we're doing, we have our own retail shop in my own town, so I sell more of my own lobster, and when the price is low, we don't have to sell them to the buyers, we can keep it as the price goes up at the end of June and then in fall like before Christmas time, so, if you're going to hold on for a year or so, you get a better price* (UB_09). There are also some small-scale fisheries related business that were surviving but could benefit from more provincial support: *Steen Newman boat building has potential job [growth] opportunities. H.W Welch employs about 100 people, and Jackson's about 12 people who work with salted and dried products* (CI_01).

Being able to anticipate the market prices was also another means of coping: *You need to look at local markets and try things that you have not done before* (UB_06). Adding to this discussion, another fisherman said: *Well, my strategy is [to] kind of fish smarter and to not fish if the catch isn't great, burn less fuel, shop around, bargain on traps or whatever, and also find a buyer who is willing to pay more* (UB_07). Similarly, another fisherman said: *I used to long line first of May. I would haul traps all day, and then fish [longline]. But I can't go lobster fishing in a halibut geared boat, so if I want to go halibut fishing I need to come in and unload, and then reload for lobster fishing tomorrow. And if I have only got 150 pounds of fish, say $800, $900, I give $116 for monitoring. So there is not a lot of profit there. So now I wait until I get done lobster fishing in July and August and September [then] I go at it hard for halibut* (CI_01).

Start-up costs

To cope with the high cost to enter the fishery, family members would pass over their licences or sell to other members: *I mean now likely my young fellow will be taking my license and pretty well everybody that fishes here is [doing it] that way; it's kind of a family affair thing* (UB_03). Some fishermen also held dual citizenship: *A lot of people have dual citizenship, so they work in the US* (CI_06). Fishing multiple species allows some to pay debts off as soon as possible: *When my dad got a new boat, he fished hard to be able to pay for it then, and always had several fisheries to make money from. He went fishing for scallops when other species were getting less in numbers* (UB_06).

Shifting employment to other fisheries and industries

People also got involved with other fisheries: *After the collapse of the ground fishery, fishermen now fish other species such as sea urchin fishery, sea cucumber, shrimp, and rock and Jonah crabs* (CI_07). One fisherman said that others in his area had been doing sea cucumbers: *Yeah, they've been doing it probably about 10 years; there are two boats fishing them using a drag* (CI_01). Shrimp is another alternative fishery: *There has been some people got into the shrimping, over here, it's been a set thing on the America side for a long time, but a couple of guys get into it and the first year, they did really well, but this winter there weren't any shrimp -- they're cyclical too* (CI_04). Other participants said: *People make their living from periwinkles, probably eight people doing this fishery, but this is better than being on welfare, shocking scallops and baiting hooks (long lines), more people [were] doing this in the past, but not so much now* (CI_02 & CI_03)

<u>Employment within the fisheries</u>

Mainland fishermen were often able to supplement their livelihoods with other types of industry jobs, whereas people from the islands mainly moved to different fisheries in their area. For example, a participant from Upper Bay remembers that people were able to work in Saint John when they were not fishing: *Lot of people in St. Martin's worked at the Saint John dry dock and a lot of people around here did and it employed something like three hundred to five hundred people, and they were big paying jobs…my father worked at the dry dock, and once that shut down around 1985 that was it* (DI_10). Another participant noted that: *Although the dry docks was replaced with a gypsum company, and then Irving started building something there, it's not the same, and does not employ as many people*. Another Upper Bay fishermen commented: *Point Lepreau nuclear generating station has being the biggest change in the Dipper harbor community* (UB_05).

<u>Employment within the aquaculture industry</u>

Moving into the aquaculture industry was also seen as another form of coping, either to help supplement income between fishing seasons or because of the groundfish fishery collapse, as government subsidies were being provided to establish other economic ventures: *With the loss of groundfish, some crew prefer to work on aquaculture sites* (CI_07); and: *Yeah, it seems to me that there were a lot of opportunities for people to go into the aquaculture business. It [received* *a] lot of government funding, so obviously a lot of people want to jump on the bandwagon, and you know there were a lot of businesses that were up and running and appearing to be successful for the first decade, but failed because of bills and not being able to control these* (UB_02). The construction industry was also another option: *There are a lot of people in construction now in trades and stuff like thats where the money is at right now. Having to make a big investment in the fishing to start it takes a long time to get it back* (UB_07).

<u>Tourism industry</u>

Venturing into the tourism industry was another form of economic coping, especially for island communities: *I have seen people who tried to have the tourism here, but the season is so short here, your season is like almost in July until August or 1st September and after that the weather starts to deteriorate a little bit and I think that's your big main thing for the tourists, the season is too short and the weather can really put a damper on things* (DI_04). Another participant described community associations that had been established to explore the potential for tourism: *Actually, there is tourism, and they call themselves the Campobello Tourism Association, and they are trying to explore some eco-tourism ventures and to get more people to come and spend more than an afternoon, but the fog is a problem that prevents more people coming here during the tour season* (CI_04).

Taking a different approach, one participant thought: *Tourism in my idea is a double edged sword. I've seen people living around Mount Zurich and they can't wait for Labor Day because they get their town back. You know they get overwhelmed with tourism in the winter, so, I mean yeah it would be great, and it would be an economic boon for select few but I don't know, unless you were directly involved with whale watching or spin offs from the restaurants, it would just be a pain in the neck to deal with all the tourists* (CI_04).

6.6 Technological changes and coping strategies

6.6.1 Technological changes

The most frequently mentioned technological changes related to: (a) fishing gear, boats and navigational electronics, and (b) reporting and monitoring procedures. With these technological advancements, skill sets that defined a fisherman were also changing. For example, one fisherman noted the shift in fishing skills gained from knowing your landmarks, currents, and sea experience to an increasing focus on technological capabilities: *You can get pictures of the bottom and so you can send almost a kid out fishing with a computer and he will know the bottom and the ledges and everything because it's all marked on the plotters. When I started you did know what was beneath you, if you had a fathometer but didn't know when a ledge is going to fall apart 50 feet ahead of you, but now you know where you are every second* (DI_03).

Fishing gear, boats, and navigational electronics

Technological changes described by the participants related mainly to fishing gear, boats, and electronics. For example, describing the change in electronics, one participant described how when he first started fishing he used a watch and compass: *Oh, tremendous changes [in] the ability to find the fish. Once you find them, you can catch them and the methods used are more geared at producing. When I first started we had the watch and the compass and you didn't know what the hell the bottom looked like. You knew it was down there somewhere but now with these new plotters, they can get it in 3D* (UB_01). Similarly, another fisherman said: *I can remember going with my grandfather and my uncle and we would go from here to Nova Scotia or here to Portland, Maine and he had a wrist watch and a compass* (CI_04). Whereas, another fisherman spoke about using landmarks to find traps: *With the plotters and GPS, [it] makes it easier to find your traps. Before we had to go by land marks, or by your radar, to try to figure how far offshore you were* (UB_09). Expanding on electronics, other fishermen discussed the improvements such as: *3D bottom mapping capabilities* (CI_06); *Plotters, yep they're getting a lot more sophisticated* (DI_01); and: *The GPS technology has grown in leaps and bounds places where you didn't think you could go to fish, we found it was really good place to fish because of the technology* (CI_04).

Describing boat and fishing gear changes, one participant noted the change from: *wooden boats to fiberglass, made them longer lasting* (UB_03). Shifting from gas engines to diesel was another major change. For example: *Gas engines, everyone had them then as more diesel engines come, there is less chance of an explosion, and gas was so explosive, so the diesel engine was a great improvement* (DI_03). Other changes also included the size of boats: *In the past, boat size was a*

45 by 18ft wooden boat was the largest, now this is only a medium size boat, most are above 50ft (CI_02 & CI_03).

Others mentioned changes in the rope, hauling system and twine used for bait bags: *The rope is good, it comes from Portugal, and the haulers are good*. Y*ears ago we didn't even have a hydraulic trap hauler. And the twine is tremendous good. Years ago we'd knit our own nets, and they would not last as long* (DI_03). Similarly, with the traps, another participant noted that: *In the past they were wooden, now [they are] wire, which will be 10 or 12 years old, and are such an improvement* (DI_03); and: *Lobster traps are lot better with wire than what they were like 20 years ago. They just started using them basically in the mid-90s, that's when people started switching over from the groundfish fishery a little over 15, 16 years ago* (UB_09).

Monitoring and reporting procedures

An important change was the way that fishermen used electronics for reporting/hail ins. For example, describing this change, one fisherman said: *There's a difference in your reporting technology. When I first started in this fishery, a lot of people used the VHF (radio telephone) to report in/call in, which was their main form communication on the water. Now its cell phones and computers, and you know there are some they like to change our reporting method to include people texting us and sending us e-mails to hail in, rather than calling on the phones* (DI_08). Others noted that future electronic trends would be: *The way you log your catches and share that sort of information or manage your fishery* (DI_02).

Other changes in electronics related to sea safety, and monitoring and reporting. Discussing sea safety, one fisherman noted that the government was a key driver for this change: *The government is big, big into that. If they weren't I don't think it would probably get done, but they are getting pretty heavy onto all the safety factors and the boats and even for insurance purposes you got to have so much stuff* (DI_02). Other participants thought that the electronics gear required for safety also increased the ability of agencies to monitor them: *Automatic Identification Systems (AIS) so that they know where the ships are* (CI_06); and: *VMS*[60] *on board scalloping boats since 96/97, was a reaction by government on new technology* (UB_03).

[60] Vessel Monitoring System

Similar comments also included: *VMS monitoring has come a long way, and these black boxes are able to track people where they are fishing to make sure that they are not fishing out of their area* (CI_02 & CI_03).

Information accessibility

With the availability of the internet and younger fishermen preference for computers and smart phones, information about markets and other international and national news is now very accessible. For example: *[One change is] fishermen being able to access information on the internet, that type of thing. I remember years ago when my husband would sell lobsters; he would come into the buying station and he'd sell them and the buyer would tell him what he's paying probably a few days later. Now when the fishermen come to the wharf, they want to know what they're being paid and they expect you to know because they could click a button and see what the market is in Boston and they just assume that's what the real market is, which is not always the case* (DI_05). Conversely, real-time information could also create a false sense of hope as what the fishermen is asking for may not be within the means of the buyer: *Accessible market price information hasn't been a positive thing for the buyers, right for the fishermen, yes but I think it gives them a false sense of security* (DI_05).

Industry automation

Participants also observed technological changes in processing plants and the aquaculture industry: *Plants are now more automated, such as Connors [is] all automated; one of the large salmon plants [is] to become automated* (CI_02 & CI_03). The approach towards advanced technology also affected small scale processers/buyers. *Smaller plants will be all hands on, and while the equipment is out there it is quite expensive as it's made for large commercials* (CI_02 & CI_03).

In describing technological changes in the aquaculture industry, participants noted: *Feed blowers now vs hand feed in the past, previously the level of feed was herring/mackerel and now fishmeal/oil pellets, and everything (production and presentation) is done by machines, like Ocean Legacy's first plant* (CI_02 & CI_03). Another participant also noted that: *In its hayday it employed a lot of people, but then they went to more mechanized, feeding and* *handling/slaughtering the fish and the more mechanization things get into, less labor is needed, so people lose their jobs* (CI_04).

6.6.2 Coping with technology changes

The most important approaches for coping with technology changes included learning from experience and adapting fishing practices.

Learning from experience

Participants noted that their main form of coping with technology changes was learning from experience. For example, one participant said: *Wire traps were just a better design, over time people figured a whole lot better ways of making lobster traps and everyone used to have their own design* (UB_09). Expanding further, this participant added: *People just try doing designs to see which work, and information gets kind of spread around, and everybody is using mainly the same kind of traps over here and those who made the best ones could sell more* (UB_09).

Adapting fishing practices

Better navigation and fishing equipment also meant that fishermen changed their approach to fishing. For example: *Better quality traps in the last 10 years, but this also requires people to change their approach, as everybody fishes differently, rigs traps to their liking* (CI_06). Hence fishermen adapted and became creative to make the most of their new gear.

6.7 Management changes and coping strategies

6.7.1 Management changes

The most frequently mentioned management changes related to: (a) DFO reporting procedures including data collection and monitoring, and (b) Transport Canada regulations. Two other topics that generated interest was a general consensus among the participants of government's apparent lack of interest in inshore fisheries and Core vs Non-core status.

Drawing from the lessons and experiences learned from the collapse of the groundfish fishery, and the relationship between industrialised corporations and government, fishermen perceived an apparent bias on the part of federal and provincial agencies towards supporting large corporations (e.g. aquaculture industry) over inshore fisheries: *The fishery is not seen as a growth industry, and with the collapse of the groundfishery in Newfoundland, the government is no longer interested and wanting to care anymore, and corporations will step up and run the ocean resources as a profit. A good example is the growth and support for aquaculture in our area* (UB_06). It also appeared that government agencies have engaged more private vendors to do the work that they previously did: *At one time, all that information, which was required to be collected was all done by someone in the agency but, the government put it onto the private industry, which, just makes for more cost expenses. Before it used to be a government cost but now it's moved to private* (UB_02).

Another fisherman spoke about the core vs non-core fishery status, and the impact it has had on fisheries like herring weirs. *When the core fishery policy*[61] *went in (by DFO) I think that adversely affected things. I've been in fishing all my life, but I'm not considered a fisherman because I'm not a core status license holder although it brings in a lot of jobs and supports the economy. Not only that, if a weir totally gets destroyed it could cause $60,000 or $70,000 to replace all the gear, the stakes, pine, the L boards if you happen to lose one, so, we have as much money invested, but we're not considered core fishery although a 100,000 fathom shut off will cost you around $12,000, so if you lose 300,000 shut off you've lost yourself some money right* (CI_04). Explaining further, this fisherman said: *The core fishery it's sort of like an entitlement program for people that already had their foot in the door. So, a license that used to cost you $50 when it has the core status on it will now cost you $25,000. In order for me to get into fisheries other than the fisheries I'm in, I'd have to buy someone that had a core status, but just that core status alone is worth as much as $20,000 just to have the permission to go buy another license that could cost you $200,000 for like say a lobster license or scallop fishery* (CI_04).

[61] Core status is assigned to enterprises headed by individual fish harvesters who, in 1996, held key licences, had an attachment to the fishery, and who were dependent on the fishery. Core status is available to a limited number of enterprises (https://www.dfo-mpo.gc.ca/reports-rapports/regs/licences-permis/nfld-Labrador-tn-labrador-eng.htm).

DFO reporting procedures

Reporting procedures required by DFO have changed, both in the quantity of information being collected and form/approach used (e.g. paper/people to electronic). For example, one fisherman said: *Yeah, there is more paperwork to it and I don't know there was lot of books and stuff like that and dock side monitor like scallops and ground fish. When I first started it was getting your license and [then] I went fishing, it was a lot less stressful [then]* (UB_07). Another change was the log books, which some participants thought were implemented to ensure that correct taxes were reported: *They reported the logs and I'll be honest I thought that was a farce because people used to juggle [them] because of EI, so there was lots of income tax. Then [people] didn't want to report everything they made, and I think that is one of the reasons when they started to do log books because of that history* (DI_05).

Data collection and monitoring

Management data collection and monitoring processes have also moved towards electronic platforms and call centers, as opposed to having a local person on site and collecting data using paper hard copies: *They've got so much of that and on computer and on paper, it looks like it's the obvious way to control sustainability but, I just don't think it's working the way the people that have designed it had hoped. You have to remember that at one time there was none of that. I mean, you wrote out a slip and, you paid the people right here at wharf side, and the slip to record it and sent to the [government] at the end of the year* (UB_02). Being a buyer/processer, this participant also focused on some of the issues that he was dealing with due to this new reporting process: *It entrenches a lot of not only our company time but, even the bigger companies and takes up so much time, and we still don't know if we are becoming more sustainable* (UB_02).

Commenting on personal connections between fishermen and DFO, one fisherman said: *When I started, these fisheries officers would come down to the beach the day before lobster season, I give him twenty-five cents, he'd write me out a lobster license and I'd go fishing. I think limited entry fisheries started in '68, so this would've been like '67, '66* (UB_11). Another example was observed in the scallop fishery: *With the hail-ins and the hail-outs, when we first started we had a woman on Deer Island who looked after it. But [DFO] said that wasn't good enough and they* *shifted it to a call center, where people have no idea about the fishery or where St Martin's is, and you get on that phone and most often you get an answering service, and sometimes you have to start all over again, it is very frustrating* (DI_10). Expanding further, this participant also noted that: *There was nothing wrong with that system but they had to change it and they never consulted the fishermen, face to face, and the first thing you got this here card in the mail about a year before that to call this number once in a while to see what you thought about it and just more headaches, so [it was] replacing people with machines basically, and it didn't make the process easier for the fishermen*.

<u>Black boxes</u>

A significant management change in the scallop fishery was the introduction of black boxes: *This is a new regulation that changed on September 1st, 2011. Black boxes are used for scallop and ground fish, and sea cucumbers. Jamie has to have one sea cumbering, and all the seiners have to have them, anything that's got dock side observing and I have not figured out why we need a black box to long-line. And I went to all these ground fish meetings in Halifax, and the black box is so that they can see that you are not fishing outside your zone or in closed areas*. Explaining further, this participant said: *So, you know how we have the summer closure on the scallops, right so that they can see where the scallopers are at, well you know how far I need to get out of my zone, it's the other side of Halifax, 4X, so why do I need one as I don't carry enough fuel to go that far. I've got my ankle bracelet onboard the boat [sarcasm]* (CI_01). In addition, this participant was concerned about the additional costs for monitoring equipment: *This was about 1800 bucks, and $80 a week to have it turn it on, $116 a week to take the fish out (whenever I need to unload a dock side monitor comes check the fish) that's if I only take my fish out once a week and I don't always want to clear it then*.

Transport Canada regulations

Changes were also noted in Transport Canada's regulations, with many of the changes dealing with sea safety: *Transport Canada is putting on the regulations. Well, the sea hasn't changed. The boats have gotten a little bigger I suppose, but you're still doing the same thing with the same gear and they feel that we need to be regulated and that we need courses* (DI_01). Conversely, another fisherman said: *Radio courses and safety courses, yeah, it's just to keep you* *alive on the water, there have been a few issues with people, and stuff happening at sea and people don't really know what to do* (DI_02). Expanding further, this participant described additional factors that could create issues when trying to take the course: *My wife was due to take the Marine Emergency Duties (MED) course next week, but they cancelled it because there wasn't enough people to take [it] here, and you got to have MED to be even on the stern of the boat, and this is a new thing that has come in and it's all to do with safety I guess* (DI_02).

Another management change was the requirement to go back to school to upskill or get new certificates for boat handling. For example, one participant noted: *Another thing that come in too that really hurt us was when Transport Canada split the fleet well tonnage-wise. Now I can't go over fifteen ton and some of the boats are over fifteen ton so if I wanted to buy their boat, I'd have to go back to school to be qualified to run that boat even if it is only two feet longer than mine. I think that is what is hindering a lot of the young fellows coming in; they'd have to go back to school so they could run a boat no matter if they fished all their life, and if they don't have time they would not be able to fish. I took the radio course this winter and what's coming in the future scares me* (DI_10).

6.7.2 Coping with management changes

This section presents examples of approaches that participants used/suggested were ways for coping with overall management changes. The most frequently mentioned approaches were: (a) establishing /engaging with community-based fisheries management, (b) fishermen's associations and organisations that provided them with a means to have a voice at the decision table, (c) involvement in projects that focused on the research needs of the community/fishermen, and (d) new or enhanced private and public support.

Community based fisheries management

Fisheries management by the community was discussed as a form of coping with management changes, but there was some doubt about the sincerity of the government to support such initiatives. For example, one participant said: *There are opportunities for community management to happen and to be able to work with the regulating bodies, but in my experience, you keep on trying but don't [be] surprised that it is really gonna be a hard job to accomplish*

(UB_01). Whereas another participant noted: *Well I mean there is a concept of more a community based fishery going way back, but the concept is still [being] looked at today. Perhaps it would be a help but in order to get back to community based fishery it would mean that you would almost have to have individual markets and harvesters, in individual areas that would be willing to cooperate with one another from the harvest right to the end result, which is the consumer* (UB_02). Similar to the first participant there was still some doubt on how well community management might succeed: *Whether that's possible, that's easier said than done. But I believe that aspect is certainly being looked at and you know, sought after because I think people realize that a lot of the failure lies within the government red tape and the expenses of shipping product all over the world* (UB_02).

Fisherman associations and community organisations

The closest that fishermen could get to community management was to join fishermen associations: *Fishermen need to organize their industry so that they know what they want* (UB_06). For example: *Fundy North Fishermen's association has helped us keep what we have from Grand Manan* (CI_01); and: *Through our association FNFA and everything I see that it flows things down, some changes coming but if we didn't have an association, we'd just be dumped on. To be together as a group you have more bargaining power than an individual* (UB_07).

Other fishermen/community based associations were the Fundy Weir Association, and Saint John Commercial Salmon Fishermen's Association. One fisherman said: *I belong to different associations. We started the Fundy Weir Association, and then after that was Fundy North, then we had Saint John Commercial Salmon Fishermen's Association, which was involved with the Eastern Fishermen's Federation, and was good because it was a forum for bringing the different fishermen's organizations together to discuss, you know problems of similar concern and in the Maritimes and Quebec when we first started off. But it's running out of money now* (UB_01).

The SWNB groundfish management board was also mentioned by one participant but there were doubts about this initiative: *We got the SWNB groundfish management board to work, and I was a founding member of it in 1993/1994. But we've got very little favor to work with them, I mean* *we do the best we can with what we did, but it's the poor way to do fishing. The board has kept what little we have for the groundfish, but don't have anything for lobster, so it would be good if this was something that could be looked into and ways to enforce rules that are there* (CI_01)

Through these associations, good fishing practices were initiated: *Examples include the increase in minimum size and traps that have escape vents, these ideas have come from fishermen* (CI_01). Reflected on how the fishermen had taken the initiative to protect their fishery, another fisherman described: *We have good conservation measures for lobsters. We have a minimum size and there's a lot of things fishermen do themselves that really DFO probably don't even hear or tell of. Like we [put] this v-notch in the lobster [tail] for females and [when they see it] they put [the lobster] back overboard* (UB_01). Comparing the lobster fishery in their area with different localities, other participants said: *Maine and Nove Scotia have hefty fishing, between 375 and 800 traps, whereas here you have about 100 -300 traps, which is more conservation minded* (CI_02 & CI_03).

Community focused research

The opportunity to take part in research projects or initiate topics of interest was one approach to dealing with management not wanting to share information. For example: *Community projects like what the Fundy North did with the scallop enhancement project, I was involved in collecting spat, but the project did not go far, and it would be good to take this further* (UB_03). Expanding further, this participant noted that: *It would be best to encourage people to take the initiative, but they needed the right attitude to reap the benefits (UB_03)*. Another fisherman said: *There are probably topics for research but it's the younger people who would have better ideas. I'm on my way out of the fishery, I'll do it as long as I enjoy it, but when I stop [enjoying], I will stop fishing* (CI_01).

Public and private support

A few participants mentioned the financial support they received from government, specifically Transport Canada to be able to take these courses: *Transport Canada is assisting when they do make a mandatory change, they will give you financial assistance* (UB_05); and: *In some of the* *courses I just took, the government paid for half, because it was a mandatory course for my occupation* (DI_02).

Looking for resources outside the community/associations was also a means of coping. For example, in the context of pesticides from salmon farms, these participants mentioned: *We had lab contacts where we could send the lobsters off to be tested, and I just kept up with my contact at the federal environment and anything that goes around I send an email or call them* (CI_02 & CI_03).

6.8 Summary

Key environmental changes since 1990 included shifts in: (a) weather & other environmental factors, (b) species abundance and composition, and (d) marine and land based pollution. Coping with these changes, included adapting fishing practices, leaving the specific fishery altogether, or moving to another fishery and/or non-fishery related industry. Participants noted the improvement in land based pollution regulations, and that fishermen were taking more ownership of their litter and waste oil. Fishermen also thought that there were industry and government regulations and plans in place in the event of an oil spill, and that they would receive compensation if such a situation was to affect them.

The most important social changes related to: (a) community composition (increase in age, decrease in population, and new comers to the fishery), (b) factors affecting the family fishing tradition, (c) growth in the aquaculture industry, and (d) community cooperation and attitudes. Addressing these changes might require a change in community identity and structure, being friendlier and getting to know new comers through social events, selling fishing licences to people outside the community, fishing in different areas, and being supportive of the Island/community identity (and that it might need to change).

Significant economic changes included: (a) increasing cost of fuel and other expenses, (b) fluctuating Canadian dollar and market prices, and (c) reduced flexibility in fishery related work. Coping with these changes required, fishing harder and/or differently, inheriting or getting a licence at a reduced cost from another family member, having dual citizenship (with the US) and fishing multiple species (similar to what they have always done). Other strategies included experimentation and being creative by establishing side businesses, anticipating the markets, or venturing into new fisheries.

Technology changes included: (a) improved navigational and fish-finding electronics, fishing gear and boats, (b) reporting and monitoring procedures, (c) information accessibility, and (d) industry automation. Responding to these changes, fishermen learned from experience and shared the information with other fishermen/community members. Participants also adapted safer fishing practices and took on board additional government required monitoring equipment (e.g. black boxes in the scallop fishery) and other VMS devices. Through computers and smart phones, market prices were also more accessible and in real-time, which helped to strengthen a fishermen's barging power with buyers. The increase in industry automation helped industry by cutting labor costs, but potentially reduced the number of jobs available, and made it harder for small businesses to find/adapt equipment tailored for bigger processing plants.

The most important management changes were those relating to: (a) DFO reporting procedures (quantity and format) and (b) Transport Canada regulations. Participants discussed the amount of data that was being collected, and how it was being done (e.g. paper to electronics, people to call centres). A few participants noted that government was more attentive to the core fisheries (e.g. lobster) compared to a non-core fishery (e.g. herring weirs). In the context of Transport Canada, respondents described seeing an increase in sea-safety regulations, and a requirement for upskilling/recertification. Coping with these changes, participants provided examples of community based management initiatives, usually done in collaboration with fishermen associations and community organisations, to help address information gaps. Having access to external resources such as testing laboratories, being in close communication with key government agencies (e.g. Environment Canada) and being subsidised to take required skills courses were also ways to respond to management changes.

Chapter 7: Environmental, social, economic, technology and management threats and opportunities

7.1 Introduction

The purpose of this chapter is to present participant's responses to questions relating to opportunities and threats in the context of the five domains (environment, social, economic, technology, and management. The chapter begins by discussing environmental threats and opportunities, followed by social, economic, technology and management responses.

7.2 Environmental threats and opportunities

7.2.1 Environmental threats

This section is divided into two parts. The first part presents examples of environmental threats to fishermen, followed by threats to the environment from human activities. The most frequently mentioned environmental threats to fishermen in general, but also impacts on lobster and scallop fisheries were changes in seasonal weather patterns and warming waters. Increasing seal populations was also considered a threat from their predation on herring and as nuisance in the lobster fishery. Threats to the environment from human activities included: (a) the legacy of past fishing practices, management approaches, and mindsets; (b) current destructive fishing practices and new technologies; (c) the aquaculture industry; (d) LNG/gas industry; and (e) general marine pollution.

Seasonal weather and environmental changes

Changes in weather patterns and temperatures were of concern to the fishermen: *Weather plays a big factor and limits fishing days and shorter season* (CI_06). Participants were also very aware of global warming issues and the impact that it could have on their fisheries. For example: *New York, Long Island water temperature is increasing by a couple of degrees according to an article, this would have to raise 13 degrees in the Bay of Fundy, but even 2 degrees can affect several species* (UB_06). Whereas, another participant mentioned: *They talk about global warming, but we are not seeing the water temperature, there is more wind and such* (CI_02 & CI_03).

Responses also reflected the safety aspect of fishing such as travelling to fishing sites in changing weather conditions. For example, this participant observed: *Like in the wintertime up here with my boat, I gotta be cautious you know in the wintertime and a lot of times I have to leave some of the bigger boats, they can stay and fish you know and you got fifty-foot, sixty-five footers fishing there; they can stand it quite it a lot* (DI_10). Another participant noted that there was: *Way more weather now than before, more rain and wind in spring and fall, especially the spring, the fish traps in Saint John and takes about 4-5 hours to get there, weather restricts fishing* (CI_02 & CI_03).

Participants also noted that expenses increased with seasonal changes. For example, this respondent noted: *It used to be years ago that you could set out the first of April or the middle of April and make enough to at least pay for your fuel, okay so you'd set them out so that they were there, fish them twice a week until they picked up, we set the second Tuesday of November in the fall, well if we've had fairly cold weather, they've already crawled off so the inshore fishery just picks up what stragglers are left*, *[and if we were to go further we would increase our fuel cost*s*]* (DI_01).

<u>Lobster fishery</u>

Many of the comments related to environmental impacts on lobster migrations patterns and prime fishing locations. For example this fisherman said: *Changes in water temperature affects lobsters more than anything and with the increase in storms this will also affect their migrations and restrict fishing days for the fishermen* (CI_07). Similarly, another fisherman asked: *What happens when the lobsters change the migration pattern, I mean lobster migration patterns have changed, whether it is global warming, I don't know, but things are different, inshore fishery is a lot different in the fall than once it was and in the spring, I think earlier. The lobsters are the same but come later in the fall* (UB_05).

Other examples mentioned by participants included: *Slower fishing in the spring time for lobster, but not much difference for scallops whether the waters are warmer* (CI_04) and reflecting on size: *They're bigger offshore than what they are inshore usually* (DI_01). Conversely, this fishermen also suggested that: *Even though the water has warmed up faster, the lobsters still do* *what they do, they come at a certain point, we start trapping them at a certain time and they still act the same as they did years ago* (UB_07). Yet this participant wondered if changes in lobster migrations patterns could also be related to pollution from the aquaculture industry: *Well I don't know too much about that stuff, but we have noticed, and I fish few traps like inshore close, which we always all did and in the last couple of years I don't know it just seems like there is the lobsters don't seem to come there for some reason. I don't know it's got anything to do with the salmon cages and dumping stuff in the water, but now we have to go offshore, so I was thinking something is changing* (UB_03).

Warming sea level temperatures also affected the health and quality (value) of the lobster as noted by this fisherman: W*armer temperatures, and with that will come poor quality of the lobster, as it's my understanding that they don't harden up as well* (DI_05). Another participant mentioned the impact of ocean acidification: *Ocean acidity is also an issue as this could maybe causing the soft shell we see in lobsters now* (UB_06).Other participants thought that soft/thin shells were a result of chemicals that were being used to treat framed salmon: *Lobster we noticed more shell disease this spring, oh, really, really thin. Well, I don't know [but I think] it's through the chemicals that they are treating these salmon with* (DI_03).

A couple of the participants observed that warmer waters might also impact the type of lobster that could be caught: *Right now our seasons ends the 29th of June, and we always miss the soft-shell lobsters and shedder lobsters which are really cheap. Like last summer, I think they were about 2.00 per pound, and they catch them in Maine, because they can fish all summer, but if global warming continues as they say it does, then maybe one day we will also catch shedders, and that is definitely going to have an impact on our economy* (CI_02 & CI_03).

Looking to the future, the biggest threat that fishermen perceived was the potential collapse of the lobster fishery. For example, this participant was concerned that: *The biggest threat would be if the lobster would start having a downturn* (DI_04). Another fishermen referred to an American biologist who had said: *They have been talking [of] a big crash in the lobster fishery, but we haven't seen it yet, yes, that's reports yeah and they keep saying that so it is very worrying* (CI_04). This would have a significant impact on fishermen's livelihoods, as many in the Islands and Upper

Bay relied 100% on this fishery: *Well, I think really myself the lobsters are at a peak right now, but they have almost [and] you would think they have got to be a downturn sometime. I can remember when I was younger, starting out, you would get a good year and you might have a bad run or two or three bad runs and a good run up and down. In these last eight or ten years, seems like it has been on a good run* (DI_04).

Scallop fishery

One concern related to shifting weather and environmental patterns was the quality of the scallops. For example, this participant noted: *I'm not fishing this year but the ones that I talked to said the scallops are not as good as they were last year far as quality-wise, finding a lot smaller scallop this year and watery scallops and usually you don't get watery scallops 'til July and August cos that's when they're starting to grow in their spine this winter they seem to just look like they do in July. They shouldn't be, as this time of year they should be nice and firm, and well they're saying it could be water temperature but they don't know* (DI_10).

Some fishermen had concerns about the future scallop stock in certain areas: *No more small seed in Friars Bay anymore* (CI_06). This fishermen also said: *For some reason scallops seemed to be able to sustain in certain places, they'll sustain their size because of the control of how people fish them, see, the price controls the fishing because the smaller the scallops, they will get less money, but more effort so less profit fishing. I'm guessing maybe that's how they've been able to sustain their size because they leave the small ones, they get a chance and they'll go back to them two seasons later then they grow, right* (UB_02).

Seal populations

As noted earlier, the decrease in the cod fishery, although potentially leading to an increase in lobster, was also thought to have influenced the expansion of the seal populations: *We have seal problems now, they would bite bait out of the traps, and a few would get stuck in traps and drown* (UB_03). Similarly in the herring fishery, this fisherman said: *Seals are opportunistic feeders, so would chase the herring, whereas in the past there was a bounty and people shot them but now with tourism here at the times, people didn't care much for that sort of practice* *now, and there is no bounty* (CI_01). Whereas, another participant said: *Some people blame the rockweed harvest because they say that it served as a breeding ground for the herring* (DI_08).

Threats to the environment from fishermen and industries

<u>Legacy of past fishing practices, management approaches, and mindsets</u>

The mindset of fishermen (many who considered natural resources as being unlimited), and poor management influenced past fishing practices, which in turn led to the collapse/decrease of stocks and habitat degradation in this area. For example, this participant said: *Everybody fished as hard as they could, and it makes you sick in your stomach when you think of what we did. I mean for every ton that was landing there were probably more dumped on bottom, and there would be 20 seiners lined up, 75 ton to 100 ton boats*. In this example, the roe was where the most value lay, but checking for roe required: *Breaking them open and checking if it's good and if it isn't roll them after you draw them up in the purse-seine and then dump them if they were not good, a few would live but the vast majority would die* (CI_01). Describing the herring purse seine fleet, another participant said: *If you want to clean the ocean up you put a couple 400 foot boats alongside each other and tow a two mile wide net, [and] they can tow whales around for six, seven hours and they don't know that they have them, and they can fish the herring on the surface, they can fish them on the bottom, and they can fish them in the middle, so get birds, seals. Its big companies that's taken over, they started small but its all big companies now* (CI_04).

Similarly, another participant thought that the attitudes of fishermen in the sea urchin fishery had changed for the worse: *The older fishermen who were the original license holders did have that inbred concern for tomorrow's meal or for next year's catch right, but for the future generations and a lot of people who have got into this now, don't take the same care and concern. For example they're taking a lot of small ones out of the water when there's vapor on the water, and you never take an urchin out because as soon as it breaks the surface, it chills and it degrades your roe, if you break your spines, it degrades your roe so they fill their tote boxes too full and they'll try to cram them in to get more, and this degrades the quality of your roe* (DI_08).

People and new technology

Having experienced different forms of destructive fishing, some fishermen considered people and new technology as being the biggest current and future threat to the environment. For example: *Too many of us, yeah well my own theory is that the problem with the fishery is there are too many fishermen chasing too few fish. It's also the gear, in the past large purse seine, with otter trawlers decimated the herring stocks and the swordfish by the longline, resulting in the state our oceans are in now* (UB_01). Referring to worldwide fishing practices some forms of fishing were considered very destructive and a serious threat to species and environment: *Fish dragging is a very destructive form of fishing, and we've seen it all up on the Grand Banks with the foreign draggers and our own draggers, its indiscriminate fishing and they will keep what they want, what they're targeting and a lot of the bycatch just gets thrown back overboard but it's already dead cos it's smothered in the drags, and it just gets dumped over the side* (CI_05). Similarly, gillnet fishing was also an issue, and this participant considered that this form of fishing usually produce low quality catch: *Gillnet fish is typically a poor quality fish because if it drowns and if you don't get to that fish within less than a twenty-four hour period, what happens is that the blood goes out and goes into the meat of the fish and then of course the fish starts to get soft* (CI_05). This participant also mentioned the issue of gillnets breaking loose from their anchorage and becoming ghost nets that continued to fish.

Another perspective on current and future threats to the fishing industry was the ability of fishermen and industry to adapt to environmental changes but not consider the impacts that these actions may have in the future: *Threats come from the people as they are adaptable to environment changes, but there is little willingness to plan for futures changes, that is the biggest threat* (UB_06). A good indicator of future threats presented by one of the respondents was the decreasing size of different species: *I've noticed like almost every species that I've bought and sold in the last twenty years the size keeps becoming smaller, if it continues, you know going smaller both in the actual weight of the species itself and the actual catch that's being landed, there will be, you know obviously more problems because the product's just not there to be harvested right* (UB_02).

Aquaculture industry

Chemicals used by the industry to control sea lice include Cypermethrin, AlphaMax and other similar substances were considered a big threat to inshore fisheries and the environment: *The threat to the continued existence of the fishery is the continued and irresponsible use of pesticide by the aquaculture industry* (CI_05). For example, in 2008 and 2009 there were major lobster loses in holding pounds: *Since 2008, we now have to be careful with holding lobsters because of what they are using on the salmon site, lost lobsters in December 2008 and Jan 2009, around $30,000 worth was lost here, not all of ours, one fishermen, half of them were his* (CI_02 & CI_03).

Participants reported seeing dead lobster on the beaches after cages had been treated: *Whatever kinds of chemicals are [being] dumping in the water, and you know it's pretty scary when you start picking lobsters up off the beach. Oh yes I picked dead lobsters on the beach before, after a so-called accident of they were treating salmon for sea lice and they said they used a little too much chemical because the salmon started to die and all the lobsters in the harbor died too. There was also a lobster die off last year (2010) and it was in the papers. It was a banned chemical they were using banned in Canada, but it was somehow being used again* (CI_04). Likewise, this fisherman noted: *This would be a significant threat in the future because it is not managed we're talking about the chemicals that put in the water and they are taking bottom. I've talked to divers and they say underneath these salmon sites, it's just a dead zone. When you put a growing fish on something like four, five acres, the feed and waste has got to go somewhere, so it all goes on the bottom.* (CI_01). Although, one participant remembered that in the past: *They were able to control sea lice by putting medication into the feed, but with more fish being packed into the pens, this approach no longer worked* (UB_01).

Many of the comments related to the lobster fishery, but other species were also impacted: *There was loss of herring fishing grounds due to the salmon farms. Coves that would normally have a weir or be a place to shut off herring, well if it was a nice enough cove they would put the salmon cage in there, and you can't fish within a thousand feet of the salmon cage, so you lost water area. This also attracted more predators, more seals because the seals were after the salmon, and then they would want to put a deterrent for the seals like a scare cannon, and it just goes bang and makes a lot of noise or they put lights up [and] you know lights and noise are two things that* *herring do not like* (CI_04). In another example this fisherman said: *Last summer (2010) we've seen periwinkles dead on the beach, and the scallop draggers were dragging up scallops that are dead in the shell* (CI_05), and: *They put their blood water out into the salt water and let the current take it away but it caused oxygen depletion, and an explosion of your green algae growth on the beach, which caused a problem for the clam spat as they couldn't get down in and settle* (DI_08).

Looking to the future, some fishermen considered pollution from aquaculture farms and other industries would be the most important threat to the environment and fishermen's livelihoods: *The most important environmental threats to the fishery in the next 10 years will be aquaculture. The reason being the chemicals that are being used to control sea lice and that sea lice* (CI_01). Reflecting further, this participant said: *I believe that's what happened to the Pollock around here, and the fishing was ruined because of sea lice, you used to see young Pollock around the same cages, I mean after the people stop fishing them because they kept coming up I think that's what happen they got full of sea lice which affected them* (CI_01). Similarly, another participant noted that the: *Biggest threat to the fishery in the next 10 years would be pollution, not just you know throwing your garbage over board pollution but run off of whatever chemical they might be spraying in somebody's field or you know, whether it be industrial pollution or just pollution in general* (CI_04).

<u>LNG / oil industry</u>

Impacts from other industries including the LNG / oil expansion in the Saint John harbor were mentioned. Comments included: *I mean in our fishery our parity have been looking at any one of those on oil, on LNG spill* (UB_05), and *Oil and gas exploration, potential loss of bottom space (some exploration off Pt. Lepreau in the 80's), and damage from oil spills* (UB_03). Fishermen from the islands were also concerned about oil and gas,, although not so much around Campobello but in Passamaquoddy bay and Saint John harbor: *Lots of ships in SJH, a couple of ships a week in Campobello, but no risk of oil spill, which is not the case in Passamaquoddy bay, where there is about 100% risk* (CI_06).

One fishermen noted that although marine traffic was not as much as in the past there were more oil tankers using the port, which increased the potential for oil spills: *More oil/LNG traffic in the* *harbor, but not as much as was predicted over the years. Port has slowed down a little, oil spills are still risks as the ships transit through the Bay of Fundy* (UB_08). This fisherman went on to share: *An increase in Very Large Crude Carrier (VLCC) tankers, number of small spills have already occurred without too much problem, but with increased shipping and larger ships, the explosion of a tanker is a real risk and could be a serious impact to the fisheries here* (UB_08).

Other fishermen that fished closer to Saint John thought the risk was less: *Oh it's a pretty good chance it could happen yeah. Maybe like a fifty percent [and] this would be a huge impact* (DI_10), and: *I don't think the risk is very high because they say there hasn't been many accidents around the oil, I'd say it's a slight chance but maybe a 25% [but the impact would be high]* (UB_07). Expanding further this fisherman said: *There would be oil spill plans, like recovery plants, I think there is, but from what I hear there is, they don't have the gear here to do anything about it. I don't think they will allow us to be involved in the management plans because I don't think they think we have the qualifications to do anything. An oil spill will affect us, if you have fishing gear in the water and there was a spill and they were using like booms or skimmers or whatever that would destroy you're fishing gear tools* (UB_07).

For Island participants, the potential of bringing big tankers through their fishing areas would be a serious threat: *In my opinion like the L&G I think would be a total economic impact to our areas, to the lobster fishery, to the herring fishery, to the property value, where they want to bring their ships is through Head harbor passage and they want to bring them on the high water slack (when the tide slacks) but that corresponds when the guys want to haul their gear in, [and] there will be conflict there. If there is an exclusion zone, they're still going to be fouling our buoys in their propellers and because of the [strength of the] tide I don't see [how] they're going to work that issue out, because there is a lot of money comes out of fisheries in that area* (CI_04). Looking to the future, one fishermen from Upper Bay thought that: *The biggest threats or risks to the fishery would be development of oil and gas industry* (DI_10).

<u>Marine pollution</u>

Marine pollution included both industry related outputs and general garbage. One participant emphasised the impact of garbage, which was an eye sore but also a threat to species that might ingest plastics and/or get caught in plastic can ring ties: *Garbage, you see it everywhere; pieces of rope, can rings and cans, plastic bags that really aggravates me when I see that stuff in the water* (DI_01). Another fishermen mentioned the impact from the potash mine near Saint John: *We got the potash mine there now and it runs into the Bay of Fundy and all their run-off and it's going into areas where we also have lobsters. There does not seem to have been any tests of any kind, I took one water sample off the end of that and sent to relevant government agency and I never heard back on it again* (DI_10). There was also some concern that despite changes being made to regulate and fix, raw sewage was still being dumped in the harbor: *Raw sewage seeping into the harbor this is still happening in some places* (UB_08).

7.2.2 Environmental opportunities

This section presents the environmental opportunities most frequently mentioned by the participants. These were: (a) investing in inshore fisheries, and (b) developing environment based industries. In general, participants were more positive about environmental awareness. For example, these participants explained: *Well I think just the overall knowledge [by people] of damaging our environment compared to what it was years ago [is much better]. More community groups caring about the environment now than in the past, and as far as the fishermen themselves, I think the reason that they would be more prone to notice is because they realize that that would probably affect their bottom line* (DI_05), and: *More community awareness by the general public on environmental and fishery issues and getting to know the community e.g. Dipper Harbor day is very effective* (UB_08).

Investing in inshore fisheries

Looking to the future this fisherman said: *If the cod fish ever came back, only very small quotas should be allowed, as the fishery of the future has to be sustainably and financially as well* (UB_03). The herring fishery also has potential, although ongoing environmental changes could cause future issues: *The biggest opportunity to me is if the herring fish stay if they were there to be able catch. This might give people an opportunity to do it and want to do it, but you have bad years, year after year like it has been in far as the herring for most of them; it is going to take a lot to change their minds to do it* (DI_04). Whereas, this participant thought: *There is potential in the herring [and] I think the secret is besides herring bait, would be to open up new markets,* *and try to sell it to people as a healthy fish because it is healthy for you. I don't know if it's because of the bones as people don't seem to be eating it as they used too, because they got other choices, but maybe even a foreign market would be good, help with food security in under developed countries* (CI_04).

Other participants considered inshore fisheries, especially lobster as a good opportunity: *Unlimited potential for growth in the traditional fisheries* (UB_06), with opportunities in the lobster fishery: *In my opinion, yeah I think the lobster fishery is better than it ever was* (UB_07), and: *So, people can see that there is opportunity and that's why everybody here want to get into lobster and they are seeing most of the catch it has been good* (DI_04).

Developing environment based industries

<u>Tourism</u>

Besides fisheries, other potential environmental opportunities that could enhance employment was the tourism industry. Participants from both the Upper Bay and Islands described tourism opportunities, including: *Tourism like the Fundy Trail, and we have the cruise ships they come in here quite a lot from Saint John but they usually straight through and they may stop at the wharfs and you know, they just asked a bunch of questions but not much is spent locally. It would be good if there were small businesses that could benefit from these tours* (DI_10). Similarly, another participant noted: *Once they are here for tourism, and once they have seen the beaches there are opportunities for other spin-offs that would help small local businesses [but we often miss out]* (DI_02). Others also commented on: *The tour boats come out of Saint Andrews, but not here. You gotta have a tour boat license to take anyone out and charge them, and I'm not saying I haven't taken anyone aboard my boat for a sail, but as far as making a living at it you need licences and safety certifications* (DI_01), and: *More tourism in SWNB as opposed to Saint John, can increase viability for tourism in Saint John* (UB_08).

Describing the situation, this fisherman further explained: *Yeah. I think our government is failing us by not supporting tourism, you know it's all about the marketing right and how they go about it. It would be incredible what they could do for our sales for seafood if the governments could get together federally or provincially and do a campaign but it's got NB province focusing on* *aquaculture marketing. Promoting lobster should also help tourism because I mean that one time visitor that comes to New Brunswick or Atlanta Canada and has lobster to eat as its number one on our menus, and if it's priced reasonably then the chances of them ordering that product online when they get home increases* (DI_05).

<u>Aquaculture industry</u>

Participants acknowledged that environmental conditions were conducive to the aquaculture industry, which in turn provided employment options. There were mixed perspectives on the value and extent of these opportunities. For example one fishermen said: I *certainly don't wanna see any of those people lose their jobs, [but] I wish that the aquaculture industry was a little more concerned about the environment and the impact that their industry has on traditional fisheries* (CI_05). Conversely, another fisherman noted: *Aquaculture is a bit [of an] issue for some fishermen but it is not a big threat, as it supplies allot of work, steady work, but [I think] a lot of people would still prefer to be a stern man on a fishery boat* (UB_06). Other participants refleced on: *Compared with fishing, aquaculture decreased employment opportunities, was never a big employer on Campobello. When it first started there were about 20 families that owned sites, and each of those sites had about 5 or 6 workers, but when the bigger farms came in, my family went from 40 plus employers to about 6 or 7 people* (CI_02 & CI_03).

<u>Senior citizens facilities</u>

Looking to the future, one Island participant mentioned the potential for catering to senior citizens, emphasising an increasing aging population: *I believe there's funding for tri-level senior housing right up to your nursing home being the final level, and with nursing homes, assisted living, and a milder winter here, a retirement community could keep your small your village stores because no matter what you say, it's cheaper to go pick something up at that village store than it is to make a trip to the mainland* (DI_08). This participant also noted: *You know we have a lot of assets here on Deer Island to offer and if you get people coming in, they may not have that island identity but they would soon learn how to have* (DI_08).

7.3 Social opportunities and threats

7.3.1 Social threats

This section presents examples of the most frequently mentioned social threats as described by the participants. The most concerning interrelated threats affecting communities were (a) people leaving the community, an aging population, loss of community connection and identity, and loss/reduced public services. Other social threats included (a) the challenge of maintaining inshore fisheries, and (b) attitudes/behaviours affecting community cooperation

Factors affecting community composition

The consequences of being under financial pressure were reflected in changes seen in the composition of the community. For example: *Less people are coming into the fishery now, and it is almost impossible for people to get into the fishery because there are only so many licenses. One would need to have a history of fishing to get a licence as the cost of buying a new one is high. When I first started, for 25 cents you could go get a license and now it's about $200,000* (DI_03). Correspondingly, another participant said: *There are people around here right now that would love to get into lobster, but you can't because there is no licenses developing and the government won't issue anymore unless they can come up with a quarter of a million or a third of a million to buy one now. Most people just getting out of high school or whatever, you know, there is no way they can do [start up fishing] it here* (DI_04). While another participant noted: *There is not much work here, so a lot of kids are moving away and getting jobs or teaching, off this area, there are some are staying in the fishery but there is not many other opportunities. There is some on shore work as lobster are being caught out there, but that's indoor labor and a lot of people work there, but there is not a lot around, and it's probably getting worse than it has been* (DI_02). This fisherman also explained: *There are no new industries, due to the fact that you got to have people to support something right, and there is there is not the number of people here, maybe some small business but not enough to support economic growth here* (DI_04).

An aging community population was of concern. For example, these participants noted that: *People moving out of the community* (UB_03), due to the lack of employment opportunities, which led to a: *Decrease in population as not many jobs, mainly seasonal jobs and the only main job is the lobster fishery, a couple of scallops, three boats that do halibut, but not a lot of jobs*

*(*CI_02 & CI_03). As such, this participant considered that in the future: *We're gonna see a continuing aging population in these small communities cos there's just nothing here. Personally I don't think that even the lobster fishery, which is still a strong fishery now, but I don't think that in twenty –twenty five years is gonna be here for these* people *[who will be getting out of school then] (*CI_05).

With less people staying in the community, another social threat was the loss of community connection and identity: *Like everyone knows everyone and there's the connections and you have to know your roots right and island identity but many they've lost the ability [to connect]. For example, local stores they used to keep stuff on hand to store up in the wintertime or store up in the summertime for your winter supply, but they've lost the value of having spare parts around because people just go to the mainland now or there are not enough people to support local businesses* (DI_08).

Another consequence of a decreasing population was the loss of public services. School closures affected communities from both the Islands and the mainland. For example: *You're going to lose your young people, island identity, island ways of life are going to be lost right? We've lost a lot of our island way of life here by our high school going over to St. George* (DI_08). Whereas a participant from the mainland said: *Well when I lived in Garnett Settlement we had a school there and they had one in Willow Grove, and they had one in Bains Corner by the fire hall in Bains Corner, they're all gone. I was probably twelve years old when they all disappeared* (DI_10), and *They used to have community centers that kids could go to, but not now, same with community halls and there is nothing like that here now* (CI_01). Banks were also another issue: *No banks, the bank left here I'd say a year or two, it all kinda runs together so it's the taking away of services on the island, and nothing coming back* (DI_01).

The loss of small local businesses and public services appeared more prominent for Island communities, in comparison with those on the mainland: *The Credit Union, which has closed down, and I now have to do my banking at St. Stephen, but there is a like a couple of hours. You would have to catch the ferry, and then if you missed it, there was another wait, so it would take you an hour and a half to the bank, if you did miss the ferry* (DI_02). Others mentioned the loss of stores, gas pumps and small local services: *Decrease in local stores carpenters and decrease in construction on the island* (CI_07), and *there used to be 5 or gas stations now only two* (CI_01). Reflecting in more detail, another participant said: *There's three gas pumps on this end of the island and one in another community. There used to be six or seven gas dealers around here all selling fuel and now there is one, it is the same well with churches, with community halls, schools, with whatever. It is the same core group of people that is doing it with the same that they have done for years, and you are just taking away from what already exists and it is still just those same core people supporting [what is left]* (DI_04).

The location of the service was also a threat, especially for Island residents: *The only reason we have the school is because they can't get the kids off the island, so that's the only reason that school is open. It's also the population, when I graduated there were 335 I think and it's around 100 now, so, kindergarten to grade 12, but the problem is that it is a small school and it does not offer many programs and its struggles because of the small student population. There are no music programs and that kind of stuff, and the parents have to pay for them big time, but there is no program here for the kids. Furthermore, for high school they go to East Machias (Maine) Washington Academy* (CI_01). Being located on Deer or Campobello Island, was also an issue in the event of a medical emergency: *For emergences the children need to go to Saint John*, *and it is a very long drive if the ferry is not running, although we have also taken them to Maine. From Campobello, the ferry is only here in the summer, and dealing with the Saint Stephen border is a pain* (CI_06).

Challenges to maintaining inshore fisheries

Although there was a lot of concern that people were not coming into the fishery, participants also understood the reasons why: *I don't see more people coming into the fishery anymore, it's very expensive. If I wanted to go out and get into the fishery, by the time I had a boat built and outfitted, and even at the low end for lobster, I'm gonna be half a million dollars in debt minimum. If I only had a scallop license and that's all I could fish I could never go buy a new boat because it would never pay for itself* (CI_05). Presenting another perspective this participant noted: *When it comes to the fishery you know, when you have enough, you don't need anymore, all you're doing is taking from someone else cos you can afford to retire, get out of the fishery and let some young fellow get* *in but it'll never happen. There should be mandatory retirement, sixty-five for everything not just the fishery, I know people that are working in their seventies when there's eighteen, nineteen year, twenty years old coming out of school that can't get a job* (UB_11).

One of the issues preventing younger people from trying out the fishery was the cost of having an additional licence onboard: *Kids are intrigued by fishing, for example, my son wants to go and try this but I say no, you can't even though he wants to try and experience what it's all about, but he can't, because he has to have a $50 license to step foot in my boat to try. I have been after, DFO every time I get into a meeting [to] let people experience it and they won't as they want their $50, but it's a shame because these kids want to try it but they don't have the opportunity as it is $50 each year and who's got $50 to keep throwing away if they don't like the job* (UB_05). Finding people to crew was also a concern: *It is hard to find people to crew. Well this winter I tried to find somebody to go scalloping, and it's hard to get the young fellows because in this area there's a lot of people that go into the city and go to work you know, and so it's just not what you call a fishing community there's only the certain few that are at it so it's hard to get help* (DI_10). Similarly, another fisherman said: *I do not see many new people coming into the fishery. Not many from this community as the crew cannot make enough money to buy an outfit and licences are not being passed from father to son. Also not many women in the fishery as it is still considered a man's work* (UB_06).

Participants highlighted the value of herring weirs as an inshore fishery. For example: *It's a very traditional, it's one of the older forms of fishery but people have sold out their sites, because the price to build the weir is very high. The time you get your twine, your weir stakes, all your material you need to build a weir and your time and the effort [because you have to go tend that weir every day, every tide] to get nothing, you're going farther behind. I [also] suppose age affects some people too when they feel they can't do it and there's not the demand because there's no fish, and the people can't make the money* (DI_08).

One of the consequences of having fewer herring weirs built is that people will lose these skills and knowledge: *Yeah, to me on the island here when it comes to fishing, the herring to me would be the one that is going to take the big hit in the years coming unless something changes,* *because there is going to be no weirs. Even my son does not want my mine, so my skills are not passed on* (DI_04). Expanding further this participant said: *Families that used to have four or five weirs, probably they are only building one now. I don't think there will always be someone who will be able to continue passing on the knowledge* (DI_04).

Behaviours and attitudes affecting community cooperation

With increasing fishing expenses and uncertain market prices people's behaviour changed. For example, one fisherman said: *Fishing is risky and anything to do with fishing goes by the rule of the day for sure, and of course when that becomes your only resource available for people to make money they exploit it right, no fault of their own, they just needed the money* (CI_04). Another participant noted that with the: *Increase in fuel prices, [you] also got to watch what they are doing now, as people are very competitive. People fishing hard, also increase the possibility of illegal fishing*. (CI_01).

A couple of the fishermen were concerned about competition among fishermen for fishing space: *Well, where we live in Deer Island there is only so big an area for everybody to fish on, unlike in Nova Scotia and Grand Manan, I think they have a broader area to fish their traps, because once the lobsters are caught there is no ways really for them to come from, because this area is quite a few licenses that fish between St. Andrews and around Deer Island* (DI_02). Whereas a fishermen from Upper Bay, reflecting on fishermen from Deer and Campobello island, noted that: *Last year we had a good haul because the lobsters didn't show up last year in Campobello 'til after the season closed in LFA 37 that's when they came (to LFA 36) so we had a good haul. Then them boats from Campobello came, and there were fifteen or twenty of the boats was up here that's what isn't fair but I guess there isn't such thing as the word 'fair' in the fishery, nothing's fair* (UB_11).

Reflecting on community cooperation, one participant mentioned: *I guess going back to my younger years when I first started, six boats would come in at one time, one place, and every one of the crews from the six boats would unload one boat, and weigh their product and that when they're finished, they go on to the next, and everyone went together. Nowadays if you want to get extreme, if one boat looks at another boat catch you could get a punch in the face* (UB_02). Others also noted that: *There is a lot less loyalty as people are more in debt [and] having to run around for 15c/lb, leads to allot of illegal buying. I also think we should try and keep money in the community [and work with local buyers]* (CI_02 & CI_03).

These fisherman also had concerns about the current attitude of fishermen, noting specifically the personal investment and the lack of preparing for the future: *So your fishermen who catches a fish does not necessarily need to be on the boat. A lot of fishermen have done that but to me that's always been a problem. You know if you're gonna fish, you need boat, and if you have your boat, well you're really invested in the fishery, and you care what happens to the fish* (UB_01). Another participant explained: *Fishermen are not going to be able to land on their feet because they have always seen the good times in the lobster fishery. So far this has been good in the last 10 or 15 years, right, but if it ever goes the other way, they would have problems, because they buy, have and want, [but also need to pay expenses] and nothing ever is going to be caught all the time* (DI_04).

7.3.2 Social opportunities

This section describes the most frequently mentioned opportunities in the context of social changes and threats. Participant responses included options for (a) maintaining inshore fisheries, (b) expanding community composition and diversity, and (c) seeking eternal support from public and private sectors.

Maintaining inshore fisheries

Looking to the future, this fisherman thought fishing could stay in the family, but it would be another generation down. *When I'm done the license would be probably sold. I might want to look at grandkids, but that's hopefully another 10 years away as my children are only 20 years old now* (UB_05). This participant also noted the difference between getting into the fisheries and the realities of expenses: *I hope there is an opportunity for young people but I'm afraid because of the price of the licenses and the gear, and unless you have a background where your father might leave the boat to you or whatever I think it's gonna be almost impossible. I [also[think you'll find it will be in time, where large companies own the fleets of boats and people fish them for these companies* (DI_05)

Another approach to encourage people to remain in the fisheries could be through educational programs and courses tailored to the needs of the community. For example: *Courses to build traps, fishing, related courses so kids will not have to drop out of school* (CI_06), and: *There are opportunities for education, not elitist but in the past, if you wanted to work where you grew up, people had the potential to do a variety of things. Anybody that shows ability to do other work/take education/training courses [should be able to do this]* (UB_06).

Community composition and diversity

For Deer Island, the opportunity to learn from different cultures could be initiated through social events that brought together locals and workers from the Paturel processing plant: *We have people here from the Philippines who have a different way of life, and it's a great learning interest, you know. They partake in the church and in the community activities so that they are part of the community, and you've got a variety of opportunities to learn from each other* (DI_08).

Another opportunity would be if there was a ferry for the full year between Campobell Island and Deer Island: *People go to Lubec, Machias and Calais (Maine), for shopping, jobs and school. I think a lot of people use [the] ferry to DI, but would be good if there was a ferry all year round, as some people might [be encouraged to] work more on the mainland and Dear Island* (CI_07). Social engagement projects also helped to sustain the structure of the community and create new initiatives: *There's also a camping ground and I am on the camp ground committee who are trying to create new opportunities to be able to maintain this site* (DI_01).

External support

A couple of the participants noted the options for external support, either from the government or private industry could help with initiating new projects: *Campobello is a rural community and [we] were able to get road repaved in 2010. We need more opportunities to get things accomplished, recreation and money for children's activities, provincial and federal parks provide up to 50 jobs in summer* (CI_07), and: *It the private sector could come up with some answers for us, we have pretty much given up on the government to try to help us. Then maybe* *that's not a bad thing, like too much government dependence in my opinion is not a great thing anyway* (CI_04).

7.4 Economic threats and opportunities

7.4.1 Economic threats

This section describes the most frequently mentioned economic threats. There was a general consensus that one of the most concerning economic threats was the increase in expenses, including fuel, bait, and fishing licences. Other threats included (a) the uncertainty of international and national markets, (b) repayment of loans, (c) loss of bottom space and loss/damaged gear, and (d) factors affecting employment options. Looking to the future, participants were also concerned about the limited opportunities for financial growth leading to the loss of EI hours, increasing expenses related to food wastage and overall fishing expenses, the influence of China in the markets, and limited government support for inshore fisheries.

Increasing expenses

Looking ahead, one of the most pressing threats is the increase in expenses, specifically fuel: *One thing that is going to hurt the fisheries is the price of fuel energy. Like diesel fuel costs more than gasoline, and most boats have diesel engines, and their cost of operating goes up with it* (CI_04), and *Diesel fuel is more than gas, which does not make sense as this is less refined* (CI_02 & CI_03). Looking to the future, another fisherman said: *In the next three to five years that I would guess would be number one threat would be the ability for the fishery to financially sustain itself, that would be their expense and that would be directly related to you know oil and gas* (UB_02).

Other rising expenses include bait: *Bait this year is the most expensive it has ever been* (CI_02 & CI_03), and having to take sea safety and related courses: *Now we've gotta take a radio course and if your boat's under fifteen ton, it's a hundred and five dollars and if your boat's over fifteen ton, you have to take the five hundred dollar course. If people who have been fishing on the water all their lives, do they need a radio course? Something's wrong with that picture that's where unnecessary fees are [being] putting on* (DI_01). Others described the high cost of domestic shipping: *[With the] Canadian money exchange rate, and if the dollar keeps sliding,* *[this] will affect shipping costs for domestic markets. We have looked at markets in Toronto, and by the time you pay Midland (which is one the cheapest places to do trucking), it is not worth it, even more expensive more out west* (CI_02 & CI_03).

<u>Fishing licenses</u>

The price of fishing licenses was also considered to be a serious threat, especially for those who were just coming into the industry: *I mean fishermen used to worry about the price of their boat and now they have to worry about the price of their license. If they have to spend $250,000 for a piece of paper that says you can go fish and that's not before you bought your boat [they are discouraged by the high upfront investment]* (CI_04), and: *There's no such thing as new lobster licenses, what's here is here and you can buy one from someone who's selling it but you can't go to fisheries and get a new license* (DI_01). Similarly, for small processing plants, the overheads incurred at the start of a business was also a serious threat: *Our insurance was 17000.00 when we started, and 74, 000 per year to break even, [with] no government help* (CI_02 & CI_03). Some of the economic (and social value) implications to the fishery as a result of high start-up costs led to: *No younger entrants coming in as it is too much money ether for the fishermen or buyer. My boy is seven years old, but I don't want him to go into the lobster fishery and he does not want to fish, but when I was that age, all I wanted to do was fish* (CI_02).

<u>Training and monitoring expenses</u>

There was concern by participants regarding regulations that required them to retrain and/or get recertified: *Well they have to go and get re-educated and you're looking at an older group of fishermen. An average of the fisherman is probably, I don't know like last time I heard was 57/ 60, and about 50 of them maybe that age group and so sending them back to school, what kind of impact would that have? As you have got the MED or operator's course and anybody new into the industry as a young individual it's like a $10,000 deal, and they need two years of history, then they have to have radar courses, plotting courses. Whereas when I started all that with Fishing Masters IV and did charting and plotting and all those, and I will do this again as it has also expired, that was 2002. I only did like three courses out of seven and that's all I have [and they have a] window [of time], so you got to take them all over again if you miss out* (UB_05).

Another participant mentioned the additional expenses incurred from having to comply with regulations: *The government, well I mean it's just the regulations they put on [you]. If they say you need a device on your boat, well they put a black box on us for scalloping and they don't care how much it costs. This is more of a threat to me than if I went out there tomorrow and couldn't catch something, you know the regulations they bring on to you, you can't fight them and it 'sometimes that's pretty discouraging* (DI_10).

Uncertainty of international and local markets

Fishermen were concerned about the impact of international markets and branding practices that could affect their fishery. For example, this fisherman said: *The republican government in USA, and the EU are doing the same, tightening boarders against free trade, Canada needs to protect its markets* (CI_01), and: *In Maine we have seen good lobsters there as being labelled from Maine, but they are not from Maine but Canada, as they don't have any hard-shell in spring. [I think] they take off the Canada brands and put US brands and then sell them. I know there was a group that was looking into branding, [so] this might be good but also might not be* (CI_02 & CI_03). These same participants also spoke about the costs of getting into food shows and the need for government to help small processing plants market and promote local fisheries at international events: *The Miami Seafood show is good but costs about 2900.00 to get in Boston Seafood show, opportunity to promote the made in Atlantic logo but Govt. does not do enough for small processing plants as the only New Brunswick food promoted there was Cookes, lobsters are not being marketed well, can't keep market in scallop*.

From a retailer's perspective, price fixing by large corporations was also a serious concern: *The problem with big players such as Clearwater, Garbo, and Pateral is that they set the price and smaller local buyers have very little influence* (CI_07). Another comment was: *Yeah price fixing is a seasonal thing. We knew that prior to the beginning of the season that there was going to be visits from certain individuals and they would tell you the price would be such and such and you would try to set that as you know a starting point shall I say because you always knew that they were telling you one price but they were probably telling the next buyer something else right, but it's with the big corporations it's not with the smaller buyer. I hate to use this word but they are almost always being manipulated by these big corporations* (DI_05).

This participant was also in agreement: *The buyers are in cahoots, the big guys, not the local little guys, it's the big fellows. They're the guys that are setting the lobster price and if you try to butt them, they'll put you out of business by setting the price of lobster so high that you'll take a loss and they'll force you out cos you can't afford to pay it. That's the way the system works* (UB_11). Explaining further, the fisherman said: *That's what frustrating it should be one price and that's it right across the board. If its four twenty-five then it should be four twenty-five everywhere, and I didn't go to school long enough to learn business or economics or how things work but I know there's an injustice*.

Loan repayments

Although the rise in lobster catches was considered an opportunity to make good money in the fishery, but in order to maximise this opportunity if fishermen did not a have the boat and/or gear, they would normally take out bank loans: *The one thing that makes difference is, that 8 to 10 years ago when the lobsters started to coming back quite fast, people got awful big boats, and started getting in over the head, and ended up making lost money just to pay off these debts, 700 or 800 horse power and you take the fuel there, burn them, oh my god its four week's work for the fuel* (DI_03). Expanding father, this participant commnted: *No support for the fishermen from the government. We used to have a fishermen's loan board years ago, which is gone, and now I guess there is a little money options available if three or four banks turn you down* (DI_03).

Having to pay back loans, which often had high interest rates meant that many lobster fishermen tended to fish harder: *Yeah, the price dropped down so you catch more to try to maintain a livelihood? You have an income that you're kind of used to run a household and whatever and when that drops it influences your bottom line, so then you got to make changes, so everybody fishes harder and longer to try to maintain that* (UB_05). Similarly, this fisherman said: *Loans have to be paid, more pressure to fish, increase in fuel, less price for the lobster, increase in overheads and higher costs of living* (CI_06). Expanding further, the fishermen noted: *The biggest lobster catches was last year (2010), and as long as you know what amount was in previous years, you take more chances now just thinking that someone else is out there getting that catch* (CI_06). Reflecting on the rarity of being able to repay all loans and debts, one participant said: *Once everything is paid for and you are just idling along and that's kind of rare today* (UB_05). On the tendency to fish harder, another participant noted *There is a lot of pressure on the lobster industry and [I] hope it is able to stand this pressure as our livelihoods are very much tied to the fishery* (CI_07).

A similar situation was also observed occurring in large corporations: *Okay it's overfishing by the big corporations in general but it's almost like a vicious cycle because they have expensive boats and gear that they have to pay for so it forces them to do things that they may have a negative impact on the stocks. At the moment its good cos there's still lobster stocks but if something was to happen then there is a problem* (DI_05).

Loss of bottom space and damaged/lost gear

Marine debris from current and abandoned salmon farms was an economic concern for fishermen as it damaged their boats and increased costs when having to replace lost gear: *Aquaculture debris, they don't clean up after, you know that without saying that the whole crap is on bottom all down there the rope, oh Jesus saying, steel cages built, they are all on bottom you can't get near it, because you know you are going to lose your gear, I have lost stuff from up to two years ago* (DI_03). Describing one experience, the same participant said: *There is a site out at Tinkers Island, and it's been gone but they left in 180 feet of water, and they leave blocks, chains and rope, and I was trolling there one day, my Jesus I get caught so hard, couldn't heist it, could not get clear of it, it was only by luck that I got my gear back because a diver was able to help cut me out, but it cost me* (DI_03). Other examples relating to lost space and gear included: *Well for one thing, they take up room, and if they put in an aquaculture site then I can't put my lobster traps in it because one will interfere with the other and they lease the bottom from the province so they have it so that's the question of room* (UB_01), and: *If aquaculture was to expand further this would cause future conflicts with fishery because we can't lose anymore bottom, we've lost all of the fishing areas we can afford to lose* (CI_01). Concerns relating to tidal turbines and wind farms also focused on the loss of bottom space for fishing (and having to learn another area), longer routes to and from the fishing area (to avoid these structures), and potential impacts to fish/lobster (tidal turbines) and birds (wind farms). For example: *Tidal turbines that's taken more area and is an increased fishing threat, looking back at* *history from the 70s and what we've lost so far I mean we just keep losing boat space, and the government just says move on to another area and you will get some results, but traditionally if you use the fishing area it takes a while, five or six years to learn a new location* (UB_05). Looking to the future, this respondent said: *Tidal and wind farms increasing, will [also] lead to the loss of bottom space for fishermen* (UB_03).

Referring to the oil and gas industry, and other sectors operating out of the Saint John harbor, this participant said: *Other industries such as shipping, oil refinery ships, L&G, cargo, that's mostly all the shipping out there, oil and gas, lot of problems, we lose traps and buoys from shipping, or they anchor on top of them or when they pull the anchor they'll take the traps with them, and this has increased over the last 10 years, and will continue to increase* (UB_09). Another fisherman from the islands, who initially thought that the increase in oil tankers could be a problem, was more open to this option as it could bring in more jobs: *Bringing in these oil tankers, well, I know when it started out 20 years ago, I was against it totally and then, over the last few years, I can't see that it is hurting anything, could be good as there are not much work here* (DI_04).

Cruise ships were mentioned as being a potential threat in this context: *Increase in cruise ships, well I'll just say ship traffic for us, I mean that's just personally here in this area, a clear loss [of fishing space] because of increased ship traffic and it's only going to get worse* (UB_05), and: *With an increase traffic in the Saint John harbor, we have issues with lost fishing space and damage/lost gear* (UB_03).

Factors affecting employment options

Participants noted the current and potential ongoing high rate of unemployment and there was a need to find ways to subsidise income, especially for island communities: *Two years that we have been asking to make jobs after a processing plant was closed down, 20 jobs lost, and this is a big thing for this community* (CI_02 & CI_03). Supporting this statement, another fisherman described: *There is no processing on Campobello, everything is shipped out, hence people are not coming back, it would be good to have a processing plant here, so that people will stay/come back* (CI_01). An issue related to the tourism is that it is seasonal so people need to find other jobs during the year. For example: *Lopin Lodge has about 13 jobs, provincial government owns it, part of Roosevelt Park, but only open in summer* (CI_01).

For the Islands, one of the issues with creating new employment opportunities was their own small population, and that they did not have many visitors coming through their area: *We don't have enough flow of people through Deer Island to have them stop here. I guess because it is close to the US, and because we have a small population about 700 people so, there are not many opportunities for developing infrastructure to bring people here*. (DI_02). Another participant commented that: *On Campobello Island there is no good jobs in the private sector. If you want a good job, you work for Roosevelt's International Park or you work for customs and immigration or you work for fisheries and oceans or you work for the government garage, or the nursing home, and they're all government, and so we are doing services, which belong to the government* (CI_04).

Reflecting on the current situation, this fisherman said: *[This is like] living in a place that's economically depressed. None of the fisheries are getting new people because the licenses are just changing hands, so the numbers I don't believe are increasing just the people that are doing that are changing, in regards where the old fellows are selling out to the younger fellows that can afford to* (CI_04). Furthermore, if fishermen were not able to sell the licences within the area this could also affect community identity and structure: *Well they sell off to other areas and that would be a way of decreasing the lobster licenses in our area or selling them to people in other zones and then they'll be able to come and fish in our zone, and the money [will] not [be] staying in our community.* (DI_05).

<u>Inshore fisheries and the aquaculture industry</u>

The ongoing conflict between inshore fisheries and the aquaculture industry continues to raise economic concerns. For example: *When you start talking about the lack or more responsible use or withdrawal of pesticides the first thing that aquaculture starts talking about is the number of jobs and people they employ. My argument is that if you take every lobster fisherman and scallop fisherman and urchin fisherman between Grand Manan and here and up the shore to Saint John and you take captains of the boats and their crews and the spin-off industries, the buyers, you're* *gonna have more people employed in that industry than what the aquaculture industry employs on this side of the Bay of Fundy. Also if you compare the gross sales of the traditional fisheries and the profitability of those industry and take the aquaculture industry and pull out their grant money, you will see just how profitable they are* (CI_05). Similarly, another fisherman also had his doubts about employment opportunities: *I don't think they create any jobs here. I think there are 15 people working on salmon sites on Campobello for starvation wages. I mean because all the big processers are paying crooks they can't even get people to work there and they have to bring in immigrants to work there, and they're paying none of them wages which you can't survive in this country on the money. If those 15 people had an opportunity to be on my boat they would, every one of them* (CI_01).

Future concerns

Looking to the future, there seemed to be few opportunities for financial growth: *Financial growth that's fairly limited, don't really see any new industries come in. There are some things they could do but I'm not sure if these are feasible to do it. For example putting a hotel here it will cost you what, half a million, but how long's it gonna take to make that money back with the amount of people that come here in the summer* (DI_01). One of the consequences from having fewer employment opportunities would be the reduced ability for people to earn EI stamps: *Fishing wouldn't do it for the whole year, and probably right now, [if] you didn't have the EI to support you, [you would not be able to survive the off seasons]. [If fishing did close] then you would have to have a job year round, which is very hard to find* (DI_02).

Food wastage in the overall fisheries sector was an ongoing threat that could get worse. For example, this participant said: *I mean, it's part of responsible food safety for sure but it costs so much. I think that's a lot of the problems with the harvest markets is that there is just a lot of waste. I won't say its unnecessary waste and perhaps it is in this day and age, and responsibility with society to keep food safe that it's necessary. But it's certainly taking away from the direct profits from the harvesters or the marketer's* (UB_02).

Other fishermen thought that the most serious economic threat will be the increase in expenses, coupled with fluctuations in market prices: *Fuel prices will increase in the future, increase in* *bait price and potential availability issues / catch value remaining relatively the same* (UB_03), and: *Yeah really I mean our lobster catches has been staying up pretty good, but if that had to drop down we're going to be in mess like you are not going to be able to afford to do it a lot of people it's going to cost more than what you are making out of it, yeah* (UB_03). Another participant noted the issue of shipping products from here: *Although it is good having processing plants set up, you know land based, very close to the harvest area in order to make that sort of product like cost efficient, the biggest challenge is shipping the goods far distance to the markets* (UB_02).

These participants also had concerns about how China could influence the markets: *There is a place in Maine where a lot of products are sold, and they also bring in a lot of international stuff. They had 2-4 oz, Pollock fillets from China, all frozen at 1.60/lb, so you wonder why some of our prices are being driven down. Some questionable stuff comes from China* (CI_02 & CI_03). Using the herring fishery as an example, this respondent noted: *Our problem was that we could catch them but we couldn't sell them because of the market conditions. So we could catch then and now you can't even see any to catch*. (UB_01).

Referring to aquaculture as a threat to inshore fisheries investment, this participant noted: *Well the way it's presented is both levels of government, federally and provincially have got so much money sunk into the aquaculture industry that they don't feel they can back out now, I don't think, The federal government keeps pumping money into them to keep the people employed so they're not out of work and on EI. I don't have a problem with that, I think there's a place for a government's support, but I just don't think there's a place for government's support in private enterprise* (CI_05).

Other comments related to competing interests of other industries and inshore fisheries for government support: *More government regulations on the fishery I think would hurt us. I think we're regulated enough, maybe too much. It looks like there is going to be some really big money in the L&G and so government is interested enough that they subsidize Irving to put an L&G terminal in Saint John. [Govt.] seemed to be subsidizing everything from aquaculture to other big companies but not the fishermen* (CI_04).

7.4.2 Economic opportunities

This section presents the most frequently mentioned economic opportunities. These included (a) exploring the potential for new species and/or developing underexploited fisheries, (b) improving marketing and branding strategies, (d) investing in inshore fisheries, and (c) developing community incentives. Currently, fishing provides opportunities for people to get employment insurance: *For many people they use fishing as an entry into the employment insurance* (UB_06). As noted previously there are many challenges to get into the fisheries. Looking to the future, this participant said: *There's going to be a lot of guys retiring within the next four or five years like in this area here they're getting my age so they're getting up there. Perhaps a lot will maybe sell their licenses or hand them down, whatever* (UB_03).

For participants around the Saint John area, there appeared to be more employment options available, but it also creates situations where it is hard to find people to crew fishing boats. For example this fisherman said: *Near Saint John, more jobs available, and so fishermen family members may not want to go to fish if they can get a Pt. Lepreau nuclear plant job,* (UB_02). As previously noted it made it difficult to find people to work the boats, as experienced by this participant: *Spring is normally good or better than fall. I used to hire a third man in spring, but now down to two, as I can't find another person who wants to work, similar in the fall, used to take 4, but now down to 3* (CI_01).

Exploring the potential for new species and/or developing underexploited fisheries

Most comments from participants on economic opportunities related to new and under exploited species. For example: *We have quahogs that we are not fishing in Saint Anne's bay. There is expansion room in [the] cucumber fishery, and we could have a Jonah crab fishery now in LFA 36 (Passamaquoddy Bay) that would support three to four boats. There are a whole bunch of markets most US side for quahogs [but] it is labor intensive, [and] which I think that's what the current fisheries needs because it puts [more] people to work* (CI_01). Expanding on the sea cucumber fishery, this participant said: *With sea cucumbers there is room there for at least that many more boats if not you know probably there is room for five or six boats on that fishery. I mean every time you had a boat, you may add three or four jobs*. Explaining further, these fishermen noted: *There have only been two experimental sea cucumber licences over the last 10* *years, and there was room for more* (CI_06) and *Might be some opportunity for quahogs as there are a lot around here, but there was no market for them in the past. A couple of fishermen were given experimental licenses, but then they are not doing it right now. They were in here up till a year or so* (UB_03). Yet, for the exploration and expansion to take place, DFO would need to first open up these fisheries: *The only opportunity would be if federal DFO's prepared to open up the fishery to more species* (CI_05).

Opening up new fisheries would also provide fishermen with the opportunity to continue their inshore practices and remain in their community: *Is there anything that might encourage people to stay in the fishery, perhaps to fish the species out there that we're not fishing now such as eels, here are all kinds of eels, a slime eel fish out in the bay* (UB_05). Another participant described a conversation with other fishermen, indicating: *I spoke with some natives that are allowed to still fish tuna, to harpoon them and they get tags and they are allowed so many, but for this zone 4X they don't issue any tags for 4X for tuna. This is kind of a shame because last year (2010) I think someone could have really done well at and you wouldn't have to get them all. I mean because they pay a big price for it, you know a limited fishery probably would have been okay I think* (CI_04).

Improving marketing and branding strategies

Comments focusing on marketing and promotion strategies included: *A peddlers licence so that you can sell your own product, but you have to have people around* (CI_06), and *I guess the first step is government to you know stimulate and start growth of some of these products and markets such as Jonah and rock crab, Sea cucumbers, eels, and mahogany clams, but first need exploratory permits to be able to harvest* (UB_02). Looking more internationally, one participant thought that: *Aquaculture can guarantee delivery time and money, but we as a traditional fishery have not looked at competitive efficiency* (UB_06). Another fisherman mentioned: *There could be MSC and eco labelling opportunities targeting European markets but our government does not seem to want to support us. If it is farmed raised salmon then they support it, [but they] should also support local and overseas markets for lobster* (CI_07).

Lobster markets

Economic opportunities discussed specifically in the context of the lobster fishery focused on better marketing and targeting specific consumers. For example: *Lobster is the back bone of the fishery and we need markets and marketing research, there might be some opportunities through the lobster council of Canada; but previous suggestions from the council were not received well by the fishermen* (UB_06) and *The lobsters from here are a better quality lobster than what they get out of the Gulf of Maine because of the water temperature, and so we should promote this as part of our marketing* (CI_05). Another fisherman thought there could be opportunities in the Asian markets: *There seems to be a growing interest in Chinese markets. Obviously there's a lot of people to have to be fed there but from what my knowledge of that is the biggest challenge is to get them into the country cheap enough so people can afford to buy it as most people are in the medium to low income. This gets back to lobster prices, even at the current harvest price by the time they get there, only a few can afford them* (UB_02).

Focusing on the local markets, one fisherman said: *We need better markets and research around public awareness to increase local markets as the best lobster is in the spring* (UB_08). Highlighting the premium status of the lobster, another participant said: *Lobster is to many people a delicacy and in a tight economy people not gonna buy lobster at ten dollars, well let's say eight dollars a pound when two thirds of it is waste when they can go buy a roast of beef and then eat all of it . That is just the reality of the market, lot of seafood; lobster, halibut, scallops, they're seen as like for people from away from here, they're seen as a delicacy and as a specialty meal you know, not something that you just throw on the supper table at night* (CI_05).

Supporting the call for marketing research and business skills, a couple of the participants suggested that fishermen needed to change their current approach by: *Doing business courses as fishing is a business and fishermen should be educated on good management practices* (CI_01), and *Fishermen should have business skills, and a wiliness to change opinion and way of doing business to better manage their approach to fishing* (UB_06).

Investing in inshore fisheries

Some fishermen saw an opportunity for maintaining inshore fisheries if there was a way to increase investments: *Opportunities exist in the fishery, and if there is a way to encourage investment in marketing, science, research, knowledge management [that would be very helpful]. There is also a need for a governance system that recognises the pros and cons of each [management] option, and the interconnectedness [of different industries]* (UB_06). Referring to scallops, these participants also said: *As we are the only ones buying scallops during the season it would be good to have more people in the scallop fishery to ensure the supply* (CI_02 & CI_03). Similar another participant called for loan boards and provincial agencies to provide more support for fishermen and processing: *Would be good if loan board could invest in fisheries by lowing interest rates and more provincial support* (CI_06).

Developing community initiatives

Looking to the future, one fisherman suggested that perhaps: *There needed to be more community-based cooperatives where people can actually contribute more to the harvest, to the market and all benefit, you know mutual efficiency. Although it'd be very complicated to implement but I do strongly believe that if there was a way to go back how it was three decades ago with more cooperation among everyone and a system that would work better and the government would cooperative with [things would be much better. But everything is set in the electronic age now everything from the sustainability, traceability, and all that stuff cost so much to work and implement* (UB_02). Along similar lines, this participant mentioned the practice of bartering: *It would sort of get back to the old days. I remember my wife's father said it would be back to changing chickens for pigs and trading eggs for milk and I think it's going to go back [to that]. Some of them old people you think they are nuts, [but] they know more what they were talking about then* (DI_02).

7.5 Technology threats and opportunities

7.5.1 Technology threats

This section presents examples of where participants have described technology threats to either species/environment or to the fishermen. The greatest threat to species and the environment from technology was the increased efficiency of fishermen to find and catch stock. The most important threats/issues of technology to fishermen was the increased expenses for bigger boats, new navigational instruments/gear, and government mandated courses/certification. As noted in the social and economic changes and threats sections, increased financial stress was considered to have a negative impact on community cooperation. For older fishermen learning and operating new technology may also have been personally challenging.

Threats to species and the environment

The greatest current threat to fisheries/lobster from technological changes/coping mechanisms was the increased efficiently of fishermen to find and catch these stocks. Examples included: *So because the equipment in the past was simple but still effective and to certain extent helped the stocks, but now fishermen and their new toys that they use now and they become more efficient. But this also [means] they have higher loans that they would have to pay and it would be more expensive. So fellows fishing harder, and some fish harder than others cos that's what they want to do*. (UB_01), and *3D mapping has increased the ability of getting good catch, on one hand good for economic return, on the other could be bad for the environment/species due to over-fishing* (CI_06). Other participants also noted: *Everybody has got newer gear right now, bigger boats and everybody fishes a lot harder than they used to, I guess. They [also] go offshore further deeper water. In the past we didn't used to leave the shore we just fished along the shore* (UB_04), and *The only threat to the fishery as far as technology goes is the gear is getting too good for the fish. Like we finally outsmart the fish, and there is no place for them to hide that is a big thing* (CI_04).

Reflecting on the current issues with aquaculture, this participant said: *I think one of the problems in our fishing and we can't blame it all on aquaculture is because we saw a declining fishery before aquaculture come along, before salmon farming come along. I think one of the major problems is that technologies outpaced the ability of the resource to regenerate itself, fishing equipment has become more efficient and very, very sophisticated* (CI_05).

With new technology, although fishermen could go further, and stay out longer, it also increased the potential to access areas where there were informal gentlemen agreements about who fishes there: *Changes in scallop fishing practices as people fish more or longer than they used to, also* *more boats and moving into other fishing areas but not sure if this effects community cooperation or increase conflicts* (UB_10). As noted earlier, other fishermen had mentioned the impact of Island boats moving into their fishing space, especially around Saint John harbor, which may also have been perceived as being crowded because of the other industries operating there.

Technological factors affecting fishermen

The most important threats/issues reported by fishermen related to increased expenses, especially the initial cost for new electronics and upgrading to bigger boats: *You've got to be able to fish when the lobsters are there, so it's bigger boats and better electronics. Huge costs, it takes $20,000 to rig a boat up, and it just basically electronics and then looking at a new boat* (UB_05). Whereas another said: *Gear is more up to date, people invest in their gear now because it has bigger boats, but also need to fish harder to break even* (CI_07). Also referring back to AIS systems, the participant noted *AIS are expensive, was around $7-8,000 when first came out, but now down to about $2-3000* (CI_02). Similarly, this fishermen thought that it would not be technology but economics that would make a person leave the fishery: *Well, I don't think technology is going to you know, decide whether to leave the fishery and all, I think what it is going to be [is] economics* (UB_06).

There were also costs associated with taking government mandated courses (sea safety, radio, etc.) required to run a fishing boat with this new equipment: *That's a lot of money now for a fisherman, when my husband took it years ago it was not that expense, and it is the same course, if you wanted to run the ferry from Nova Scotia to Saint John, so it's like one size fits all sort of approach* (CI_01). This participant also commented: *There were many courses needed and these are quite expensive, although some are subsidised by government*.

One of the older fishermen mentioned the sense of being overwhelmed with all the new technology: *All the technology it is great, but I haven't got the knowledge to run half the stuff. Over the years, I just fish where I have been fishing for the last 30 years now or 40 years really. I have got all the new electronics, but I don't know why? I just bought it for the sake of buying* *them but I hardly use them. Although I'll admit they can make things easier but I'm just used to doing it the old way I guess* (UB_10).

As mentioned in earlier social and economic sections with the considerable pressure to recuperate costs, fishermen tended to be less cooperative and/or honest amongst themselves and/or with the regulators/buyers. For example, this fisherman noted: *The more efficient you get the more money you need to make ends meet. We are not planning the kind of fishery that we want, and it puts tremendous pressure/incentive on people to cheat just to pay the bills* (UB_06). Looking to the future, another participant observed: *Technology is going to have huge impacts. Oh yes, we just take more and more and more, and we are fishing on quantity instead of a quality, and it's how much can we catch because the price is so low* (UB_05).

7.5.2 Technology opportunities

This section describes examples of the most frequently mentioned technology opportunities. The greatest opportunity was the increase in fishing efficiency, but as noted earlier, the flip side was that this approach also had negative impacts on species and benthic environments. As electronics became cheaper to produce, prices for older versions tended to decrease. Other opportunities that grew from technology advancements included improvements in sea safety, marketing options and exploring new/underexploited species, and intergenerational learning.

Fishing capacity and capability

Improvements in fishing gear, electronics and bigger boats have allowed fishermen to find lobster and other fish more easily and efficiently: *So the lobsters are definitely more successful in being caught in the last 20 [years] and I believe it's because we have come quite far in technology and in their ability to catch them. I mean, 30 years ago, people used to put their traps in the water and they never moved them the lobsters always came, they migrated up and down the bay, and the lobsters would come and be caught and when left again, they would generally take the traps out. But, nowadays fishermen move with the migration, wherever they go* (UB_02). Another fishermen said: *Well when I first started we all hauled the traps by hand and of course we went to the haulers and the hydraulic hauler, and everything's fingertip control now and you can handle more gear* (UB_01). The increasing use of electronics and the improvements also meant that fishermen could easily share knowledge about fishing areas, navigational hazards and other information amongst themselves: *Loran then into GPS/Chart and plotters, video chart plotter/3d bottom means knowledge can be easily passed along* (UB_03).

Reduced expenses

Navigational electronics also helped fishermen find lost gear more efficiently: *Yeah, finding new areas and getting back to your gear. Like years ago, say if it was foggy you might not go and haul your gear, but today you just you know what you set it because you punched into the computer and the computer will take you right back through so you could go. It helps you that way as far as being able to haul your gear on days when you normally wouldn't be able to* (CI_04). Looking to the future one fishermen suggested the possibility that there might be a specific lost gear finding device invented: *Technology could be used to manage and improve fisheries management, for example fog is an issue, and perhaps could come up with something that would help fishermen find lost gear* (CI_07).

With these technological improvements, participants were able to cut down on costs and in some cases clean up the environment: *Technology helps us to re-locate lost gear, which in turn helps keep costs down and clean up the environment* (CI_06). In another example, this respondent said: *Before when we were using ordinary bait bags (cotton) we would lose a lot of the bait to the sand fleas, but now with the velcro, we save on these costs as they are stronger* (DI_03). Whereas this participant commented: *In the past we would get the spruce poles off the tress and take them to the saw mill so we could make our own traps. Now, everything is all wire, and that's been a blessing as they last longer, and fish just as good, with less repair and upkeep* (CI_04).

Improved sea safety

Sea safety improved with the change from wooden to fiberglass boats, gas to diesel engines, and the incensed use of navigational electronics: *Fiber glass boat has been a tremendous improvement they are strong and no/much leakage all, I would never want to go back to wooden boat again* (DI_03). Radios and safety equipment/DSC also made fishermen consider themselves safer. A specific issue for fishermen in this area is the fog. For example: *Radar was the good thing, because it is very foggy here. During the first year when I had my first boat the only thing*

I had was radio and I didn't even have the depth finder, I had a CB radio up [by] my head and the compass and a watch. Of course, now the GPS saves a lot of grief, those are the like the two most important I would say (CI_01). Another respondent said: *When we first started we never had radar, so we didn't go as far. I would say the deepest trap we had was probably what we called then was a forty fathom line and that wasn't very far offshore, now we are able to get to within a mile, mile and half off, whereas before we would be like probably nine mile off* (UB_10).

Marketing and exploring new and underexploited species

Looking to the future, this fisherman said: *We need to be more economically viable over the next 50 years* (UB_03), and one approach would be to improve marketing through the internet and business websites: *Oh there's huge marketing potential for a small business to set up a site for people to order direct from you and then you ship it out the next day* (DI_05). Technology could also be used to economically explore species that were currently not being harvested or under exploited: *Well there's a number of species that are not being harvested, such as quahogs, eels, and hagfish, which have the numbers now. Although they're not a terribly desirable fish there is a market for them* (CI_05).

Intergenerational learning

Changes in electronic reporting and monitoring protocols provided opportunities for intergenerational learning. For example, this participant noted: *With the e-log system, we still have to enter it into the system and we would still have to verify [the information]. I have two children that are in the IT industry so they're a big help as they are teaching me to keep up* (DI_08). Amongst fishermen, new technology also provided them with opportunities to learn and share information: *Technology has opened up a lot of opportunities and that's going to be I think a good thing. New 3D bottom mapping with sonar, picture of the bottom, and like if you got one and I've got one, we all got one, we all get our own information and so can help each other out* (CI_01).

7.6 Management threats and opportunities

7.6.1 Threats attributed to the implementation of management practices and policies

The two most frequently mentioned threats emerging from management practices and policies were (a) the potential introduction of lobster quotas, and (b) fishermen's relationships with government agencies. In addition to these threats, participants were also concerned about weather and environmental changes, and the apparent misalignment with current fishing seasons.

Weather and environment impacts on fishing seasons

A big concern resulting from shifting weather and environmental patterns was how well fishing regulations reflected these seasonal changes. Of major concern was the timing of lobster migration runs. For example, this fisherman said: *After all they got to come, the whole Bay of Fundy length, I'm not sure how 30 miles across there, 30, 40 miles like sort of Grand Manan is sort of not in the middle, but I think Maine comes up this way and Grand Manan is way down and Nova Scotia is way down, so migratory patterns for lobsters have to go through other fishing areas before they eventually they got to come here* (DI_02). Note: starting with 2017/2018 season and continuing for three years DFO extended the spring season for 10 days as a pilot study[62].

For some participants, this was their biggest threat: *I think our biggest threat is if we don't get a change on the season. Our fall lobster is dependent on the weather, [and] when they (DFO) canceled the season for two days last fall, fishermen with payments, needed to go, and they went because they also had bigger boats. But other fishermen will follow who may not have these same capabilities [because they also have debts, and so may ignore safety warnings]* (CI_02 & CI_03), and *We have tried for quite some time to get those seasons shifted by one week and they won't do that either, so they are not following conditions that reflect the environment* (DI_01).

Introduction of lobster quotas

The introduction of lobster quotas was the most discussed topic under management threats. Most participants considered current regulations as being adequate: *Currently the lobster fishery is doing so well under current management, why change what is working* (CI_02 & CI_03), *Lobster quota, why, we have seasons and trap limit with other conservation measures and log*

[62] https://www.dfo-mpo.gc.ca/decisions/fm-2017-gp/atl-20-eng.htm

books, seems to be okay and effective for the fishery (CI_07), *The lobster quota coming into the lobster fishery, I hope not, you know the lobster industry right now is sustainable* (CI_05), and *Quotas don't work, they work really good on paper there's no doubt about it* (UB_01).

Although generating a few positive responses (see opportunities section), many of the participants had concerns citing past examples of where quota had been introduced. For example: *If they put quota that would be tragic for us like what happened in other fisheries, but they could I suppose*(DI_05), *The biggest threat here would be if government put some stupid regulations like quota on the lobster, like they did with scallops, they just wrecked the scallop history here for us, lobster quota would not make the fishery profitable* (UB_09), and *I don't know how long it will take, but if they were to introduce quotas it's just the mechanism to eliminate the owner operators and the small fishermen and they want to give it to the company, which is the government agenda, they did the same with the ground fish fishery, right* (UB_07). Also referring to the groundfish experience, this participant responded: *I think the minute they introduced it we would be over like the groundfish fishery. See governments like quotas because it gives them paper and numbers for people who are being accountants. Quota is the poorest management tool, it's impossible to enforce whereas the season, it's the easiest thing to enforce both because you can't be on the water, you can't have eyes everywhere, all the time watching people* (CI_01).

Similar issues have also played out in the herring fishery. This fisherman from Upper Bay noted: *Like the herring fishery, for example these forty-nine vessels that had the original quotas they're down to eighteen and thirty-two or thirty-three percent belong to one large fishing company and another eighteen or so belong to another and that's what happens so your fishery becomes a corporate and the fishermen are fishing them, there are some owner-operators now in that purse seine fishery but very few of them and I would say in another generation there won't be any, it'll be all company controlled* (UB_01). Whereas, this participant from Campobello said: *We had 16 purse-seiners and 96 jobs but we only have one now I think there was Connors, Scotia Gardens, The Murphy's, they took all the quota and now most of the quota is owned by these companies and they super boats. They have 60 footers they got 120 footers and they can do what they want to do and you lose jobs because the money goes instead of hiring crew to these super boats,* *which are mechanised processing and so only need one person, when five could do the job* (CI_01). Explaining further, this same participant said: *The only thing that quotas would result in is that they will be gathered up by larger processers like Clearwater. You would have two to three boars from Deer Island, and two to three from here, and the crew would be paid next to nothing, and that would be the end of the community. The only thing that's keeping Campobello along right now is the lobster fisher.*

There was also some concern about DFO's knowledge of the lobster stock: *I think the reason that the lobster fishery is right now the only surviving viable fishery is because department of fisheries has not gotten their hand involved in it. First of all DFO has absolutely no idea what the strength the resource is to begin with, and they've openly commented on that themselves at various meetings I've been to. If you don't know the strength of a resource, how do you monitor it, how do you set a quota on it, how do you manage it, you know they're just throwing darts at a target on the wall is all they're doing* (CI_05), and *What they are doing now is collecting data on your catch history in this area without knowing where different stocks are coming from. The Bay of Fundy is broken up into different fishing areas, but DFO has no knowledge about what is happening, where the lobster come from and what the environment is doing to the stock* (UB_07).

Fairness in the allocation of quota was also a big concern: *I don't know how they would make it so that is fair for everyone. Although my catch might not be as much as everyone, as I only started fishing last year, but when I was fishing with others, I caught as much as everyone else. Also some people had much cheaper licences like 10,000, whereas I had to pay 150,000, how do you make it fair?* (CI_02 & CI_03).

Questions relating to complex shifting environmental conditions and the impact that quotas might have on the fishery were also raised: *Lobster quotas would have an impact for us. Like we have a trap limit but we have no quota on pounds, but if they shifted to quota I would not be happy because like we're seasoned and then we have our trap limit right, so that's plenty because our spring season opens the first day of April or the last day of March depending on what day it falls on, and you couldn't catch enough lobsters to pay your fuel bill let alone* *anything else before at least the middle of April, if not the end of April, first of May* (DI_01). Describing another issue, this participant said: *A quota wouldn't help because the catch can be up or down, for example this spring's catch compared to last spring's catch at the same time is off about nine - ten percent, which I think are influenced by the weather patterns., I mean everything's a week late this year, so back about six, seven years ago, the fall fishery was the strongest fishery that the guys have seen here in a long time and then after that it dropped back to your average weights. Its s a very fickle industry, and the spring fishery is weaker than the fall fishery, so it'd be very difficult if DFO brought in a quota and said, 'okay quota's gonna be three million pounds but it wouldn't make any difference to us because our boats can only sell to us what they catch* (CI_05).

Relationship with the government

Groundfish fishery legacy

Participants reflected on the past history of the fishery and the role is has played in their relationship with government agencies, specifically DFO: *The collapse of the ground fish fishery started out when the EEZ for Canada was established when the government recognised the economic value of the fishery, but we can be our own worse competitors* (UB_03). The consequence of ocean management not meeting its goal, was thought by this participant as being one of the main reasons for: *Going from an unregulated ground fishery to no fishery now* (CI_01). As such, another participant described: *Regulations as being put in place after harm is done, [but it] should be done before hand. We need to monitor changes, and let someone know of these changes* (CI_07).

Current relationships

Describing the mistrust between fishermen and the government as a serious threat to being able to work collaboratively, this fisherman said: *Not enough discussion between government and fishermen. From what I could see dealing with government if it is DFO or whoever I've seen at meetings, if all the fishermen agree to something, then they think there is something wrong with it, that's the whole problem, people have no trust. Sometimes we would like to try something different but the only trouble is, it's written in stone, and the government are scared to take any chance at all. Yes we would like to try this or try that but the government doesn't want to take* *chances so they just say no to the fishermen. [I don't think] it'll ever be changed, so it's very discouraging* (DI_10). Another concern was the privatisation of the lobster fishery: *I know government or community or academics could help if government tried to privatize the lobster fishery. I mean government makes rules that we have to play by, and the only way that that lobster fishing will be privatized will be lobbying by the companies* (CI_01)

Sharing his experience of working with government officials this participant said: *I was in fisheries for one year as I thought it might be good to see what it was like by working with them. But they did not want the fishermen to work with them, even if you went down and had a coffee with the fishermen, the office would say we don't want you have a coffee with them anymore as if we don't even want you to be friendly with them. [I think this] was sort of an internal policy* (DI_03). Whereas another fisherman described the situation as being: *Government is playing one industry over the other, aquaculture, fishery, LNG and gas, need to level the playing field and recognise all users. Some of these new management regimes following 9 11 security regulations, was an excuse to get rid of the fishermen at the Saint John Port* (UB_08). Explaining further, this same participant noted: *Government is saying that it is all about jobs and economy security, but not about conservation of the environment*.

Not all regulations made sense to fishermen. For example, this fisherman described some of the issues he has faced when collecting ghost traps: *I'm not allowed to keep a ghost trap aboard my boat, I gotta throw it back over. Well I guess it's because it's somebody else's trap, DFO are afraid that you're gonna put a buoy on it and fish it. I'm not interested in fishing somebody else's traps, I just want to call you up and I'll give you the tag number and I'll tell you what time I'm gonna be at the wharf with it so you can collect. So now I bring them in anyway and I don't pay any attention to DFO, I just have them aboard the boat and I put them on the wharf .All the regulation changes are not for the better* (UB_11).

Collaboration on research projects with government was also considered to be limited: *Government not interested in consulting with locals, and research projects are a concern as they are government/industry driven, we also need scallop surveys* (CI_06). Another issue was information transparency: *Most research is being done by government, but we do not get to hear much about results* (UB_03)

Government support and fairness

Although, some fishermen had considered government as being a resource that they could seek assistance from, others differed. For example, these participants though that: *Government was more supportive toward larger operations, but 10 employees is a big difference to a small community, much of the provinces funding goes to Gulf, made in Atlantic Canada logos to increase prestige/sales/awareness, but somewhere along the line money needs to be passed to the little man* (CI_02 & CI_03). Describing this situation further, these same participants noted: *Processing is the added value and money making arm of fisheries, and government does not support small community initiatives. If we could get money from government we could process clams and lobster all year long. At the moment [our] licence is only for 10% of our lobster catch, and we can make work, but it costs allot* (CI_02 & CI_03).

Fishermen also had concerns about other fishing associations, such as Grand Manan, and their political clout: *Government always works with Grand Manan. If Grand Manan don't want lobster quotas there won't be lobster quotas here. If they want lobster quotas they will be here as they runs the fishery here. For example, we'll say a couple of times, we'd like to have the season extended in the spring or maybe opened early in the fall and Grand Manan say we don't want that but we are one area and if they don't want it in their area that's not none of their business, but they want the say on everything* (DI_03). Another participant noted the perceived favoritism by the government for Grand Manan: *In a way there is already a quota albeit it's not a level playing field. That quota is based on traps, right, we can fish three hundred traps on a single license; yet in Grand Manan they can fish three hundred and seventy-five traps on a single license, Alma can fish three hundred on a single license, Nova Scotia has two limits; they have a spring limit and a fall limit, so it's not a level playing field. Grand Manan can fish three hundred and sixty-five days a year because they fish the grey zone, but we are (LFA 36) not allowed, in this area. We fish in LFA 36 from April one to June twenty-eighth I think it's gonna be this year and then we fish from the second Tuesday of November to January fifteen but the guys usually are in before Christmas, so it's a much shorter season* (CI_05).

Native fishermen

Some fishermen commented on how regulations and management policies were being applied differently. For example, this fisherman said: *In the native fishery, in St. Mary's they don't need it, they just take 10 people off the street, give them names and away they go, but for anybody else it's the $50 deal* (UB_05) and *It is difficult for young folk to get into the fishery because government's made it so difficult now. When I started with my cousin he showed me how to fish. The way that's set up now, the first thing you gotta do if the young fellows walks through that door and wants to go fishing with me, is I have to buy him a $50 fishing permit so he can go with me. If he goes with me, I can probably get away with a year without him having to take his Marine emergency duties certification (MED) and that's four hundred dollars. So either I would have to pay it or he would just say no I'm not paying that to go fishing, and I mean, cos all they're after is a job* (DI_10). This participant also considered the bias in politics as being a threat to who gets licences: *If your licences were guaranteed more young people would enter fisheries, but, politics plays a big factor in determining who gets what* (CI_06).

Aquaculture industry

Management's responses to ongoing aquaculture issues was considered a major threat by fishermen: *There has been lot of salmon pollution, and I suppose the aquaculture companies could be responsible for cleaning up some of their mass as far as the companies that are dumping chemicals into the water. That would be I don't know the environmental oversight (Environment Canada) would have to take care of that as I can't make them stop dumping chemicals* (CI_04). This participant also thought that government were not doing enough to hold the aquaculture industry accountable: *The government [should be] saying when you start a farm, you need to sign a waiver that says you are going to clean up if you leave, or there is some other issue, maybe leave $30,000 in a kitty, or if you don't clean it up someone else will [and arrangements have been made]. But the government don't even ask them because the government is in with them, it's the government's own baby* (DI_03).

Looking to the future, the continual use of pesticides and apparent lack of concern by the industry is still major concern to fishermen: *You know the way I put it is it's going to be a flip of a coin as to what dies first; the aquaculture industry or the Bay of Fundy because right now it's been shown* *through Environment Canada testing that the pesticides that they are using on these sites kill all crustaceans including lobster larvae. Lobster larvae comes into the shore to mature and the pesticides that was being dumped in the Bay of Fundy by Cookee's and Ingalls last summer, we won't see the impact this fall but I would say three or four years down the road we're gonna see an impact where we've had young lobster killed off* (CI_05).

7.6.2 Management opportunities

This section presents examples of the most frequently mentioned management opportunities. These were: (a) aligning fishing seasons to reflect environmental changes, (b) implementing lobster quotas, (c) building government relationships, and (d) community based management and research projects. Some participants also reflected positively on current regulations and procedures. For example this fisherman noted: *I mean right now abuse of the fishery is I think minimum, and I think is pretty tightly controlled. We've got fisheries officers who show up at the wharf to check the product, to make sure that there's no undersized or berried, that there's no v-notch and that control extends beyond the fishermen to the buyer, so DFO can check that product as well and we're also required not to have in our possession undersized lobster or berried lobsters or v-notch lobsters* (CI_05). Describing new regulations in the industry, another fisherman noted: *They have started to use some of the American techniques as far as conservation on the lobsters here is like, what they call them jumbos and they cut to what the maximum size and throw them back because they produce more eggs* (CI_04).

In the context of the herring fishery, this participant saw an opportunity if: *They do away with the core fishery for the weir fishery, and the individual transferable quotas in the herring fishery, I think those two things that really hurt the fishermen* (CI_04). Expanding further, he said: *If the fishery is being over fish, put a quota on it yes, but don't allow one person with a little bit of money to buy everybody's quota, so there should be restrictions on how much quota one person or company could have* (CI_04).

Aligning fishing seasons with environmental changes

Participants would also like to see fishing seasons changed to better reflect environmental changes, and hence maximise the opportunity to catch lobster when they would be best for the market: *Well the environments changed and the migration pattern has changed but the seasons haven't. So it's not truly reflecting what's happening, it's more a paper thing that's all. We've tried to get the seasons changed, and we'd give up two weeks in spring to get one week in the fall and they won't give it to us* (DI_01), and: *If we could fish another week in July, and take off a month of April when our catches are low [would be best] as what would happen would be we'd have a better product, it's a harder-shell lobster, so it's worth more. The effort to catch that amount of lobsters that you are used to for your income would be less, and because weak lobsters drive a lower price, if we can work on harder shell, better quality lobster we would retrieve a higher price* (UB_05).

There was also an issue of fairness and the perception that some fishing areas benefited over others because of ongoing environmental changes: *Other fishing districts are benefiting because of the changing weather/water temperature patterns, it would be good to change the seasons to better suit the weather patterns/conditions* (UB_09), and: *A better season structure, April and January are useless, it would be good to level the playing field, have come a couple of times close to having an extra week* (UB_07). As an example of what this could look this participant described: *We were trying for years to get a better of season out of that than what we have. It's very short and there is one month that's well sometimes two months are totally useless, April and January. Whereas our neighboring districts Glengarry may fish all winter, not that they catch lobsters all winter but they have that option* (UB_07).

Lobster quotas

Although most fishermen thought lobster quotes were a threat, a few participant also considered this as an opportunity: *Lobster quotas could be an opportunity and not a threat, with the ITQ market, there is the potential to make more money and encourage better management decisions, which could reduce the competitiveness with neighbouring fishermen* (UB_06) and *Only fishery without quota, is this a threat or opportunity, I think this depends on quota, would be better if ITQ were introduced as it would allow fishermen to make a business plan/allocate fishing time/ and align schedules* (CI_06).

Contemplating further, this fisherman said: *Lobster quotes, when they come in will be a good thing as I can make my business plan, if I know how many lobsters I'm allowed to catch, I'm gonna go catch them when the market's right, when price is right and I don't have to worry about seasons, trap limits, any of the rest of that foolishness, I go do my thing, catch my lobsters and I'm done. I can also do it in good weather, in July and August if I wanted to but the problem that I have with it, and like I've told DFO this already; I'm not against quotas in the lobster fishery as long as you don't do to me what you did with the groundfish and the scallops*. (UB_11). Explaining further, the fisherman noted: *The problem that I have right now is that I have a hundred and seventy-seven bosses telling me what to do, so if 'I should have a quota. I shouldn't have to consult with all of them because all its gonna do is benefit them, and that's why nothing can get done no matter what you try to do in the fishery as [there are] so many guys you have to get consensus from them to change a thing, and so it'll stay the way it is from now to eternity* (UB_11). Still, if quota was to be introduced, another participant responded: *If DFO went to a quota it would probably they would probably look at ITQs based on historical catch of the fishermen that certainly would be the fairest way to do it with historical catch* (CI_05).

Building relationships with government agencies

Participants considered working together as a primary component for creating management opportunities that could benefit both the communities and the environment. Many participants thought that to do this they would need a stronger voice at the table: *Fishermen's voice, good voice to have at the table, representatives can take ideas to government, [present] smaller projects but [could introduce] big change. For example without an association when quotas [for scallops] were set we would not get our share* (CI_07). Other suggestions included: *Having a Minsters round table and allowing fishermen to voice their need for change* (UB_08), and *Other ways to raise profile is to keep everyone involved, but [the downside] being possible burn-out. Committees tend to come together when there is a crisis, but need more work on being proactive, such as making space for fishermen in the Saint John land use plan as this is important for us* (UB_08).

Another participant thought that a coordinated effort in the lead up to elections could help bring about changes to the fishery, and create a stronger voice for fishermen: *Need to put pressure on* *the politicians and regulators, the only way to make sure that fishers are heard is to put pressure under politicians, especially in the election year. In this area where my constitution is, it would be hard to put pressure on fishing issues because there is so many other issues o here it would only be a small percentage. In Charlotte County for instance a lot of fishing goes on down there so, would be an opportunity to make fishing an issue* (UB_07).

Integrated governance was considered a possible opportunity, although there were also some concerns: *I am a strong proponent of set governance system that is integrated, but currently [there is] no system in place to be able to make decisions. The biggest hindrance is the process is being able to make decisions* (UB_06). Explaining further, the fisherman said: *How do you bring industry, community, government together and how do you motivate the people on the outside, this is where ITQs level the playing fields, so overall it is not a terrible threat* (UB_06).

Highlighting this challenge, other fisherman noted that although it: *Would be nice if industry and government would work together but there are many fishermen with other opinions, which distract from areas that need discussion such as the grey zone* (CI_06). Conversely, this fisherman also remembered pervious warnings from the government about changes coming, but no one had paid attention: *Government has told us for years that things are coming and they are going to come. We had [the] opportunity to consult with Transport Canada to help what they are now enforcing such as safety training etc., and up skilling where the costs are high ($5000) almost as much as trade school, and we were told about this 10 years ago now it has come back to bite us, same thing with marketing lobsters* (UB_06).

Other participants discussed successful collaborative projects such as: *We have had success with DFO and academics around whale rescue from entanglements in fishing gear and lobster traps* DFO (CI_06) and *Anything that has helped fishery in LFA 36, like the increased minimum and maximum size on lobster and size of maturity initiated by the fishermen and supported by DFO* (UB_11). Other good examples of collaborative research and agreements included: *Traffic committee resurrected during the LNG issues, and arrangements with authorities responsible for traffic lanes worked very well. There were also good group of stakeholder engagement for the ghost trap retrieval project. Another example was Velta's school project, which invited* *fishermen to speak to the class. Two of us did this, and we very much enjoyed doing the experience, but we were surprised at the lack of knowledge in the central city regarding local fisheries* (UB_08).

Aquaculture industry

Dealing with the aquaculture industry required a collective effort by fishermen, supporting NGOs, research/academic studies and media to highlight the seriousness of these issues. *I contacted people in provincial department environmental and the lobster lab at the Vet school in PEI, but did not go anywhere, until federal Environment got involved. I think provincial were trying to cover things up, because when Environment Canada was contacted, progress was made and an investigation was conducted* (CI_02 & CI_03).

The response from the aquaculture industry based on Environment Canada's findings was to introduce well boats that contained the chemicals within a closed environment (as opposed to the substances being directly released into the salmon cages). Even with this response, some participants continued to be concerned about future flow-on impacts: *The well boats started two weeks ago, doing the lice treatments and the problem is that we are not going to see [all] the effects [now]. There is an immediate effect now such as die-offs, but [more impacts may] could come later. Perhaps that why we don't see many lobsters this spring. I was thinking it is the weather but it could be other things* (CI_02 & CI_03).

Community based management and research

There was quite a lot of discussion about communities being more involved in decision making and research projects. For example: *I think the traditional fishing industry is responsible enough to be able to police itself without all the government red tape in it* (UB_02) and *Less government involvement the better. Every rule and regulation we have was bought in by the fishermen or fishermen groups e.g. trap limits, fishermen asked for it, fishing seasons, fishermen asked for it. It is easy to rubber stamp a regulation, but harder to put it into practice* (UB_03). Another participant noted that it: *Would be good if government let fishermen have more say in the management of the lobster fishery, so we could manage it ourselves but they keep talking about* *that but that never, really make any changes. You really have no say, lobster is king, so there are many spin-offs that could be beneficial to the community* (UB_09).

Focusing on research, participants talked about projects that they had been involved with, and areas that needed further studies: *Minimal research goes on that involves communities, I have taken part in lobster surveys and is good to get an idea of what was happening, hope lobster fishery stays the same, very big impact if it went, we need a precautionary approach. DFO science and organisation have a lot of experience in the past but communities have only taken part mainly as observers but we can also contribute knowledge based on being on the water daily* (CI_07), and: *The government should do more projects and involve the fishermen in these projects* (UB_03).

Suggestions for new research areas included: *Might be good to have a lobster hatchery to see if that would help support the stock, maybe put jumbo lobsters in a protected zone, allot of things that could be changed* (CI_02 & CI_03), and *Scallop spat collections, DFO used to do this 6 or 7 years ago not so much now. [We] would also like more science done on the lobster fishery* (CI_07). Conversely, this fisherman also had some doubts as to the efficiency of current research projects being done by government: *I think government does some research but I don't know if they have the right people involved when they're doing the research. Some fishermen have done a lot of research and stuff and even if government does look at them but how far that goes or whether it's just looked at, or doing something that's another thing* (CI_04).

Participants were also very interested in social-economic studies: *Research on markets and prices for products would be good* (UB_03) and *It would be helpful to get PhD students to do research in the social economics of District 36 and reveal some the incomes. For example, look at what is it costs to run a house hold and a boat and payments, what do you need to maintain a community based fishery, and why are people going out west so as to make the required changes and produce guidelines. We can then take the study to the government and say okay we need a change here because this study says this what we depend upon and need to have to make a living* (UB_05).

Looking to the future, these participants suggested that they: *Would also like to see a fuel committee set up for all users* (UB_08), and a project on: *Inter-provincial license transfer, but you would have to get Fundy North involved to put a project together. For example around an experimentally fishery, but you'd have to have a study saying that we're dirt poor and we're all dependent on employment and we need some other resources or we need a licenses buyback or you need to justify probably why you need to come up with some other alternative fishery* (UB_05).

7.7 Summary

Frequently mentioned environment threats to fishermen were from seasonal weather and environmental changes and increasing seal populations. Threats to the environment from human activities included (a) the legacy of past fishing practices, management approaches, and mindsets, (b) current destructive fishing practices and new technologies, (c) the aquaculture industry, (d) LNG/gas industry, and (e) general marine pollution. Environmental opportunities most frequently mentioned by the participants were: (a) investing in inshore fisheries, and (b) developing environment based industries.

The most concerning interrelated social threats affecting communities were (a) people leaving the community, an aging population, loss of community connection and identity, and loss/reduced public services. Other social threats included (a) the challenge of maintaining inshore fisheries, and (b) attitudes/behaviours affecting community cooperation. Social opportunities included options for (a) maintaining inshore fisheries, (b) expanding community composition and diversity, and (c) seeking eternal support from public and private sectors.

There was a general consensus that one of the most concerning economic threats was the increase in expenses, including fuel, bait, and fishing licences. Other threats included (a) the uncertainty of international and national markets, (b) repayment of loans, (c) loss of bottom space and loss/damaged gear, and (d) factors affecting employment options. Looking to the future, participants were also concerned about the limited opportunities for financial growth, increasing expenses related to food wastage and overall fishing expenses, the influence of China in the markets, and limited government support for inshore fisheries. Frequently mentioned economic opportunities were (a) exploring the potential for new species and/or developing underexploited fisheries, (b) improving marketing and branding strategies, (d) investing in inshore fisheries, and (c) developing community incentives.

The greatest threat to species and the environment from technology was the increased efficiency of fishermen to find and catch stock. The most important threats/issues of technology to fishermen was the increased expenses for bigger boats, new navigational instruments/gear, and government mandated courses/certification. For older fishermen learning and operating new technology may also have been personally challenging. The greatest technology opportunity was the ability to improve fishing efficiency. Other opportunities included improvements in sea safety, marketing options and the potential to explore new/underexploited species, and intergenerational learning.

Threats emerging from management practices and policies that were most frequently mentioned by participants were (a) the potential introduction of lobster quotas, and (b) fishermen's relationships with government agencies. In Participants were also concerned about weather and environmental changes, and the apparent misalignment with current fishing seasons. The most frequently mentioned management opportunities were (a) aligning fishing seasons to reflect environmental changes, (b) implementing lobster quotas, (c) building government relationships, and (d) community based management and research projects.

Chapter 8: Exploring relationships between specified resilience and risk

8.1 Introduction

This chapter will illustrate that although risk and resilience approaches both have important contributions to make in helping communities become more prepared for familiar events (e.g. rising operational costs), when considered together, it allow for a more coherent approach to SES management. Here, I explore the relationship between concepts of specified resilience and risk drawing from key themes and sub-themes from the interviews. Specified resilience refers to the resilience of some part of the system to a particular kind of disturbance (Carpenter et al., 2012; Walker & Salt 2012). General resilience will be discussed in more detail in Chapter 9. This chapter begins with a summary of changes, coping strategies, threats and opportunities described in the previous two chapters, followed by a discussion of key themes and sub-themes developed from a second and third round of interview coding. The emerging themes and sub-themes demonstrate that although environment and social stresses play key roles in how fishermen respond to changes, threats, and opportunities, what may often be overlooked in the traditional risk and resilience literature are conceptual and mental models that influence the actions of an individual or community.

Similar to findings from the groundfish fishery study, what may have initially been a copping or adaptation strategy for a community or individual has the potential to become a risk factor at a later date. Although, this could be considered true in many situations, the focus on short-term management strategies to address a crisis may often overlook the need to plan and manage for other potential risks that emerge from current interventions. In this context the bow-tie visualisation tool is a useful approach to identifying different threats and building in strategies to either prevent or mitigate the consequences of these events. Another contribution to the risk and resilience literature builds on the Brooks and Pelot (2015) risk and resilience model, by drawing insights from Cutter et al., (2008). Here, resilience factors could potentially be built into a risk management framework to help strengthen the SES, both prior to, and following an event.

The chapter begins with a synthesis of chapters six and seven, followed by summary and discussion of the themes and sub-themes that have emerged. This is followed by an exploration of the bow-tie visual tool both in a general sense (as a brainstorming tool), and then as a means to identify areas where specified resilience factors could be built into the risk management model to strengthen the system prior to an event (e.g. building the resilience of the inshore fishery in relation to impacts from the aquaculture industry). The chapter concludes with a presentation of two insights that have been gleaned from this data.

8.2 Synthesis of chapters six and seven

8.2.1 Summary of changes, coping strategies, threats, and opportunities

Table 12 provides a summary (frequency) of specific responses provided by participants for each of the four categories (changes, coping strategies, threats, and opportunities) across the five domains (environment, social, economic, technology, and management). A total of 482 data reference points were drawn from the interviews and coded first by domain and category (Table 12), with detailed examples provided in Tables 13 a-e.

Table 12: Breakdown of responses by domains and categories
(% within respective column)

Domains (n=482)	**Categories**				
	Changes (28%)	**Coping (18%)**	**Threats (33%)**	**Opportunities (21%)**	**Totals (n)**
Environment (17%)	20	16	19	9	80
Social (21%)	35	23	16	6	99
Economic (29%)	18	44	32	28	142
Technology (11%)	12	5	9	17	52
Management (23%)	15	13	23	40	109
Totals (n)	134	87	158	103	**482**

Most comments (Table 12) relate to economic (29%) and management (23%) domains, followed by social, environment, and technology. References to threats (33%) and changes (28%) were mentioned more often than opportunities and coping strategies. Changes were frequently mentioned in reference to the social domain (35%), followed by the environment (20%). Coping strategies were more frequently described under economics (44%) followed by the social domain (23%). Responses relating to threats were primarily referenced under economics (32%) and management (23%) domains. Environment threats were divided between threats to the environment from human activities and threats to the fishermen from the environment.

Opportunities were more frequently mentioned under management (40%) followed by economics (28%).

Participants frequently referenced economic and management topics, with most comments relating to threats and opportunities. For example, threats included increasing operational expenses and distrust in management's knowledge of the stock, whereas opportunities involved exploring new fisheries pending DFO approval for pilot fisheries. Tables 13 a-e provide summaries of responses within the five domains and categories. The examples presented in these tables align responses to changes, coping strategies, threats and opportunities as a starting point to explore the interactions between risk and specified resilience concepts.

As noted in Chapters six and seven, discussion topics relating to changes included inshore fisheries, the aquaculture industry, particularly its expansion, weather and environmental factors, operational expenses, advanced technology (boats, navigational gear etc.) and DFO management policies and processes. Coping mechanisms included leaving the fishery and joining fishermen associations, which provided them with a stronger voice at the decision table. Adaptive practises included being creative and experimenting, and changing fisheries. Important threats that participants were concerned about included aging community populations, loss of public services, limited potential for financial growth, the introduction of lobster quotas (although this was also considered an opportunity for some), fluctuating market prices for fish and seafood, pollution from aquaculture farms, changing weather conditions and the associated misalignment of fishing seasons, and the decrease in lobster stock from a number of factors, including illegal fishing practices, pollution, and shifting weather patterns.

Table 13a: Environment domain: categories and examples

Domains	Examples from (Chapters 6 & 7)	Categories			
		Changes	**Coping strategies**	**Threats**	**Opportunities**
Environment	Weather and environmental changes	• Warmer seas and seasonal temperatures • Increased frequency & intensity of storms /weather events	• Adapting fishing practices to weather conditions and seasonal migration patterns (e.g. lobster)	• Impacts on lobster and other species, migration patterns, health and size • Fishermen's safety at sea, increased expenses	*~Although none of the fishermen mentioned this, warming waters could also introduce new species to the area that could be marketed*
	Inshore fisheries (groundfish, lobster, herring, scallops, wild salmon) and other species	• Decrease in groundfish, closure of cod fishery • Decrease in herring, scallops, and smaller sizes, closure of the wild salmon fishery • Increase in lobster, but smaller and softer shell • Changes in food webs	• Leaving the fishery and moving to another area/province for work • Moving to another fishery in the area • Moving to another industry in the area	• Legacy of past fishing practices, management approaches, and mindsets • People and technology • Impacts from other industries (see marine and land based pollution/activities below)	• Natural return/increase in depleted stocks • Lobster fishery • Investments in inshore fisheries by private and public sector • Conservation and research practices
	Environment based industries (aquaculture and tourism)	• Growth in aquaculture • Increase in debris from abandoned/current salmon farms and chemical pollution • Fluctuating tourist numbers, less spending locally	• Inshore fisheries sharing space/environment with aquaculture industry	• Increased risks of sea lice and disease to salmon from overstocking (aquaculture) • Impacts to the environment/other users from chemicals /antibiotics • Space conflicts with weir fishermen	• Employment in the aquaculture industry (fishermen) • Subsidies from provincial Govt. (aquaculture) • Employment in the tourism industry • Support for local tourism development, linked to inshore fisheries

Table 13a: Environment domain: categories and examples cont.

Domains	Examples from (Chapters 6 & 7	Categories			
		Changes	Coping strategies	Threats	Opportunities
	Marine/land based pollution/activities	• Improved land based pollution regulations • Improved oil management practices • Increase in plastic pollution	• Recycling and waste oil management strategies (fishermen) • Reliance on industry /government oil plans • Compensation from the government /industry	• Oil and gas, potential oils spills, loss of space a • Point source pollution e.g. mining, garbage and sewage	• Increased community awareness of environmental issues

Table 13b: Social domain: categories and examples

Domains	Examples from (Chapters 6 & 7)	Categories			
		Changes	Coping strategies	Threats	Opportunities
Social	Inshore fisheries	• Shifts in which fishery was king • Fishermen encouraging family members not to go into the fisheries • Younger generation wanting a better life/ • Attitude of youth towards work (perceived by older fishermen)	• Fishermen selling their licences outside of the community	• Intergenerational learning e.g. fishing learnt from ones father, but sons will need/want to learn other skills • Changes to community composition	• Interest in fisheries by other family members, e.g. grandchildren • Education courses related to fisheries
	Community composition	• Aging population in many communities, as younger people have left for school /work	• Shifting into a retirement facility /location (Deer Island)	• Tensions between Upper Bay participants and native fishermen over	• Increasing diversity and learning about different cultures through interactions with

		• Tolerance/acceptance by communities for native fishermen & international workers.	• Fewer people, but younger generation having more children • Services and social events for international workers.	non-native fishermen captaining their boats • Loss/reduced community services • Fewer people coming into the fishery • Loss of knowledge and skills (weirs)	international workers • Investments from the public and private sectors for projects • Full year ferry service (Campobello Island)
	Aquaculture industry	• Loss of local businesses/plants that supported small scale farms	Fishing in a different area, although it could increase expenses and/or competition with other fishermen for space	Community identity (looking inwards) perceived to be shifting from inshore fisheries to aquaculture	See economic opportunities
	Community cooperation	• Less openness and working together • Increased competition among fishermen, and with buyers/processers/corporations	• Being friendly and getting along with people • Maintaining pride in an island/community identity	Factors affecting cooperation included competition (stock, prices and space), attitudes towards the future, and personal investment in the fishery	See management opportunities

Table 13c: Economic domain: categories and examples

Domains	Examples from (Chapters 6 & 7)	Categories			
		Changes	Coping strategies	Threats	Opportunities
Economic	Increasing expenses	• Fuel has risen sharply, other costs such as bait and gear have also gone up • Start-up costs have greatly increased, especially in the lobster fishery (licences, boat, gear)	• Fishing harder or differently • Being given a fishing licence (and/or gear/boat) by a family member • Dual citizenship e.g. Canada/US, thus	• Increasing expenses Employment challenges (people not coming into the fishery, hard to find crew) • Cost of fishing licences and start-up costs • Loan repayments	Investing in inshore fisheries by public and private sectors

		• Tidal turbines and wind farms, loss of space for fishermen • Marine traffic, lost/damaged gear	allowing people to work in Maine • Fishing multiple species	• Uncertainty and fluctuations in market prices (e.g. China/US markets) • Loss of bottom space and damaged/loss gear (marine traffic, wind and tidal turbines, oil and gas) • Limited government support	
	International and local markets	• Fluctuating fisheries prices and CAD (mostly decreasing, but some participants thought prices have stabilised) • Herring prices slightly increased, but many plants closed because of the decrease in stock • Drop in lobster prices after 9/11, mindset that it is a luxury item	• Experimenting and being creative, including anticipating market prices, setting up a side business, saving for a rainy day, and building /repairing own gear • New fisheries e.g. sea cucumber, shrimp, rock and Jonah crabs		• Improving marketing and branding strategies for promoting products at international, national and local markets • Using technology to increase market accessibility • Exploring the potential of new and underexploited species
	Employment factors	• Less opportunity to work across different fisheries/job types • Breadwinners would work in fisheries related jobs, or only one would work, now more likely that both would work and one would be working in a non-fishery related occupation	• Upper Bay fishermen have the opportunity to work in other industries (e.g. Saint John Port, Nuclear plant, construction) • Island participants rely more on fisheries/nature related occupations	• Loss of EI stamps if not able to work the required number of hours • Location and number of employment opportunities • Few opportunities for financial growth (islands)	• Able to obtain EI stamps for seasonal fisheries related work • Employment with the aquaculture industry • Tourism ventures, but subject to short seasons and weather conditions

Table 13d: Technology domain: categories and examples

Domains	Examples from (Chapters 6 & 7)	Categories			
		Changes	Coping strategies	Threats	Opportunities
Technology	Inshore fisheries (Fishing gear, boats, & navigational electronics)	• Increased ability to find and catch fish/lobster • Shifting from VHF radios to cellphones and computers for reporting in catch • Better gear and boats, safer and longer lasting	• Learning from experience, being creative, and sharing information with other fishermen/community • Reduced expenses e.g. easier to find lost gear, less expensive to buy now	• Increased efficiently by fishermen to find and catch species • Increased expenses for fishermen, which could lead to illegal practices and fishing harder	• Advanced fishing capacity and capabilities • Improved sea safety • Marketing of products
	Reporting & monitoring procedures	• Increase in the number of sea safer regulations • Increase in monitoring equipment (e.g. black boxes, scallop fishery)	• Adapting fishing and sea safety practices • Intergenerational learning	Mistrust of government's use of information and/or objectives (DFO)	See management and economic sections
	Information accessibility	Increased access to real-time data such as market prices	For the fishermen this could increase their ability to bargain, but for the buyer this might also increase their expenses.	Fishermen need to understand the technology, international market influences and critique prices on the internet.	Faster and more accessible information gathering (also see management and economic sections)
	Industry automation	Increased automation in processing plants and the aquaculture industry	Small facilities either making do with what they have, or become creative and experiment with different options	A reduction in jobs for the community and/or increase in costs for small scale processing facilities.	For the industry reduced labor costs and faster processing

Table 13e Management domains: categories and examples

Domains	Examples from (Chapters 6 & 7)	Categories			
		Changes	**Coping strategies**	**Threats**	**Opportunities**
Management	DFO Management procedures & regulations	• Increase in the amount of data collected and approach (e.g. paper to electronic, people to call centers) • Perceived there being less support from government for a non-core fishery (e.g. weir) vs a core fishery (e.g. lobster)	• Community based fisheries • Fishermen association and community organisations • Community focused research • External testing sources and communication with key government agencies	• Relationship with the government • Introduction of lobster quotas • Fishing seasons in relation to weather and other environmental changes • Aquaculture industry accountability	• Aligning fishing seasons • Working together • Community based management and research • Regulations in general • Lobster quotas • Information transferability (technology)
	Transport Canada regulations	• Increase in the number of sea safety regulations and requirements	• Subsidies provided by Government to pay for courses and recertification	• Course expenses • Risk that not everyone will comply with new regulations	• Safer boating practices and knowledge and skills to apply in the event of an accident

8.2.2 Key themes and sub-themes

This section presents the results of a second round of coding focusing on key themes that participants considered the most valuable/interesting to discuss. This synthesis draws insights from Chapters six and seven, across the five domains (environment, social, economic, technology, and management) and categories (changes, coping, threats and opportunities) to identify interactions between risk and specified resilience concepts. Collapsing the five domains and categories based on the saturation of responses, resulted in 14 broad themes. Table 14a presents these key themes and their frequency (%) as an indicator of participants' interest/knowledge on the topic.

Table 14a: Broad themes that were of importance to the participants

No.	Theme (n=482)	#	%
1	Inshore fisheries	115	24
2	DFO management process and policies	90	19
3	Operational expenses	56	12
4	Aquaculture industry	40	8
5	Markets (local, national, international)	31	6
6	Community composition	30	6
7	Employment factors	30	6
8	Weather and environmental changes	22	5
9	Social ecological systems (e.g. relationships that integrate environment and social practises)	20	4
10	Marine and land-based pollution	16	3
11	Community cooperation	11	2
12	Information accessibility	8	2
13	Transport Canada regulations	7	1
14	Environment based industries	6	1

Based on this summary, the top three most discussed topics were inshore species (24%), followed by DFO management process and policies (19%), and operational expenses (12%). The next most mentioned topics referred to the Aquaculture industry (8%), markets, community composition and employment factors (6%).

To further explore these broad themes, a third round of coding was conducted to identify sub-themes. Thirty-three sub-themes were identified and are listed in Table 14b. Naturally there is some overlap between themes and sub-themes (e.g. inshore fisheries, community composition, markets, weather and environmental factors, employment factors) so frequencies are not included, as the context is of more importance. Sub-themes that are italicised were more frequently mentioned than others, and those with an asterisk and bolded were the three most referenced sub-themes (Behaviours and attitudes, Environment, and Inshore fisheries).

Table 14b Sub-themes that were of importance to the participants (alphabetical order)

Adaptation strategies	*Government support*	Native fishermen
****Behaviours and attitudes***	*Growth (aquaculture and fisheries)*	*Relationship with the government*
Community based management/fishermen organisations/collaborative/ research projects	Industry automation	Saving/reducing costs
Community composition	Information accessibility	Sea safety
Community cooperation	Intergenerational learning	Seafood industry
Conceptual models	*SES legacy*	Senior citizens facilities
DFO Data collection/reporting and monitoring	Loan repayments	Services
DFO management process and policies	*Lobster quotas*	Tourism industry
Employment factors	Loss of bottom space and damaged/lost gear	****Inshore fisheries***
****Environment***	*Management issue*	Training and monitoring expenses
Experimenting and being creative	*Markets (local, national, international)*	

These sub-themes have been described in Chapters 6 and 7. The natural resource base of this SES provides an opportunity for fishermen to make a living by diversifying across different fisheries. The environment also supports multiple food webs and ecological processes that both directly and indirectly influence these fisheries. Surrounding this natural resource base are themes and sub-themes that describe the social system (Table 14 a – b). Using inshore fisheries as an example of a SES, Table 14 c describes four clusters of sub-themes that have emerged around this broad theme.

Table 14c: Sub-theme clusters emerging from the broad inshore fisheries theme

Clusters	Description	Sub-theme examples
Cluster 1: Mental/conceptual factors	This cluster describes examples of mental/thought factors that influence (positively or negatively) actions taken by the participants	Values (personal /community), Behaviours and attitudes; SES legacy, mental and conceptual models
Cluster 2: Coping/adapting factors	Examples of actions that participants took to deal with changes, threats or opportunities	Adaptation strategies, Experimenting and being creative, and intergenerational learning
***Cluster 3**: Fisheries related stress factors	Factors relating to pressures fishermen were facing (may also be influenced by their conceptual models and actions)	Sea safety and community cooperation.
Cluster 4: Social stress factors	Factors that relate to general community stresses, which are also influenced by fisheries related stresses and conceptual models.	Community composition and employment factors

Notes: Cluster 3 also has linkages to the broad themes, including: operational expenses (theme 3), the aquaculture industry (theme 4), markets (theme 5), and marine and land based pollution (theme 10). Sea safety is also linked to Transport Canada regulations (theme 13) and was mentioned in the context of weather and environmental factors.

The DFO management process and policies cross-cut across all four clusters given the agency's mandate to protect the fisheries, but also promote economic development. For example, based on the experience a fisherman might have had with DFO, there might be little faith in the agency's ability to manage the resource or ensure that regulations are applied fairly. For example, by changing the timing of different fishing seasons, the department seeks to manage the stock when it might be at its most vulnerable. However changing weather patterns also influence fish migratory patterns, and the new timing may not always align with when fishing might be the most profitable. Fishermen coped with these changes by taking out bank loans to refit and upgrade their boats and equipment, yet this also put some at risk of not being able to make their monthly bank payments if the fishing was poor and/or markets prices low.

An example of one connection between these themes and sub-themes can be summarized as follows. The collapse of the groundfish fishery was a significant event as demonstrated by the changes documented across the five domains. This event influenced (positively or negatively) what participants' believed/experienced was happening in their SES at that point in time (mental/conceptual factors), which in turn influenced how they dealt with this event (coping factors). Adpative strategies were successful for some fishermen (if the objective were to stay in the fisheries vs making a living by any means available), but also created other pressures upon SES. Inshore fisheries are embedded within a social /cultural /economic environment that includes factors such as community composition and employment. The combination and interactions among different factors may lead to opportunities for some fishermen - but pose threats to others. Similarly, the ecological environment is also affected by factors such as species lifecycles, population trends, climate change and impacts from other industries.

Clusters 2, 3, and 4 are self-explanatory and have been presented in detail in the previous chapters. The first cluster (mental and conceptual models) may not be so evident, despite the important role this plays in influencing how individuals and communities cope or adapt in response to fisheries and social stress related factors. The next section describes this cluster in more detail, especially in the context of the literature.

Mental and conceptual models

Community values

As noted earlier, risk implies both facts and values, and as such, encompasses objective and subjective components (Boholm, 1998; Hansson 2010). Charles, (1995) also notes the importance of including values and attitudes to better understand community actions and responses to environmental and social issues. Understanding the underlying drivers of people's values and behaviour can play a large role in defining the resilience of SESs. Drawing from other sub-theme examples and chapters 6 and 7, these values include: trust and fairness, maintaining a community identity, cooperation, youth opportunities, pride in being a relatively crime-free community, learning from other cultures, and the independence of being your own boss. All fishermen valued the freedom of being their own boss and considered fishing as a way of maintaining their community identity. Participants also valued different ecosystem services as presented in Table 15. This list also notes other relevant categories from the literature (e.g. MA, 2005; Hattam et al., 2015), which could be important considerations in the future. Italics indicate the services that fishermen noted during the interviews.

Table 15: Ecosystem services valued by the participants

Service		Category	Form/Function
Provisioning	Food provision:	*Wild capture sea food*	Products obtained from ecosystems
		Farmed sea food	
	Biotic raw materials (non-food)	*Genetic resources*	
		Ornamental resources	
		Medicinal resources	
Regulating		*Climate regulation*	Benefits obtained from the regulation of ecosystem services
		Disturbance prevention/ moderation	
		Nutrient regulation	
		Coastal erosion prevention	
Cultural		*Recreation & leisure*	Non-material benefits obtained from ecosystems
		Cultural heritage & identity	
		Inspiration & culture	
		Aesthetics/ relaxing	
		Education and research	
***Supporting**		Lifecycle maintenance	Services necessary to produce all other ecosystem services
		Gene pool protection	
		Nutrient cycles	
		Primary production	

<u>Trust and fairness</u>

An important value, which is partly attributed to the groundfish fishery legacy, was trust and fairness, especially between the fishermen and DFO, but also in the context of other/more powerful fishermen associations, large corporations, and politicians. Recognising the legitimacy of regulatory frameworks by fishermen (Jentof, 2000), Hirschman (1970) describe two forms of responses that reflect fishermen reactions to a regime that is marred by distrust: disobeying rules, leading to a risk in prosecution and fines; and finding a voice and capitalising on voting power to bring their issues to the attention of the authorities. Provisions provided for the entry of native fishermen (as a result of new regulations and policies), government's bias towards large corporations (e.g. aquaculture) and other fishermen associations, (e.g. Grand Manan), and the general limited approach to research and knowledge sharing led to further erosions of trust with DFO.

DFO management process and policies sub-themes included: community based management/fishermen organisations/ collaborative/ research projects, data collection/reporting and monitoring, government support, lobster quotas, native fishermen, and relationships with government. Many participants described what the fisheries was like during their father's time, and provided reasons as to why the groundfish fishery collapsed. Frequently mentioned reasons were DFO's poor management of the stock and the impact on benthic habitats and spawning grounds by commercial draggers. Countering these issues, fishermen joined local associations and collaborated with academic and NGOs groups. There were also collaborative projects with government agencies and other industries but these were often formed either because of a crisis or because of existing personal relationships/trust that had already been tested and /or facilitated though a trusted association like the FNFA.

Conceptual models

Participants referenced their belief in the circle of life and that lobster, herring, shrimp, and scallop fisheries would improve (or decline) because ecological processes happen in cycles. Cyclic patterns included the weather, and the abundance of different species leading to good and bad years. Some participants resigned themselves to the uncertainty and risk of working in the fisheries, and that they were meant to deal with life/economic pressures as these were life's issues. Believing that there are good and bad years for different species, fishermen coped and adapted to these changing circumstances by putting aside funds for potential bad years that might follow successful fishing seasons. Alternatively, other fishermen would take advantage of these good years by investing heavily in upgrades to their boats/gears at the risk of either having a more than average profitable fishing season, or losing heavily, resulting in additional loans and incurring higher debts.

Stoll et al., (2017) notes that fishermen who are involved in more than one species, and/or harvested in different areas/parts of the marine environment, have multiple perspectives that contribute to the broader knowledge about the system. For example, participants observed that many of the species were declining or getting smaller, and that eventually there would be none left. Authors such as Uusi-Heikkilä et al. (2016) and Audzijonyte et al. (2013) state that by targeting large individuals from a population, will over time, lead to both evolutionary shrinking of the fish but also erode the natural trait variability of the fish stock. The observation of the latter is a concerning flag, as variability facilitates population viability to changing environments (Uusi-Heikkilä et al., 2016). Drawing from the experience of the groundfish fishery, some participants considered a collapse could also happen in the lobster fishery as it was under a lot of fishing pressure and seasonal changes were affecting migration patterns and possibly the health of the species. Given these ongoing threats and the uncertainty from increasing operational costs and fluctuating markets many of the participants were encouraging their children not to pursue a fishing career. As many of the participants interviewed would be leaving (or have left the fishery) the limited recruitment of younger people into inshore fisheries could be considered a threat to its continuation.

Behaviour and attitudes

The media plays an important role in informing the public about what happens in the world, especially in areas where audiences may not have direct knowledge or experience (Happer & Philo, 2013). Although this was outside the scope of the study, the increasing accessibility of online news and mass media (including social media) has a powerful role in influencing the public's perception of events and issues (Weitzman & Bailey, 2018). Participant's responses indicated positive behaviours/shifts in attitudes (e.g. recycling practices, being aware of destructive local and international fishing activities) as well as increasing negative attributes (e.g. competition and greed by individuals and companies and less cooperation among fishermen).

Competition among fishermen, and with buyers/processers appears to have increased. This change in attitude could partially be attributed to making a profit/break or even being able to stay in the fishery, and the misconception that you could get rich overnight by participating in the lobster fishery. For example, many older fishermen thought there was much more competition among younger fishermen as they had large bank loans, with high interest rates and thus needed to fish harder to pay these off. With increasing expenses, bank loans, uncertainty in weather conditions and fluctuations in stocks and market prices, fishermen were being less cooperative with each other and other stakeholders.

Other participants thought that greed was an underlying factor, and that older fishermen needed to sell locally or pass on their licenses to other members/people so as to keep the fishery alive, rather than selling to someone from outside the community for more money. Greed was also considered to be a major factor in the salmon industry, with farms overstocking the pens, leading to an increase in sea lice and other diseases. While addressing these issues by using chemicals and antibiotics helps the aquaculture industry respond to these threats, it also has harmful impacts on other species and the environment if not managed correctly.

8.2.3 Specified resilience from a community perspective

This section discuses insights gleaned from the exploration of specified resilience, drawing from earlier sections of this chapter. Specified resilience in this case has the “to what” being the fishermen, and from “what” the environment or social/economic/management issue that affects either their daily livelihood and/or community. Fishermen wear many hats. For example, they are business owners, with the objective of making a livelihood from the fishery, which in turn allows them to support their family, repay their debts, maintain their business and enjoy social time with their family, friends and community. Depending on their interest, fishermen also play a role in implementing conservation and research projects that support their fisheries/environment and/or businesses (e.g. marketing and economic studies). Outside of the fishery, some fishermen also have interests in community, social issues and technology advancements (among the younger fishermen). Actions that fishermen took in response to changes in their SES can be categorized as either coping (allowed them to still provide for their family but no longer through fisheries occupations and/or working in the immediate area) or adapting, which allowed them to remain in the fisheries and/or area but required some changes such as shifting industries or fisheries.

Participants who were interviewed have remained in the fishery indicating at this level they have been able to adapt and continued to function as fishermen or in fisheries related occupations. For many this required a refocus on another target species (groundfish to lobster) due to changes in species populations or new regulations. Others were able to adapt to the changes by leaving the fishery to work in another natural resource based industry (e.g. aquaculture). Those who followed a coping strategy left the area and/or fishery altogether. Remittances that were sent to their families by those who moved away, allowed the remaining members to continue functioning as part of the community. This option required the most changes in lifestyles for both the individual who left, and for the family members who remained.

Lobsters are perceived as a lucrative fishery for those able to participate and as long as market prices and stocks provide economic opportunities, fishermen will continue in this fishery. Fishermen who refocused on lobster were in many cases individuals that already had licences either bought when prices were at a minimum or had these passed down from family members, thus lowering their start-up costs. For those that had to start fresh, their economic risks were much greater with the added burden of having to repay bank loans in addition to ongoing operational costs. Technology improvements were an adaptive strategy that allowed fishermen to increase their fishing efficiency, although as noted above, there were also economic risks to them, and risks to the environment. For some people, the lure of initial high prices and continual stock abundance (opportunity) were incentives regardless of possible risks and the uncertainty of the fishery. Others tried to diversify livelihood options by exploring other economic ventures in the context of their fishery, building on creative approaches that allowed them to get the edge on their competitors. In many situations, their options were influenced by internal factors such as their values, conceptual models, and attitudes, or external forces that drive social, economic, management, and environmental systems.

Yet as seen in the groundfish fishery case study (Brubaker, 2000; Neis et al., 2013) coping and adaptation strategies, although providing for immediate relief, may in fact lead to other risks in the future. The lobster fishery had always been around, but was initially considered a secondary or third priority fishery, behind herring and groundfish. The emphasis on the lobster fishery required upscaling boats, gear and navigational equipment so as to be competitive with other fishermen, including being able to fish in less favourable weather conditions. Yet to repay loans and other financial debts bought upon by upscaling and the increasing operational costs, including licences and fuel, fishermen tended to fish harder (e.g. going further, and staying out longer). This competitive environment may lead to fishermen engaging in illegal fishing/activities (with an impact on the environment). These activities (and management penalties if caught) create community issues, such as social stigma, reduced community cooperation and reneging on informal agreements around specific fishing areas, within a designated zone. As such, the resilience of what to what/and from whom is a shifting phenomenon that changes in response to different social, ecological, economic, technology, and management influencers. The next section discuses important risk factors that participants identified through the interviews, and resulting themes and sub-themes.

8.3 Examples of risk factors from a community perspective.

Drawing from the analysis presented earlier in this chapter, this section focuses on participants' responses in the context of risk factors. Firstly, Figure 20 describes a generalised bow-tie visualisation. The structure of the bow-tie follows the adapted approach of Ramsden et al., (2013) as noted in the Methods chapter. Central to the diagram is the problem i.e. the loss or reduction of inshore fisheries, in this case the focus is on the lobster fishery. Recalling the definition of risk being used in this study[63], a management objective could be: to achieve and maintain the sustainability of inshore fisheries. The definition of sustainability and what is success is, would need to be defined in the context of environmental, social, economic, and institutional domains.

Beginning on the left (Figure 17) examples of causes, threats, and management strategies that can be taken to prevent the loss or reduction of inshore fisheries are presented. If the objective, which is to maintain the sustainability of inshore fisheries or some level of sustainability, fails to achieve its goal, than options to mitigate/adapt to changes/impacts can be implemented to allow fishermen to continue making a living. Examples of causes (1st column) are drawn from interview questions relating to change and are noted by numbers 1-8. Threats resulting from these causes (drawn from the interviews), are noted in the second column. Chemical pollution (2.1) could also be considered under marine/land based pollution as it has similar impacts as 3.1 and 3.2 but participants considered the impacts from the aquaculture industry as being much more significant when compared with other industries.

Columns relating to avoidance/prevention and mitigation strategies are drawn from interview questions that focused on coping and opportunities. Consequences and escalating factors are drawn from interview questions relating to changes, threats and coping strategies. Most of these consequences are negative to the community, individual, or environment but they can also be

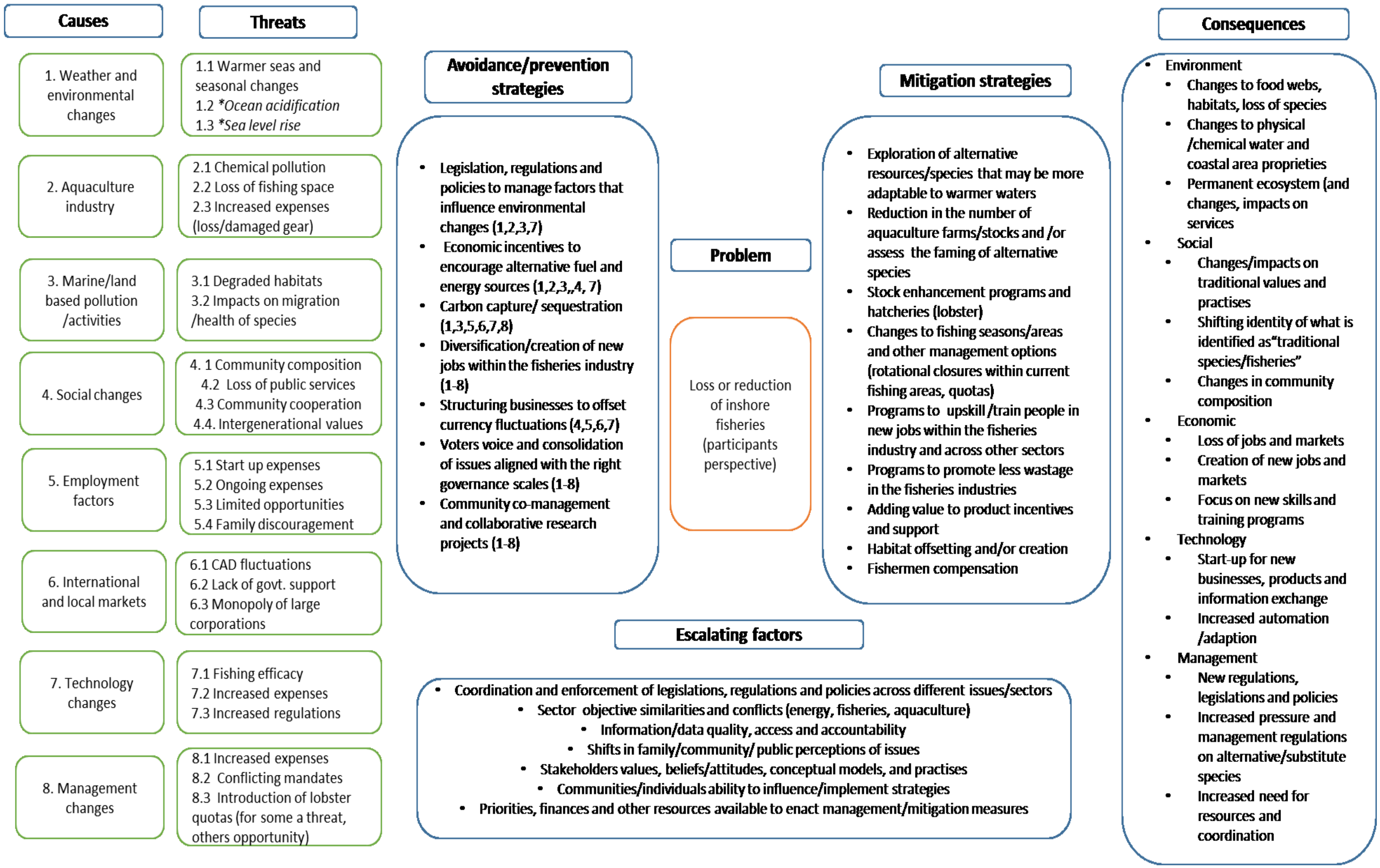
[63] The "effect of uncertainty on objectives" of which an effect can be either a positive or negative deviation from what is expected (Standards Australia, 2009).

positive, such as new jobs/careers in technology that currently may not be conceptualised or new species coming to the area as environmental conditions become more suitable. The trade-off could include changes to the migration and recruitment patterns of lobster as waters become warmer. Fishermen would then need to go further offshore to deeper and colder waters, thus increasing their expenses and incurring potential safety risks.

As a note: in the Fisheries Productivity Investment Policy, 2013 (Figure 17), habitat offsetting and creation refers to “measures that are undertaken to counterbalance unavoidable serious harm to fish resulting from a project, with the goal of maintaining or improving the productivity of the commercial, recreational or Aboriginal fishery”[64].

[64] https://waves-vagues.dfo-mpo.gc.ca/Library/4060018x.pdf

Figure 17: Generalised bow-tie visualisation using inshore fisheries as an example.



A bowtie is useful in most risk assessment areas as it helps to structure a brainstorm session such that different perspectives and disciplines can contribute to the discussion (CGE Risk Management Solutions B.V., 2015). One of the strengths of using a bow-tie visualisation method is that horizontally, causes, strategies and the consequences can be easily constructed through the participation of different stakeholders. As a tool to focus discussion and obtain a bigger picture of the SES, connections between risk factors, and management strategies can be identified and prioritised based on an agreed upon (or emerging) set of criteria, which may include an assessment of the feasibility for each strategy. For example, the aquaculture industry may not agree to share information about their operations or for logistical reasons lobster pounds cannot be moved further offshore/out of the contaminated area. Agencies /groups/ individuals responsible for implementing each strategy can also be identified, resources allocated, and timelines developed based upon agreed prioritised actions.

As a discussion tool, the brainstorming that creates the visual can be further explored by diving deeper into understanding how different impacts from 1-3 contribute to threats aligned with 4 and 5. Causes listed as 6-8 may also have impacts on 4 and 5, which could influence outcomes (positive or negative) depending on the vulnerability and/or resilience of an individual and/or collectively as a fishery (consequences). Chapters 6 and 7, and earlier sections of this chapter, also describe cross-cutting linkages between causes, for example, environmental factors affecting the social system and vice versa, and among social factors, such as social changes, driven by employment and economic factors. Technology, in turn can be both a threat and opportunity, depending on the context.

Similarly, environmental threats comprise acute/point-source threats, such as chemical diffusion from aquaculture sites, or creeping threats, including warming waters, shifts in migration patterns and degradation of habitats, that further compounds the lag-time of stock recovery. Legislations and regulations are implemented often in a silo environment, driven by the mandates of specific departments and agencies, hence creating the potential risk of conflicts between management objectives that in turn can create new risks or allow important issues to be overlooked, until an unexpected crisis emerges. Mitigating strategies can also create new risk in the process of addressing an immediate concern. The case of the groundfish fishery is a good example of where the focus on reducing the risk to the social and economic components of the SES eventually led to collapse of the ecological system. The strategies that were used to rebuild social and economic resilience in turn created new social risks. Economic resilience being based on a natural resource, further increased the risk to ecological (and eventually the social system) because of the limited diversification livelihood options and the slow recovery of fisheries stocks. Another example is fishing down the food web, such as exploring new species, as an alternative fishery, yet these potential fisheries may also be important food sources for higher trophic levels (Pauly et al., 1998; Bieg et al., 2018).

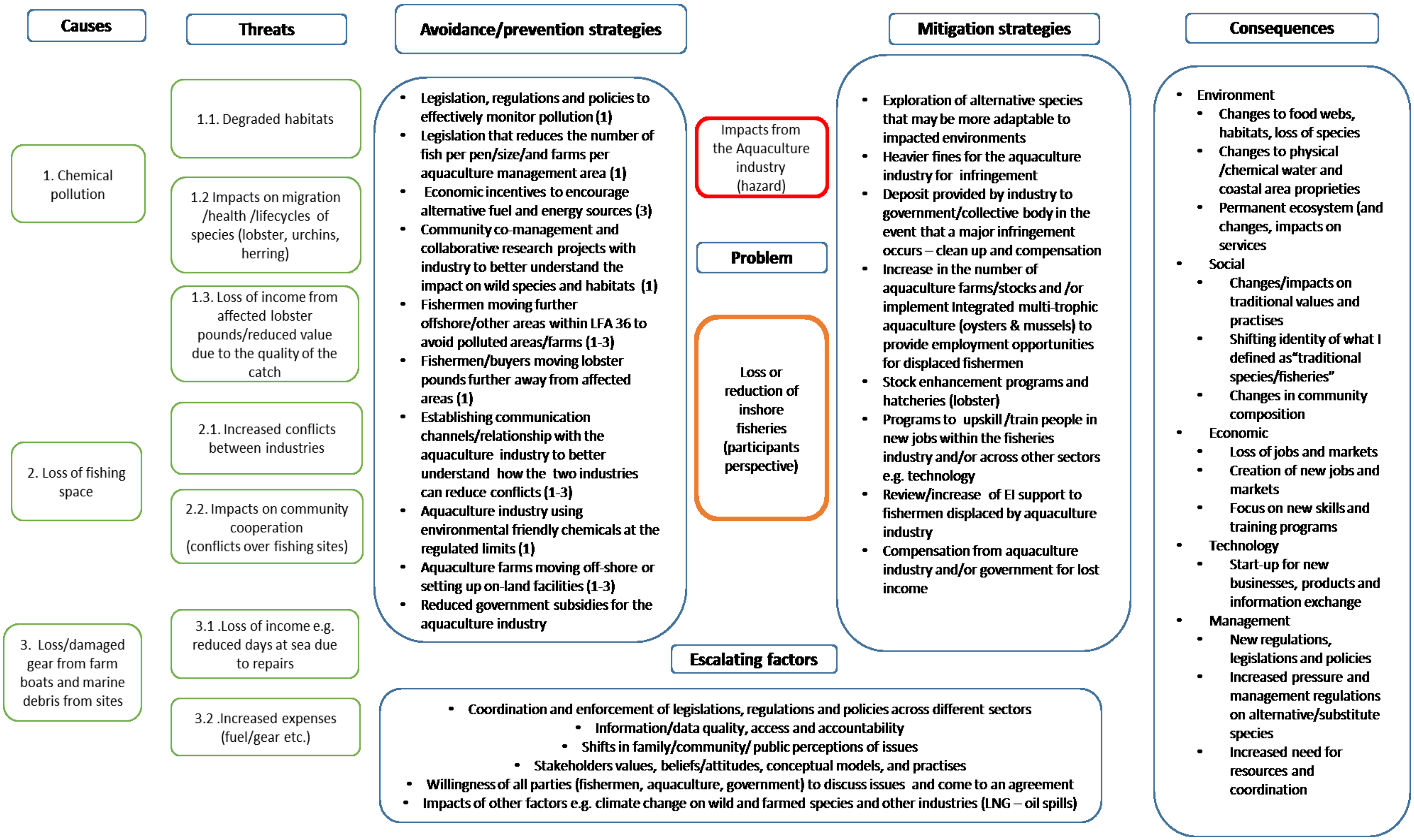
One of the disadvantages of this approach is that the interconnections among different causes, threats, and consequences may not be that evident (McLeod & Paul Bowie, 2018). Furthermore the visual is presented as a linear representation, but the relationships between different components of the SES are interconnecting and dynamic. Yet, it is because of this SES complexity that including additional details to the bow-tie that identify and indicate each connection (factual and/or perceptive) reduces the value of this tool as a participatory and engaging discussion tool.

8.4 Understanding the issues between aquaculture and the inshore fisheries sector

Inshore fisheries can be considered its own SES, but these are also nested within the larger SWNB SES. Viable inshore fisheries identified from the interviews include lobster, herring, and scallop. Some fisheries appear more vulnerable to environment, economic, social and management changes than others (e.g. weir herring vs lobster). From a specified resilience perspective, the objective (Figure 18) is to explore opportunities that could prevent or mitigate impacts to inshore fisheries from the aquaculture industry, but with a specific focus on the lobster fishery. Drawing from Figure 17, Figure 18 describes a specific bow-tie visualisation for the impacts on inshore fisheries (to what) by the aquaculture industry (by what)/whom) using the themes from the interviews and data from the literature (Walters, 2007; Wiber et al., 2012; Chang et al., 2014).

.

Figure 18: Bow-tie visualisation of the aquaculture industry and inshore fisheries



As the example draws from participants' responses and the literature, the list of consequences in both figures has remained the same. As an actual exercise, the consequences column would change to better reflect the realities of the causes and threats. The strategies would also be more factual and aligned based on the feasibility assessment for different options.

In earlier studies as noted in the Literature review chapter (e.g. Walker, 2006, 2009), the approach to understanding specified resilience appears to align well with the traditional risk management, as both have a similar structure for analysing the topic (See Figure 5 and Figure 7 a-c), and have emerged from the science fields. However, as noted earlier, understanding risk and specified resilience from a community perspective also includes taking into consideration the conceptual models, ecological and social values, beliefs, and attitudes. For example, reflecting a subjective risk perspective, fishermen also value independence, freedom, and the acceptance of working in a risky and an uncertain environment (ecological and economic).

Referring to Chapter 4, in SWNB initially many of these aquaculture farms started as a means to diversify and adapt to environment and social changes following the groundfish collapse. Government support (with a focus on rural development and employment) also created incentives for community members to explore aquaculture as an option. One driver that may have seeded conflicts between fishermen and aquaculture industry was when farms became amalgamated by large corporations, both from leased herring weirs being ceded at the end of their term, or from owners selling the farms to these companies (Knott & Neis, 2017). Conflicts began emerging in the late 1980s (e.g. Stephenson, 1990; Chang et al., 2014), became more prominent in the 90's, with an escalation of complaints in 2010-2012 due to issues such as chemical pollution, salmon farms debris/gear damage, and loss of fishing space (e.g. Harvey & Milewski, 2007; Wiber et al., 2012; Barnett et al., 2016). Aligning these timings with Chang et al., (2014) and other development trends, these peaks correlated with an ISA outbreak in the late 90's to around 2006, followed by sea lice outbreaks in later years. In 2018, conflicts over lost fishing space was still a major issue (Parlee & Wiber 2018). Other papers have highlighted privatisation issues between the herring fishery and aquaculture (Knott & Neis, 2017), and the impacts of sea cages on lobster stocks (Milewski et al. 2018) and reproducing females (Maillet et al., 2019). Milewski & Smith (2019) also refer to DFO (2012) Aquaculture Sustainability reporting initiative[65], which identifies key sustainable issues and potential indicators for the environment, economic and social issues. Indicators were developed by a range of participants involved in the industry but there was an absence of representatives from national and regional environmental /community development groups. Their paper also notes issues with the indicators, monitoring procedures, and reporting transparency (Milewski & Smith, 2019).

A few studies have been more positive towards the aquaculture industry (Walters, 2007), and explored solutions to deal with aspects of these conflicts, such as effective communications through social licencing (e.g. Mather & Fanning, 2019), governance models (e.g. Liu et al., 2013) and public discourse on net pen aquaculture in the media (Weitzman & Bailey, 2019). For example, from 542 articles and references, covering topics on environment, society, economy, management, and science and technology, a considerable number focused on technology (90%) and economy (75%) communicated positively about the industry, with environmental (10%) and management (20%) issues reflected the industry poorly (Weitzman & Bailey, 2019).

As an important sector of the SWNB SES, the aquaculture industry shares similar environmental and social capital with traditional fisheries. Both industries have undergone similar changes in technology (e.g. equipment, feed/feeders, processing facilities, antibiotics etc.) and economics (e.g. fluctuating prices). An interesting note is that despite the one major operating company (Cooke Aquaculture Inc.) being founded by a local resident, is run as a family business, and provides employment for about 2,000 people, there are many tensions between the two industries. Participants had noted they knew people/had family members working in the industry both in field/plant and management positions, but there was still some debate on how many people were being employed and the value of that employment to the economy. Although, it was not mentioned directly, conflicts between fishermen and the aquaculture industry had somewhat also affected the community cooperation at the local level. One of the main differences between these two industries is that traditional fisheries is composed of many individual fishermen, each set in their own ways and practices, guided by common conceptual models and beliefs. The aquaculture industry consists of a few large corporations, reliant on mechanised technology, and with workers that often do not have the opportunity to express their opinions in public forums.

[65] https://www.dfo-mpo.gc.ca/aquaculture/lib-bib/asri-irda/asri-irda-2012-eng.htm

The aquaculture industry also has its own internal and external risks, many of which are similar to those faced by the inshore fisheries, such as fluctuating market prices, changes in environment and weather conditions, diseases, and management regulations. Some of the actions taken by the industry, such as the use of chemicals to reduce diseases and sea lice or automating their facilities could be considered from their perspective, forms of building economic resilience. The downside is the impact to the resilience of the environment, and other stakeholders.

As a part of the larger SWNB SES, these practices will also need to be taken into consideration if the overall goal of any governance strategy is to build the resilience of the Bay. Focusing only on building the resilience of traditional fisheries from a known and ongoing shock/event may not: (a) accommodate new and unexpected shocks, and (b) take into consideration the complexities and dynamics of other parts of the system, which in turn can influence (increase/lower) the consequences of an unknown shock. In the context of building general resilience, Chapter 9 will explore these opportunities in more detail.

As noted in earlier chapters, aquaculture is regulated by DFO and the province, a situation that has caused considerable confusion and some conflict, given that both agencies have a mandate to regulate and enable its development (Liu, 2013, Milewski & Smith, 2019). During the interviews, it was interesting that participants never mentioned DFO in relation to the industry, which may have been a reflection of their having interacted mainly with province and/or Environment and Climate Change Canada.

8.5 Specified resilience and risk management insights

Two insights reflecting on the relationship between specified resilience and risk concepts are proposed: (a) past adaptation practices by fishermen have led to current threats, and (b) the potential to build resilience attributes prior to an event may enable parts or all of the SES to recover faster. Other examples mentioned earlier in this chapter, such as connections between the availability of new technology, taking out bank loans/incurring debts, and then needing to fish harder, or leaving the community/area for employment opportunities in other provinces/locations, has impacts on population composition and the loss of public services.

8.5.1 Adaptation practices turning into future threats

Initially, both options (refocusing on the lobster fishery and aquaculture growth) were considered effective adaptive strategies to deal with environmental, social, and economic changes. Over time, one form of adapting is now impacting fishermen and the environment. As such, another column could be added to the left of the bow-tie to further unpack and better understand the factors leading to these causes (e.g. why are these impacts to fishermen emerging from the aquaculture industry, and if regulations are in place to control these impacts, why are they not working, and what could be done to increase their effectiveness). Similarly, another column could be added to the right of the bow-tie to better understand if mitigating strategies or consequences lead to new risks, how these may occur, and for whom? In this context, risk management has helpful contributions to make in that each strategy can be assessed to determine the impacts to the resilience of inshore fisheries /fishermen if strategy goals are not achieved. There are also risks associated with the implementation process for the different strategies, including factors that could distract/weaken the lead/coordinating agency/organisation (i.e. escalating factors).

One of the big challenges that affects this process is incorporating the diverse perceptions that different stakeholders may have of what is at risk, why, and the effect it may have on them/fisheries/communities. Another issue relates to the creation of knowledge, and methods used to determine resilience and implement risk management. Both approaches have drawn from the sciences, with only a few considerations/inclusion of other forms of knowing, including local knowledge sources, and contributions from the social sciences. Engaged participation and polycentric governance (e.g. co-management) could be helpful, but perceived trust issues and power relationships across fishermen, government, and large corporations is another challenge.

8.5.2 Building resilience attributes into practices and strategies prior to a known event

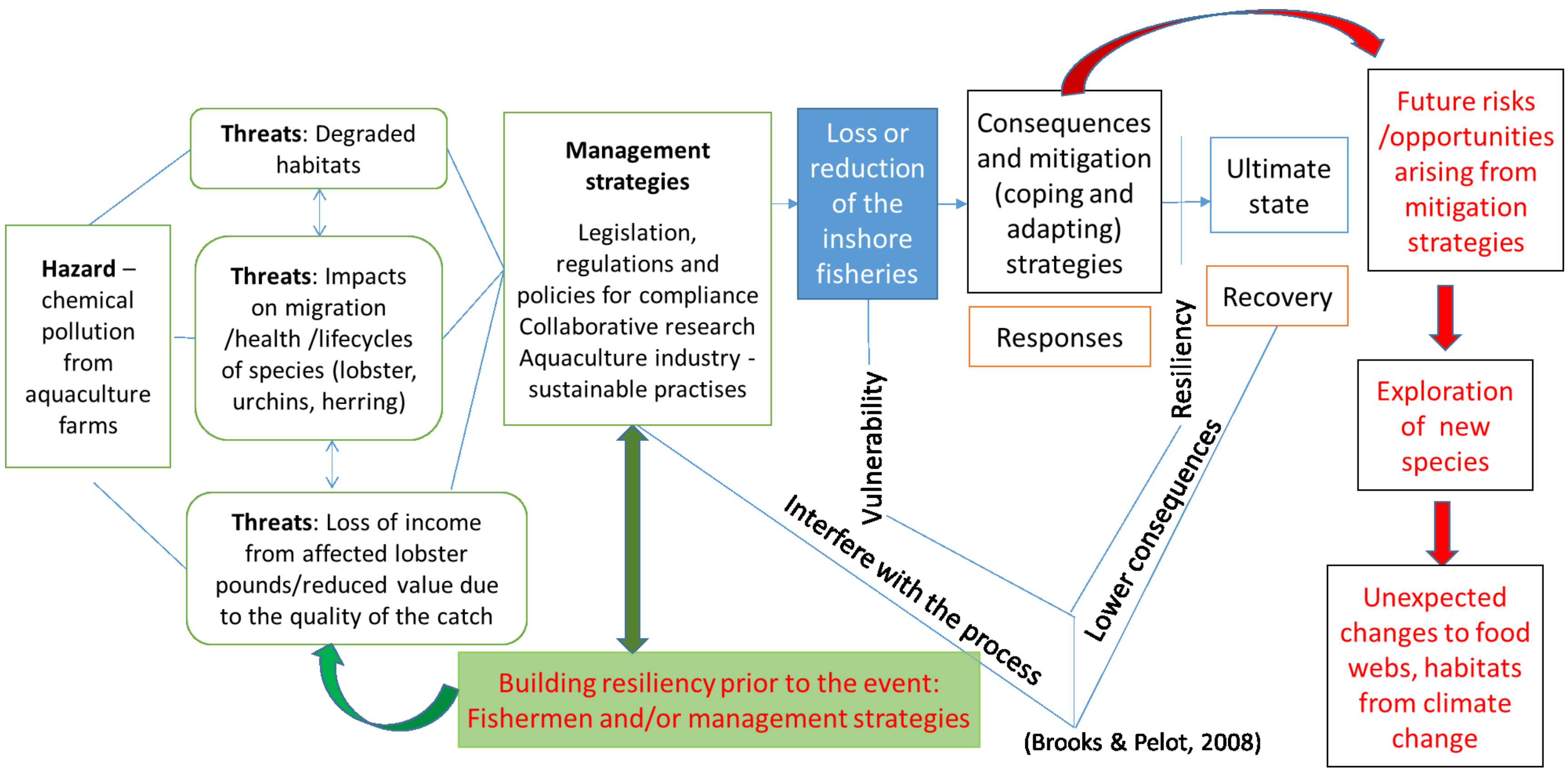
Drawing from the risk management, disaster, and climate change literature, the concept of resilience is considered after the event and enables a system (or part of a system) to recover and continue to function. The model presented by Brooks & Pelot (2013), is a useful guide towards better understanding the connections between risk and resilience concepts. As noted earlier, resilience is placed after the event, as attributes moderate impacts to the system by lowering immediate and future consequences (i.e. absorbs some of the shock, allowing the system to recover faster). In this model, vulnerability is assessed prior to the event, as it acts as a buffer between the threats and the system of interest. Cutter et al. (2008) propose that in addition to the inherent vulnerability of the system, there is also inherent resilience prior to the event, both of which are nested within social, natural, and built infrastructure. Although there are some attributes that are either characteristic of resilience or vulnerability, there are also overlaps such as socio-economic status and education within the social system (Cutter et al., 2008).

Building from the Brooks and Pelot model, and synthesizing the information from the risk visual tool – this integrated risk and resilience approach (Figure 19) considers building resilience into the system – both before the event, as well as after. For example, questions could be asked as to how diverse are fishermen's income and what do they have in place to buffer their livelihoods? Similarly, questions could also be asked of preventive management strategies – are they working, how do we know they are working, and what happens if they fail?

At the far end of this diagram – questions could also be asked regarding – how might mitigations strategies create new risks (or opportunities) in the future – or how might these coping or adapting strategies create new threats? In this context, risk management has helpful contributions to make in that each strategy can be assessed to determine the impacts to the resilience of inshore fisheries /fishermen if strategy goals are not achieved.

Considering these two additional elements in a visual risk and resilience tool could help communities and resource managers consider both aspects in their responses to known threats, which may collectively help them better prepare for known changes in the SES.

Figure 19: Specified risk and resilience framework



Based on the interviews, vulnerability factors could include their reliance on the fisheries (such as percent of income derived from fishing), species fished, other sources of income, maturity of family/obligations to family, location (island or mainland), fishing location (near/far to salmon farms) education level, and age. Examples of resilience attributes from the interviews and aligned with Biggs et al. (2015) seven principles, include exploring opportunities for income diversification (Principle 1) by upgrading skills in business and technology literacy, creating side businesses, setting aside savings, investing in their children's education, and creating succession plans, which all contribute to adapting complex thinking (Principle 4). This sort of approach would be important in the context of anticipating/preparing for unknown events such as the time lag between species recruitment and population abundance, and impacts from climatic events (Principle 3). Collaborative projects on topics that are of interest and/or concern to fishermen and shared with other stakeholders, such as impacts from climate change and market fluctuations, and species movements, incorporate different learning opportunities and forms of knowledge and enhance learning (Principles 5 & 6).

8.6 Summary

The purpose of this chapter was to explore the relationship between concepts of specified resilience and risk, relying on key themes and sub-themes drawn from the interviews. Four hundred and eight two (482) data points were coded, with many of the comments relating to economic and management domains, and focused on threats and opportunities. Thirty-three sub-themes were identified, which can be clustered into conceptual models, coping strategies, fisheries related stress factors and social related stress factors.

Based on identified themes and sub-themes, and drawing on the theoretical literature, two bow-tie visual representations were presented. The first describes examples of general threats to the traditional fisheries including avoidance, mitigating strategies and resulting consequences. The second bow-tie builds on such models by describing a hypothetical example of the interaction between the aquaculture industry and traditional fisheries. Drawing from this analysis and models from the literature, two insights that relate to the interactions between specified resilience and risk are presented: (a) adaptation practices that turn into future threats, and (b) building resilience approaches into practices and strategies prior to a known event.

Fishermen wear many hats, which influence the approaches taken to cope with changes, opportunities, and threats. Coping strategies included leaving the fishery /area completely to find work in other provinces/locations. Adaptive strategies, such as fishermen remaining in the fishery and/or shifting to other occupations but staying in the area/community, included changing fishing practices, increasing the use of technology, being creative and diversifying their business, joining /supporting fishermen associations, and being involved with collaborative projects that were of interest to them.

Resilience strategies that can be incorporated into a SES (or parts of the system) prior to a known or unknown threat allows for a greater degree of buffering by reducing vulnerability before an event and/or lowers the impacting consequences post event (Brooks & Pelot, 2013). However, understanding how resilience strategies may also lead to new risks or opportunities (to whom/from what?) will contribute to a better understanding of the complex and dynamic relationship among different components of the system across different spatial and temporal scales.

Chapter 9: Exploring the relationship between general resilience and risk

9.1 Introduction

The chapter integrates the results from the primary data with the literature reviews and analysis to present examples of factors that could increase general resilience that could enhance risk management approaches. General resilience as noted previously is the capacity of the system to adapt or transform in response to unexpected or unfamiliar events (Carpenter et al., 2012; Walker & Salt 2012). As noted in Chapter 8, both the inshore fisheries and the aquaculture industry can be defined as their own SESs (sector boundary). However, these two SES, are also embedded within the SWNB system (informal jurisdictional boundary), which in turn can be considered a component of the larger Bay of Fundy System (ecological and jurisdictional boundary). Understanding the connectivity between different parts of the ecological system, integrated with the social and management systems, including the interactions within and across different components, requires fostering complex thinking approaches. The application of the seven resilience principles is one approach to providing a baseline understanding as to what is happening in this SES, and to identify a process that can be used to better prepare coastal fishing communities in the face of unexpected events. As noted earlier, I am not proposing that this is the only approach, nor that the resilience principles (Biggs et al., 2015) are a universally accepted and proven set of guidelines that communities should adhere to. In this context, I am using the seven resilience principles as a lens to better understand how risk and resilience concepts interact in a SES, and how to better manage for known and unknown risk events (and opportunities).

Acknowledging that it may not be feasible to apply/address all the principles at once, being able to identify the ones where the objectives may be most at risk of not being achieved could be used as a starting point. Here I have used two main criteria to categorize the data: firstly, by taking into account the frequency and saturation of comments around a specific topic that is coded based on the explicit references to the principle; secondly, flagging the principles which appear to have fewer comments, and questioning why this maybe so. As noted previously, some of these terms may not have been familiar to the participants (e.g. principle 3. Slow and fast variables and feedback loops), yet they may have experienced/observed these interactions. By reframing the interview questions, a more in-depth discussion could have been applied using specific examples to demonstrate their understanding of this principle. Another reason, especially in the case of principle 6 (participation), which refers specifically to being able to take part in management decisions relating to their fishery, the low response rate may have been a reflection that there are barriers that prevented participants from being more actively involved.

Recalling Figures 17 and 18 in Chapter 8, and extracting one example, climate change, including changing weather patterns, warming waters, and ocean acidification has the potential to affect coastal communities, and the sectors that rely on natural resources. Yet, climate change is only one of many threats that could have unexpected consequences upon fishermen, the aquaculture industry, coastal communities, and individuals, either through the accumulation of different threats over a specific short time frame (as seen in the groundfish fishery example) or synergies of different events that lead to new threats that may not be immediately evident.

This chapter begins with an overview of the resilience principles, followed by a summary of comments that reflect positive, negative and neutral perspectives (coded from the interview data). Two examples demonstrating initiatives that could be considered to address the objectives of principles 5 and 7 specifically, with some overlap with principle 6 are then discussed. These examples provide an opportunity to build on the existing networks, and create opportunities for coastal communities to prepare for ongoing and future changes within their immediate and larger SES.

9.2 Resilience principles

This section presents a summary of the resilience principles (Biggs et al., 2015) to determine which ones appear to be doing well in the SWNB area, and those that may be most at risk of failing to meet their objective. Figure 20 identifies the principles that participants were the most interested in discussing (diversity, learning, connectivity and complex adaptive systems). Principles relating to slow and fast variables, and feedback, and participation were the least discussed, possibly because the first is more often considered from an ecological perspective but harder to conceptualize within and across the other four domains. Comments aligned with participation may have been low because the definition focuses on actively participating with official management decisions and participants may not have had opportunities to contribute in this capacity. Most of the comments relating to polycentric governance focused on organizational/associational activities as a means towards community-based management of their fisheries. It is interesting to note that when these interviews were being conducted in 2011/2012, the SWNB Bay of Fundy Marine Advisory Committee (MAC) was in its second phase of operations, and one of the participants was on the committee, yet it was not mentioned at all. This may have indicated a low interest and/or faith in the committee or perhaps a lack of awareness by the respondents.

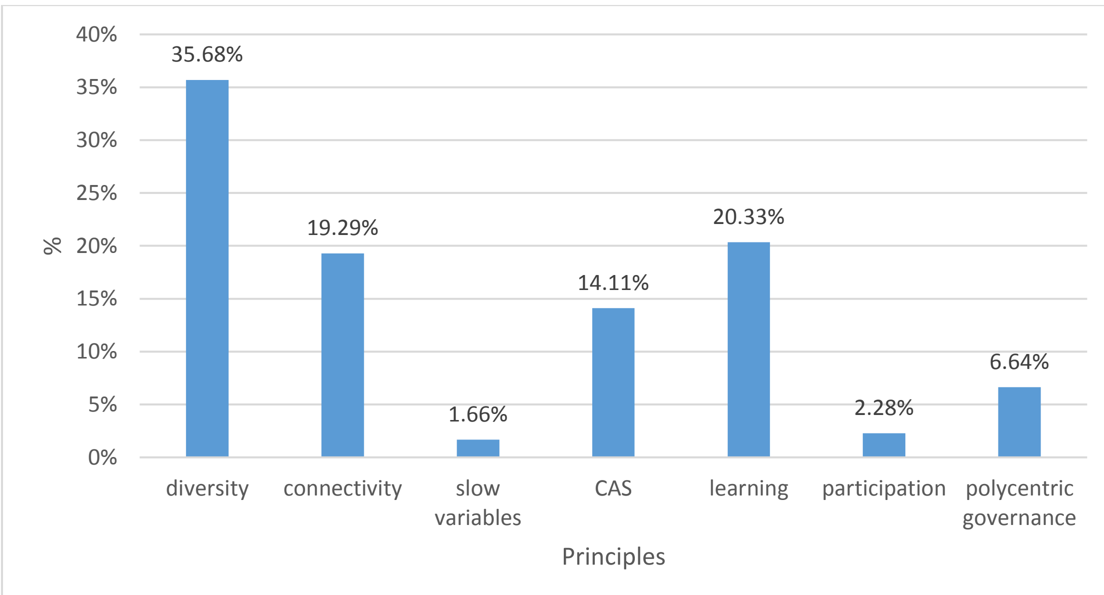


Figure 20: Distribution of participants' comments coded to the resilience principles (n=482)

9.2.1 Describing the resilience principles in the context of SWNB

Principle 1: Maintain diversity and redundancy**:** *Diversity and redundancy are important for resilience because they provide options for responding to change and disturbance. The diversity of system elements include multiple species, employment options, management and institutional approaches that provide the bases for innovation, learning and adapting to slower, ongoing changes (Biggs et al., 2015). Functional redundancy refers to the capacity of functionally similar elements to partly or fully substitute for each other (Elmqvist et. al., 2003).*

Ecological systems: The productivity of this Bay is driven by intense tidal forces, which mix nutrients, plankton and decaying material high in the water column, which in turn supports different species of fishes, marine mammals, invertebrates and birds (Lotze & Milewski, 2004). Species diversity has changed considerably since indigenous hunters and gatherers harvested from this area prior to 1800 (Conservation Council of New Brunswick, 2002). The most notable changes were in the food structures of the marine ecosystem (Lotze & Milewski, 2004). As large predator species such as marine mammals and birds declined or disappeared (i.e. large groundfish and herring), smaller species such as dogfish, hake, and sculpins moved in as replacements as they required less specialized habitats and/or food and as such were more suited to take advantage of opportunistic conditions (Conservation Council of New Brunswick, 2002). While biomass does not appear to have declined for primary producers such as phytoplankton, changes are now being noticed in the composition of different species (Conservation Council of New Brunswick, 2002). For example, in recent years there have been more blooms of toxic red tides, and a greater proportion of the phytoplankton biomass is composed of less edible dinoflagellates (Conservation Council of New Brunswick, 2002).

Social systems: The boom and bust nature of the fisheries required fishermen to adapt to management and seasonal changes and market influences. Following the collapse of the groundfish fishery, fishing effort shifted to lobster[66]. In addition to non-fish fisheries (e.g. periwinkles, clams), eels and Gaspereau (the latter two mainly in the upper Bay area), a study by Wiber et al., (2009) highlighted that most onshore harvesters also had multiple sources of income, with many relying for part of the year on employment insurance. Wiber et al. (2009) further notes that although most participants considered their income as doing well, a few mentioned the need to increase the intensity of their harvesting in order to maintain incomes levels. Other respondents noted that due to the shellfish beach closures their income had significantly declined in 2008. Clam harvesters' numbers were also decreasing but it appeared that periwinkle harvester numbers had increased (Wiber et al., 2009). The decrease in clam harvester numbers was also observed by SWNB participants in this study. Reasons proposed for the increase in periwinkle harvesting included not needing a license, as it could be done year-round by any members of the family and was used to supplement livelihoods when the clam flats are closed (Wiber et al., 2009).

[66] Similar approach happened in Newfoundland, where fishermen switched from fish to crustaceans (snow crab, shrimp, and lobster)

Management Systems: Several federal, provincial, and municipalities have management responsibilities in this area (See Chapter 5). In addition to these agencies, the NB Department of Natural Resources is mandated to manage all Provincial Crown lands, including approximately 2.1 million hectares of tidally-influenced submerged land and overlying waters (DFO, 2016[67]). The provincial department also has shared responsibility for managing and protecting wetlands with the provincial Department of the Environment. Federally, the Department of Natural Resources (DNR) manages protected natural areas, including islands, coastal areas and gorges. Other roles of the DNR include the administration of the Oil and Natural Gas Act. The Geological Surveys branch maintains a coastal studies program to map and monitor coastal erosion. Coastal erosion is significant in New Brunswick due to factors such as sea level rise, storm surges, and sediment deficits. DFO is the lead department for both fisheries and aquaculture, yet in total there are twenty-three Federal Departments and Agencies that have ocean related activities, and thirteen that have relevant legislation (DFO 1997).

Principle 2: Manage connectivity. *Connectivity is defined as the manner by which and extent to which resources, species, or social actors disperse, migrate, or interact across ecological and social systems (Bodin & Prell, 2011). Connectivity in SES facilitates the exchange of material or information and affects the spread of disturbances and facilitates recovery after a disturbance Biggs et al., 2015).*

Ecological system: High connectivity between the physical-biological components of the ecosystem is evident, for example, the physical shape of the SWNB coastline, and the velocity of the water moving through the passages supports diverse biological communities (Conservation Council of New Brunswick, 2002). The topography/bathometry of the area permits large volumes of water to be pushed through many small passages that surround Deer, Campobello, and the other islands in the western portion of SWNB and into Passamaquoddy Bay, which in turn mixes and brings volumes of nutrients, plankton, and decaying materials high into the water column (Conservation Council of New Brunswick, 2002). This flushing process has also created a conceptual model that because pollutants are being daily washed out, dumping sewage and

[67] http://www.dfo-mpo.gc.ca/oceans/publications/pg-gp/page06-eng.html

industry discharge into the area does not affect the environment. Hence, the long history of the Bay being considered a natural flushing process for industrial and waste discharge.
Temporal connectivity included past fishing practices of fish draggers and gill netters that may still be having a negative impact on current herring and lobster stocks. DFO has also licensed experimental fisheries around the Passmaquoddy Bay for sea cucumbers, yet many of these harvesting techniques require dragging gear, which damages or destroys bottom habitat crucial to many fish and benthic species (Conservation Council of New Brunswick, 2002). Commercial harvesting of rockweed has also increased and is potentially removing key habitat areas. Though there may be some immediate visual changes/impacts, the greater risks might only be seen in the future, in lower recruitment rates and a decline in the health of different species (Conservation Council of New Brunswick, 2002).

Social system: The social structure of the community is largely formed around fishing and processing activities. As with Newfoundland, when the groundfish fishery was at its peak, the connectivity between the fishing fleet and processing plants was very strong, as communities both fished and worked at these plants. Social networks such as fishermen's groups like FNFA and the Weir fishermen are another form of social connectivity and act as a bridge between research and educational institutions. However, the efficiency of such groups at the decision table is largely dependent on good leadership, trust, and the ability to organize. Knowledge dissemination and learning is another form of intergenerational connectivity, which is important in passing on fishing knowledge and experience within and across families. More recently, another form of connectivity has been with the younger generation helping older family members navigate/use online communication platforms.

The connectivity between investments from government, and possible voting pressures appear to still have an influential presence. External factors such as regional market prices, linked with the internal pressures of higher expenses and loans contribute to increased fishing pressure. Connectivity between markets and consumer preferences also drives fishing practices. For example, as one participant noted: *An average lobster may take eight or more years to reach legal catch size of one pound (0.45kg) or 81mm carapace length. At this stage lobsters are still immature as a mature lobster will measure 104mm carapace length and weigh nearly two* *pounds. Yet the preference in the market is for plate size lobsters, which targets smaller lobsters and there is some concern on how this will impact future lobster stocks, especially given their slow growth rate*.

Management systems: Connectivity in the form of trust and information sharing between DFO and fishermen is not strong, based on the historical groundfish legacy. At the provincial level, the experience with the aquaculture industry has also created trust issues and resentment. Small improvements have been made to sharing data collection (e.g. tagging programs) and information around lobster stocks, however there is still a feeling of unfairness and perception of government bias towards large commercial business. This perspective is based largely on many of the same reasons as that seen in the groundfish fishery i.e. easier to talk to one or two lead contacts as opposed to many smaller groups or individuals and the emphasis on economics vs conservation goals, which may be swayed when politicians are heading for elections.

Principle 3: Manage slow and fast variables, and feedbacks. *SES consist of variables that change and interact on a range of timescales (Gunderson & Holling, 2002). Slow variables determine the underlying structure of SES, whereas the dynamics of the system typically arise from interactions and feedbacks between fast variables that respond to the conditions created by the slow variables (Biggs et al., 2015).*

Ecological system: Slow and fast variables, and feedback loops are often used to refer to population recruitment, trophic level dynamics, environmental and habitat changes. In this context, participants have described the collective impacts from past fishing practices (e.g. draggers) on species that have slow life cycles, shifts within the food web structures, changing oceanic climate, and the uncertainty of current fishing impacts on the SES. Although participants were aware of ecological cyclic patterns and had some thoughts as to what could be causing these trends, there was still a high degree of uncertainty as to what were the underlying factors. Examples of possible reasons for more lobsters included the reduction in groundfish and good conservation practices. In the herring fishery, the decrease in numbers was attributed to overfishing in the past and current coastal developments. The loss of wild salmon was due to overfishing in the past and the current degradation of streams and habitats. Catching smaller lobsters and an increase in softer shells was attributed to climate change and warmer waters.

Social systems: A conceptual model reflected in both ecological and social systems that may have helped sustain community resilience is the belief/approach that changes will happen, and that after a period of bad times, there will be good years, and vice versa. For example, changes in food web relationships (e.g. seals and groundfish) and fluctuations in species numbers over different time periods (i.e. seven good years for scallops, followed by seven poor years) meant that people continued to fish even if catches were low. A similar perspective was also noted within the herring fishery with respect to good and bad years. Changes in social attitudes were directly connected to the fisheries, for example, in the past the herring purse seiner was king whereas now it is the lobster fisherman.

Management systems: In addition to new governance regulations, which are often initiated as a response to a crisis, other slow and fast variables and feedback loops, include knowledge translation/mobilisation and mental models. For example, oil spills and source based marine pollution from salmon farms and other points require prevention and mitigation plans to address such risks. Although there could be plans in place, many of the participants were not be aware of such measures, which in turn created a deeper sense of distrust between fishermen and industry[68]. There also appears to be some disconnect between how DFO managers observed ecological patterns through their modeling approach, and what fishermen saw/thought from being on the water daily. Despite there being some attempt to integrate management agendas, most stocks are still managed as single species, with only limited opportunities for aggregation and data analysis. With the event of impacts from climate change, having a better understanding of other factors (migration patterns, diseases, changes in prey species, availability and condition of feeding and spawning grounds) that could influence the lobster fishery would help to improve both specified and general resilience.

---

[68] Since this study was conducted, in 2016 FNFA started a project with DFO to document the local fishing areas that should be protected in the level of an oil spill. Hence there has been some work to address this issue of uncertainty.

***Principle 4: Foster complex adaptive systems thinking**: Properties of CAS and their implications for the management of SES include the possibility of emergent macroscale SES behavior that cannot be predicted from individual system components (Biggs et al., 2015). Understanding CAS requires a particular conceptual model that interprets the SES in a holistic manner, including the importance of trade-offs, slow variables, feedback loops, and systems uncertainty (Pahl-Wostl, 2009).*

Social systems: As noted in Principles 1- 3, participants were aware of changes in the environment, markets and social structures, and how these may interact leading to different scenarios for them. Yet there was not always consensus on what could be driving dynamics, within and across systems. As a first step, one approach would be to break down boundaries that prevented timely and non-biased information and data sharing between different stakeholders. Collaborative initiatives such as lobster tagging (migration routes and life cycle monitoring), right whale conservation projects (migration and trophic levels) and retrieving lost gear (proactively reducing the impacts on different species) attempt to take a more holistic approach to understanding these complex systems.

Management systems: One of the biggest challenges to implementing this principle is moving away from a reductionist or silo approach towards thinking and implementing cohesive and aligned management strategies. The current management system is still largely structured within boundaries that do not allow for much data and/or information exchange, either across different agencies or with other actors outside the agency. Part of this arrangement is due to the need to simplify the responsibilities of different agencies as a means of accountability to a fixed mandate. This working environment does not provide much flexibility to take into consideration other factors that could impact either the species (across different stages of their life cycles) or the overall SES. For DFO to have both the mandate for conservation and economic development is a good starting point for complex adaptive thinking as these two areas both fall under one department. However, like the groundfish fishery case, rather than acting as a bridge, power dynamics and information biases can lead to some goals (e.g. economic) being prioritized over others (e.g. conservation). Another risk related to fostering complex thinking is the focus on data collection and monitoring (current management conceptual model), as opposed to encouraging adaptive processes that allow for uncertainty (Biggs et al., 2015). Driving this issue is the rational management approach to risk avoidance and the need for reducing uncertainty.

Principle 5: Encourage learning. *Learning is defined as the process of modifying existing or acquiring new knowledge, behaviours, skills, values or preferences. This principle is based on the assumptions that knowledge is always incomplete, and that uncertainty, change, and surprise are inevitable in complex SES (Biggs et al., 2015). Learning can take place at the individual level and through social interactions (Reed et al., 2010).*

Social systems: Knowledge in this context includes the contributions of academic and research institutions, government agencies and fishermen' observations and experience from being on the water daily and their insights into environmental and social trends. Crises have emerged as a result of fishing practices, natural variations, and impacts from other industries requiring stakeholders to collaborate within and across different groups to increase knowledge and understanding of their SES. Fishermen and community organisations have taken the initiative to seek new markets and re-train. Since this study, new projects initiated by FNFA included a workshop series of best practices for financial management approaches, improving profitability, and reducing debt loads.

Collaborations with the lobster node of the Canadian Fisheries Research Network (CFRN) were aimed at better understanding the structure of lobster stock and how these differed in areas throughout Atlantic Canada (see http://www.cfrn-rcrp.ca/CFRN-RCRP for details). Under the CFRN approximately 38 Master's, PhD students, and postdoctoral fellows were supported on a wide range of research topics. One of the products was the development of a fisheries evaluation framework for sustainable fisheries. Focusing on the SWNB planning process, a notable case study informing this process was the role of resolving conflicts over risk management in the marine environment through strengthening governance institutions (Parlee, 2016). Other organisations such as the Conservation Council of New Brunswick run programs like the Fundy Baykeeper who focuses on monitoring environmental law compliance, conducting habitat restoration, tracking climate change, and supporting sustainable fisheries.

Management systems: The first four principles are important processes for bringing all parts of the SES together to better understand what is happening within and across different components. As noted in Chapter 5, several federal, provincial and local department and agencies continue to initiate environmental and social monitoring programs to advance management's understanding of the SES. The dissemination of knowledge from monitoring programs is often done in the form of reports and distribution maps that are shared on agency websites. However, because of the silo approach to data collection and analysis, it is often challenging to get a holistic picture and/or overall understanding of subtle feedback loops and changes in the SES. There is also the question of how accessible these reports are to community members and whether there is a forum to ask critical questions (internally and externally) relating to this information. Furthermore, there are also critical questions to be asked as to who will use this information, and according to what mandate. Community members, fishermen, academics and NGO's often question who makes the final decisions, how are they made and who benefits/ loses out?

Principle 6. Broaden participation. *Participation refers to the active engagement of relevant stakeholders in the management and governance process (Stringer et al., 2006). The resilience literature generally considers participation that focuses on stakeholders with an active interest in the management of ES, or with relevant local, traditional and scientific knowledge (Olsson et al., 2004).*

Social systems: This principle is linked closely with Principle 5. Broadening participation requires the willingness to learn from past failures and to create and accept new knowledge sources that will allow for a more comprehensive assessment and management of different fisheries. The ongoing reliance on single species assessment models provides barriers to broadening participation by others who are not associated with DFO. As seen in the groundfish fishery, community voices are usually heard after the crisis has occurred, as other more powerful economic players' needs are given priority.

Management systems: Traditional management systems appear to still be very inclusive, however, participants noted the opportunities for collaborating with organisations like FNFA, DFO, and Environment Canada on projects that were of community research/interest including the impacts from salmon farms, scallop enhancement and new markets. Research projects that allowed for wider participation could include the feasibility of a lobster hatchery, assessing seafood wastage (from the harvesters, processors, retailors and customers), and high school awareness and training for coastal and marine careers, including traditional fisheries. The perception of fairness and maintaining ongoing fishing rights between native and non-native fishermen is a potential risk that could reduce the effectiveness of Principles 5 and 6 for different community groups.

Principle 7: Promote polycentric governance**:** *Polycentricity refers to a governance system with multiple governing authorities at differing scales, thus matching problems with appropriate scale (Ostrom, 2005). Polycentricity contributes to the resilience of ES by providing a governance structure that facilitates other key resilience-enhancing principles, especially redundancy (P1), connectivity (P2), learning and experimentation (P5), and participation (P6) (Biggs et al., 2015).*

Management systems:

Individual SES are often viewed by both government and communities in a very fragmented manner. Fanning (2002) has emphasized the importance of matching the system to be governed (SES) with the governing system. Resilience Principles 1-3 set the context and general boundaries for the implementation of Principle 4. The process for fostering complex adapting thinking resides in the social system's ability to encourage learning (Principle 5) and broaden participation (Principle 6) so that governance levels can be appropriately aligned with the temporal and spatial scale of the problem(s).

There are some examples of polycentric government in this study. On a large scale, the monitoring of lobster migration patterns and population numbers are being done by both DFO and in collaboration with other stakeholders (see CFRN's work), which allows for data at both a macro and micro scale. Linkages between climate change, lobster populations and migrations are also being monitored and studied by the St. Andrews Biological Station and DFO. The information or some aspects of this is being potentially shared with its equivalent US fisheries management department. The Bay of Fundy Ecosystem Partnership (BoFEP)[69], which includes

[69] http://www.bofep.org/

Nova Scotia, and Maine (US) and the SWNB planning initiative[70], currently hosted under BoFEP have helped coordinate different stakeholders around priority issues for the Bay of Fundy and Gulf of Maine regions. Focusing mainly on ecological interests, BoFEP is a virtual institute, open to both individuals and groups with an interest in the wellbeing of the Bay of Fundy. The SWNB initiative focuses on the New Brunswick side of the Bay and had included both social and ecological system issues. Both organisations drew representatives from a diverse range of backgrounds and professions, including government agencies (provincial and federal), first nations, community/fishermen associations, NGO's, and academics. dYet, what is often lost in these management discussions is the reality of collecting, analyzing, consolidating and sharing timely data that informs decision making. To be able to do this in a manner that captures both chronic and acute SES changes requires financial and political willingness, which in turn is influenced by priorities set by government institutions at different levels, and compounded further by the influence of voters.

9.2.2 Identifying concerns and opportunities towards meeting the objectives of the resilience principles

This section describes the concerns and opportunities that participants considered important. A short summary of comments coded specifically to each principle is presented first, followed by two specific examples demonstrating how these principles have been effectively applied.

Principle 1*: Maintain diversity*

Concerns referring to ecological diversity are related mainly to impacts from the aquaculture industry, including chemical and other pollutants affecting lobster, fish and other species. Marine and land-based pollution included both current impacts (e.g. raw sewage, outputs from the potash mine, debris from the salmon farms, and plastics in the environment) and future threats, such as oil spills. Participants also noted general changes in species composition and health from human activity (fishing, pollutants, and coastal development), and natural processes such as an increase in seal predation on other species. There was some concern that lobsters were getting smaller, which might be due to changing weather and environmental factors.

[70] http://www.bofmrp.ca/home/index.php/home/

Concerns relating to social diversity referred to the negative impact that the growth and monopoly of the aquaculture industry was having on inshore fisheries, especially as many participants perceived that their development was being constrained by the lack of government support. Different perspectives also led to conflicts among some community members who had family members working in both industries. For example, fishermen perceived the industry as being greedy and not supporting local businesses.

Other concerns related to community demographics such as an aging population, and there was less demographical diversity. The perceived lack of government support for small local businesses was seen as one reason for limited employment opportunities, which in turn resulted in people leaving the community. Smaller populations led to the closure and/or consolidation of public services, thus impacting community composition and diversity. Fishing harder and competing for fishing space also affected community cooperation, as in the past, people were reportedly more willing to help each other and were friendlier/more open.

Comments that referenced technology noted the move away from more labor-intensive jobs as processes become more mechanized thus decreasing employment opportunities. Processers also felt that there was not enough diversity in the services being offered by equipment manufacturers, as these suppliers tended to focus on large corporations as opposed to small /local business. Yet the most significant aspect of technology was that it increased fishing efficiency (opportunity) but there were also concerns about the impacts this had on operating expenses and the environment (threat).

Concerns relating to management systems noted the increase in the quantity of information that is now being required by DFO. This has impacted fishermen's time and increased operational expenses. With the transfer to more electronic and less local forms of data collection, participants noted that opportunities to build rapport and trust through face to face interactions were being lost. The move to electronic data collection may have also created a digital divide for older fishermen who were not comfortable using online communication forms.

Opportunities relating to ecological diversity identified the current potential of the inshore fisheries, specifically lobster. Other comments that were more neutral, included the cyclic nature of the fisheries, and the ability of people to adapt to the loss of species by moving to other environment based industries in the area.

Positive comments relating to social diversity noted past experiences when the aquaculture industry consisted of mainly locally owned small farms, which provided flexible employment opportunities for local community members. In the past, people fished multiple species and community life was very much centered on fishing and related occupations. The diversity of local business/small industries also provided flexibility for seasonal work. Relating specifically to Deer Island, having international and national workers provided an opportunity to enhance cultural learning and exchange, thus contributing to the diversity of the community. Considering approaches to enhance local economic diversity, participants noted the importance of keeping money within the community (i.e. supporting local employment and businesses). Diversity within traditional fisheries could be maintained if younger generations are able to get into the fisheries. Technology advancements and accessibility also provided opportunities for more diverse forms of electronic marketing, communication and outreach.

Principle 2: Manage connectivity

Concerns relating to ecological connectivity focused mainly on the fluid nature of the ocean and how impacts such as pollutants could increase the risk of affecting different species and important habitat areas. Other comments referred to the connectivity between international and national destructive fishing practices. These practices increased the risk of low catches for local fishermen because of the connectivity between feeding and breeding grounds and changes to predator-prey interactions. Connectivity was also noted within spatial and temporal scales reflecting different trophic levels and food webs, and variations in population dynamics, habitats, spawning/feeding grounds, and species migration routes. For example, many participants noted that lobsters being migratory species were influenced by ocean climates, and tended to stay in colder waters during winter and moved inshore when the waters were warmer.

Concerns reflecting social connectivity focused on the divide between the younger generation and older fishermen around values and attitudes. Many of the older fishermen thought that the younger generation had different expectations and values relating to work. Shifting away from the fisheries, some parents would now prefer their children to find other occupations and/or continue tertiary education. From an economics perspective, participants identified the connectivity between upgrading boats, gear, and navigational devices, taking out loans, and then the need to fish harder and be more competitive so as to maintain operational costs. Some fishermen thought that greed and taking more than enough to make a living was also a factor that sustained this trend. The issue of selling licenses to outsiders as opposed to community members was considered as a potential risk that could disrupt the connectivity between community identity and composition.

Concern relating to management connectivity refereed to the linkages between political agendas and management decisions specifically those that led to the collapse of the groundfish fishery. The legacy and the lived experience of these decisions has continued into other fisheries, including the lobster fishery. Examples include fishermen's mistrust in quotas and government's knowledge of the fisheries. Other issues include their perception that government agencies are reluctant to hear/work with fishermen, and that these agencies have a bias towards large cooperation's.

Opportunities relating to ecological connectivity included: the belief in the cyclic nature of the fisheries, such that good years and bad years, and the change in attitudes towards garbage that has been influenced by increased medial connectivity and local awareness through general marine pollution campaigns. Maintaining social connectivity was important for island communities, and having a yearlong ferry between Campobello and Deer Island and/or the mainland potential could potentially open up more employment opportunities, hence increasing livelihoods diversity. Maintaining an island identity and social events were also important strategies for keeping communities connected and encouraging cooperation. From an economic perspective, participants noted the connectivity between fishing and the contribution in hours towards employment insurance. The seasonal nature of the fisheries and other environment based industries provided employment opportunities, while still allowing people to remain connected to their community. Examples of neutral comments included: the connection between different industries and how these sectors had influenced/changed community values and identity, the cyclic nature of people following different fisheries/seasonal employment opportunities, including younger people moving into and out of the communities, and moving between different fisheries when opportunities were lost. Another example of a neutral comment was where participants believed that they just needed to deal with economic changes as a part of life.

Principle 3: Manage slow and fast variables, and feedbacks

Referring to both environmental and management systems, a concerned raised was the potential impacts from current aquaculture farms on future populations of lobster and other species (e.g. reproduction rates, health etc.). From a management perspective, current policies and legislations in place to deal with these impacts might not adequately reflect future risks (based on current knowledge) and/or provide proactive means to deal with an unexpected crisis.

One important social concern noted that the biggest future threat was the low potential for financial growth, and the opportunities for youth in small local communities.

Yet, one of the benefits of living in these small communities, where everyone knows each other, is the low crime rate (as a slow variable), which if it increased and/or became more serious could led to individual /group conflicts (as in poaching, for example). From a management system perspective, the lead into federal and provincial elections every four years (slow variable) provides the opportunity for voters to influence political outcomes (via elected officials). The release of that power after elections and the resulting fast feedback loop may have positive or negative connections on voters depending on the mandate of the elected official.

Principle 4: Foster complex adaptive systems thinking

The complexity of the ecological system, and it implications on how the social, economic, technological, and management systems adapt to these changes requires a better understanding of what is happening now, so as to avoid or mitigate negative consequences (known and unknown) in the future (e.g. shifts in species interactions and migration patterns, habitat changes etc.).

Many of the negative comments focused on weather and environmental factors that could collectively lead to the collapse of the lobster fishery. Other comments highlighted the issues of marine and land-based pollution and the impact (current and future) on the environment. Adapting to international market fluctuations and the flow-on effects to the local fisheries also requires an understanding of economic systems at local, national and international levels. Linked with understanding the ecological system, is also The complexity of relying on seasonal work, and its contributions to being able to draw EI benefits can also be risky (and costly) if this work is limited and/or a specific fishery collapses.

Reponses reflected the concerns that participants has regarding the ability of government agencies to manage current lobster stock, due to the complexity of the species ecology and changing environmental factors. This attitude is partly a legacy of the groundfish fishery and continues to affect the relationship between fishermen and government agencies. Other issues were related to the aquaculture industry and reflected confusion around having multiple management agencies, polices and regulations operating at different levels (municipality, provincial and federal). The lack of coordination, and sometimes inconsistences across agencies, biased perhaps by competing economic mandates, limits the effectiveness of developing a holistic management approach. Another issue was the perceived perception of governments understanding of changing weather and environmental factors, and the impacts this has on current fishing seasons. Many respondents consider regulating agencies as not wanting to align fishing seasons with environmental changes, which in turn create less than ideal conditions for the fishermen. Besides issues affecting catch, fishermen/processors are also trying to align products with optimal market conditions and consumers preferences.

Understanding complex adaptive thinking in the social and economic systems context, one opportunity would be if there was a fairer marketing and promotion approach by government (as opposed to just supporting the aquaculture industry) as this would be very helpful for inshore seafood products, especially if integrated with the tourism industry. Other positive responses noted the opportunity for additional economic gains if new and underexploited species were opened to fishing by DFO. Although, these new fisheries are a form of adapting and/or being creative, future risks to the species and/or fishermen's livelihoods may arise if not enough is known about food web interactions between different tropic levels.

Positive comments reflected on the potential for integrated management, provided fishermen had an equal voice and were heard at the table. Being on the water, fishermen believed that they could contribute to monitoring environmental change if given the support and opportunity. There was also the potential through collaborative projects (government, academics, NGOs, and indigenous peoples) to better understand the connections and complexities between environmental and social changes, and the impacts these have on different communities. Lobster quotas offered management solutions but only if done fairly and with the required research to justify the allocations. Being fair and working collaboratively with fishermen would help to navigate the different layers of complexity (e.g. information gathering, allocation, monitoring stock, decision process, proactive management etc.). Neutral comments reflected upon the lobster populations doing well, and the uncertainty as to what effect quotas might have on the fishery.

Principle 5: Encourage learning

The loss of knowledge in the herring weir fishery as fewer fishing structures were being built and the decline in this form of fishing, is one example of a key threat towards encouraging learning. Other comments focused on behaviours and attitudes, citing examples of personal investment being focused on the now, rather than anticipating/considering future outcomes and youth being more interested in technology skills as opposed to taking up a fishing profession due to this being hard work, and the uncertainty in hours/pay. Another comment warned that because lobster stocks were doing so well, fishermen may not be preparing for a major event/situation if populations were to collapse and/or there was a prolonged period glut of supply on the market (or consumer demand diminished).

Positive comments relating to learning included changing behaviours and attitudes towards recycling garbage, initiating good oil waste management strategies, and having respect for other marine users. There was also a realisation that opportunities that might be considered positive for fishermen could also create risks to the environment and/or others if risk management is not taken into consideration, as a component of adaptive planning and implementation.

For the few fishermen with family members thinking/having the advantage or being able to enter the fishery, the importance of intergenerational learning and being able to pass on both fishing skills and life lessons to help prepare the younger fisherman for unexpected events was one approach to encouraging learning. Other examples included the learning and technology developments that have led to safer boats, longer lasting fishing gear, and navigational equipment that allowed fishermen to more easily retrieve fishing gear.

Positive comments relating to social learning included community projects and collaboration with other stakeholders facilitated through fishermen associations. Integrating school projects with the fisheries and training courses in fisheries management and supporting skills could help both social and individual learning. The use of newer technology appeared more appealing to individual younger fishermen, although the ability to share electronic information relating to sites etc. was also a form of social learning and more appreciated by older fishermen. Neutral comments included the observation of trends where technology outpaced the ability of the environment to regenerate, and fishing skills changing between different generations of fishermen. Other comments noted the potential careers for youth in management and other government departments, but require both hard and soft skills.

Principle 6. Broaden participation

Concerns were raised on the lack of meaningful participation in government projects/decision making, and information transparency. There was also a desire to be more involved in government led, research projects, decision making and information transparency.
For example, the aquaculture industry and fishermen working together on shared research topics and projects. However, as seen in the groundfish fishery, issues of power and other agendas may often dilute hard facts that then lead to the misalignment and/or delay in appropriate action being taken.

Many of these respondents felt that belonging to a community-based association helped them to cope by having a stronger voice when dealing with decision makers, and having the ability to efficiently address some of the management challenges that their fishery faced. Yet one of the challenges is the diversity in opinions among fishermen, which can distract from coherent discussion.

Principle 7: Promote polycentric governance

One of the biggest issues noted by fishermen was the perceived bias of DFO and the provincial government towards inshore fisheries. Attention for funding and support was considered to be more favourable towards the aquaculture industry and other fishermen associations such as Grand Manan. Fishermen also noted that for some previous studies where they had worked collaboratively with government agencies, findings were ignored, when management decisions were made. Neutral comments reflected on past government (e.g. Transport Canada) warnings regarding changes in regulations such as sea safety. Some fishermen disregarded these notices and were unprepared when changes were made.

The issue of marine debris from current and abandoned salmon farms was an economic concern for fishermen and many felt that the government was not holding the aquaculture industry accountable for their actions. Although there was some support for an integrated governance system, fishermen also noted that the biggest problem was that there was no system in place to be able to make collective and collaborative decisions. Community based fisheries had been discussed previously, but many felt that it was all talk and no action at the higher levels.

The general consensus by fishermen towards native fishermen was that they should captain their own band boats, rather than hire non-native fishermen. Yet there was a sense of unfairness that this was being allowed to continue to happen because DFO had another set of regulations and management processes for these fishermen. Another issue was the use of mandatory electronic monitoring equipment required for safety, and the perceived ability that this was being used by agencies to monitor them for fishing infringements.

The closest that fishermen could get to community-based management was to join fishermen associations. For example, dealing with the aquaculture industry through their associations, fishermen and other stakeholders could lobby for better clean up regulations and policies to prevent the treatment of salmon with harmful chemicals that affected the environment. Comments also reflected the positive outcomes of some of these processes (e.g. lobster v-notching, size limitations etc.), and the many other shared projects that were successful and helped to build stakeholder trust (e.g. ghost trap retrievals, traffic committee, and whale entanglement projects). Some participants noted the financial support provided by Transport Canada towards upskilling and recertification courses/programs.

9.2.3 Summary of positive, negative and neutral comments

Based on examples presented in the previous section, Figure 21 shows the distribution of comments referring to negative, positive and neutral perspectives drawing from the coding exercise. Negative perspectives were found mainly in comments relating to diversity, connectivity, and complex adaptive systems principles, followed by polycentric governance.

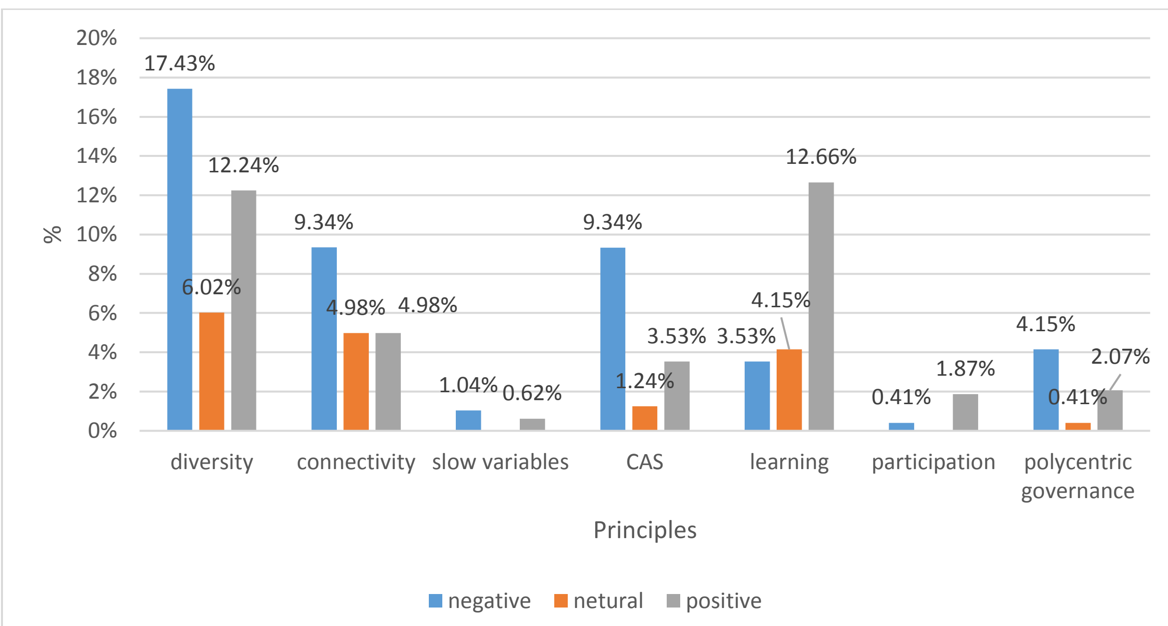


Figure 21: Participants perspectives coded to the resilience principles

Positive comments centered on the learning and diversity principles. Reflecting on this distribution and the above assessment, fostering complex adaptive thinking appears to be the principle most at risk of not being met because of the frequency of negative comments. Diversity and connectivity principles also had a large number of negative perspectives, but these may have been more balanced by the positive and neutral comments in comparison with the complex adaptive thinking.

One of the aspect of qualitative analysis is that it allows a researcher to explore deeper meaning to a context through the synthesis of broad themes and specific sub-themes. As such, it is possible to not only note what participants have said, but to also document what is not mentioned and to question why this may be so (Corbin & Strauss 2008). For example, participants recognize and use the term diversity and so, were able to provide specific examples relating to this principle. Comments relating to slow and fast variables and feedback loops, connectivity, and polycentric governance and participation are terms that participants may not be familiar with, and hence would not have been specifically mentioned. However, drawing from examples participants provided to further explain their perspective, it is possible to make informed estimations of which principles these comments would best align with. Another flag that allows a qualitative researcher to further question the data is the absence of a specific detail or topic (Miles et al., 1994; Corbin & Strauss 2008). In addition to perhaps not being familiar with these terms, another reason that participants may not have focused on these principles relates to the lack of opportunity (as in the case of participation in resource governance). Yet, these are the principles that help build strong management systems that have a better chance of preventing and/or mitigating threats (or responding to opportunities) to the SES.

Drawing from the overall assessment of the seven principles that would support general resilience, Table 16 identifies the principles that appear to be most and least at risk from not being met. The scale ranges from 1 where the objective of this principle is at high risk, 2, medium risk, 3 some risk, 4 low risk and 5 no risk. In this context, the principles that appear to be most at risk are: (a) understanding slow variables and fast feedbacks, (b) fostering complex adaptive thinking, and (c) establishing polycentric governance. Overall, principles relating to diversity, connectivity, and participation are at medium risk, with learning being at a lower risk. These principles are summarized below in the context of general resilience and potential threats.

Table 16: Principle objectives most at risk of not being met

Principle	1	2	3	4	5
P1 Maintain diversity & redundancy		X			
P2. *Manage connectivity		X			
P3. Slow and fast variables and feedback loops	X				
P4. Foster complex adaptive system thinking	X				
P5. Promote learning			X		
P6. **Encourage participation		X			
P7. ***Polycentric governance	X				

* Connectivity between components of the SES appears average but may be lower between management / social components (e.g. fishermen and government).
** Participation with specific government personnel, academic institutions, and NGOs on collaborative projects that can help inform governance decisions has some good examples that demonstrate successful participation. Yet the ability of community stakeholders to participate in the actual governance and management processes appears limited.
***Although not mentioned by the participants, the SWNB marine planning committee was an opportunity to be involved in governance decision making but was limited as members of the committee needed to be approved by the government representatives (MAC Meeting Minutes, October 2017).

Principle 1: Maintain diversity and redundancy. Despite numerous historical changes and disruptions, provisioning ecosystem services are still able to maintain current social systems. Yet the quality and quantity of different ecosystem services has been reduced and/or changed, as current fishing practices work down the food chain. Similarly, demographic, intergenerational values, and attitudinal changes are taking place within the social system, but communities are still able to maintain their traditional fishing identity. Management systems are diverse and cover many critical habitats and processes. Conversely, an overall connecting process between different agencies and jurisdictions may not align with temporal and spatial shifts that are occurring at the SES level. NGO's, fishing associations and universities have contributed to important research and advocacy activities that provide for a better understanding of environment changes, and the impacts these may have on community members

Principle 2: Manage connectivity**:** Environmental connectivity is a feature of this area, given the influences of the tidal regimes and other environmental factors. Economic connectivity is also an important factor, indicated by events that ripple from international events (e.g. 9/11 and the financial crisis of 2007–2008) through to ramifications at the local and national scales. Although management systems are quite diverse and cover different areas and jurisdictions, the potential lack of connectivity between different agencies may have diluted the ability of management and science agencies to proactively prepare and/or react to both subtle and acute environmental and social changes, and the interactions and processes across both systems. Families with a history in the fisheries and/or area are reflected in how they identify and structure their communities. The connectivity between fishermen and place/community is strong, with participants noting the value of different ecosystem services, community identity, and cooperation. The growth of different industries (oil and gas, Port, nuclear energy) provides alternative employment options to fishing, however, these opportunities may be more accessible to people from the mainland than for those from the islands. Aquaculture, tourism and potentially facilities for senior citizens are options for island communities. The influences of these industries, and other careers in the technology field could reshape the composition of these communities, and potentially influence how communities identify themselves in the future.

Principle 3: Managing slow and fast variables and feedback loops**:** The conceptual model that many participants have, indicates some degree of comfort and patience with respect to reaping the benefits of good years and setting aside provisions for bad years. Communities and management agencies are also aware of changes in slow variables (e.g. species life histories and the influence on maturity and size) and fast variables (e.g. species abundance and diversity). The absence of timely monitoring information on changes in slow and fast variables and feedback loops, vested and competing interests, and the lack of agreement on the appropriate responses, and management interventions have the potential to obscure, remove or ignore stabilising feedback trends within and across different components of the SES. From a social perspective, fluctuations in market prices generate a high degree of uncertainty. Strategies to counter slow variables and fast feedbacks could take a resilience approach, such as diversifying markets and automating facilities and processing plants to reduce labor costs, or expanding harvesting/farming areas to reduce the risks of disease and allowing areas to recover.

Principle 4: Complex adaptive thinking requires understanding the dynamics between slow and fast variables and feedback loops across and within different systems components, and being able to prepare for expected and unexpected events. At the sector level e.g. fishermen, aquaculturists, and other industrial stakeholder groups focus on risks that affect their industry, which is similar to businesses and services. NGO's consider risks to their specific area of interest (e.g. clean waters, ecosystem health, sustainable economic development, climate change), Government agencies are mandated to manage (which also includes the agency's internal risks) people to prevent activities that threaten ecological resources. Conversely, departments like DFO and their corresponding provincial agency are also tasked with providing economic opportunities drawing from the resources that they are responsible for protecting. These at times conflicting objectives, in addition to the social-economic and environmental pressures are a good examples of where complex adaptive thinking is required.

Principle 5: Encourage learning: It appears that more could be done to increase transparency, overall dissemination of data and timely reporting. For example, although under the responsibilities of Environment Canada, DFO and Provincial governments, many participants described the difficulties of getting responses to their questions on the impacts of pesticides, and/or their requests for chemical testing. Encouraging learning would also include the inclusion of different knowledge sources, but also the ability to integrate these into a cohesive manner, that allows for some data flexibility (e.g. participants made specific mention to the need for further research on the impact of pesticides being used by the salmon aquaculture industry) but still maintains the integrity of the information. For example, the opportunity to learn from other knowledge systems that incorporate the principle of *Netukulimk*, an approach applied by organizations such as the Mi'kmaw Conservation Group (https://mikmawconservation.ca/) and the Unama'ki Institute of Natural Resources[71] could help inform and integrate different mental concepts about resource use Having more diversity and accessibility to independent reviews and testing agencies would also help build resilience and transparency.

[71] Defined by the Unama'ki Institute of Natural Resources, Netukulimk is the use of the natural bounty provided by the Creator for the self-support and well-being of the individual and the community. Netukulimk is achieving adequate standards of community nutrition and economic well-being without jeopardizing the integrity, diversity, or productivity of our environment. The Mi'kmaq way of resource management includes a spiritual element that ties together people, plants, animals, and the environment. http://www.uinr.ca/programs/netukulimk/

Principle 6: Broaden participation. Many respondents believed that belonging to a community-based association helped them to cope with stressful policies or management plans by having a stronger voice when dealing with decision makers. Working with academics on community research projects was felt to be helpful as it allowed fishermen to take ownership in research being conducted on their fishery, but also having access to timely data and information. The ongoing reliance on single species assessment models provides barriers to broadening participation by others who are not associated with DFO. A disconnect resulting from the distrust between fishermen and within fishing communities (e.g. native and non-native), large corporations, and regulating agencies (groundfish fishery legacy) suggests there is still much work to be done to achieve this principle.

Principle 7: Promote polycentric governance. Although not mentioned by the participants, the BoFEP and SWNB marine planning committee initiatives are attempts to broaden governance opportunities on issues that are of relevance to multiple stakeholders, and across jurisdictions, sectors, and organizations. Yet it is to be seen how fast management systems can change and adapt based on information that is received from these studies. At the community level, government funded community - research alliance and collaboration projects (such as CFRN and Coastal CURA) support research that is important to both government and communities, while also providing opportunities for meaningful data sharing and discussion. Given these types of platforms, there is potential for creating enabling polycentric governance. At the end of the day government elected officials are still responsible for the overall management of SESs, but there are still many roles that communities and other stakeholders can play to better understand the processes and factors that underpin this SES.

9.4 General resilience and risk management insights

This section discusses some of the challenges and opportunities for building general resilience into the overall SES to prevent or mitigate unexpected threats and risks. The discussion is based on insights gleaned from previous sections in this chapter, Chapter eight and the literature. **Appendix 2** provides a summary of the seven principles identifying general and resilience characterizes.

9.4.1 *Complex adaptive thinking*

Fostering complex adaptive thinking requires understanding the principles of diversity, connectivity, and slow and fast variables, and feedbacks. The principle of diversity and redundancy (ecological, social-economic, management) provides a buffer that allows for different options in the event of an unexpected threat. Diverse ecosystems deliver provisioning, cultural, and regulating services, which in turn support healthy livelihoods. Diverse organizational, research projects and initiatives help to fill research and education gaps that are not addressed by government agencies. Yet, this can also create conflicts when many different conservation groups vie for a small pot of funds or findings are influenced by self-interest. Diverse management agencies cover different jurisdictions, with agencies mirrored across federal and provincial departments. Yet these policies and legislations can create different sets of risks for groups of stakeholders based on, for example, gaps/limitations in the implementation /enforcement of regulations, resources maybe limited and/or there is a lack of overall coordination.

In this context, ecological variables and feedback loops relate to shifts in species and predator-prey interactions food chains, migration patterns (deep waters-colder), abundance and distribution (lobster), shifts in species health (quality) in response to environmental and temporal changes. Social and economic feedbacks include community conceptual models (good vs bad years, resilience on government subsidies) and international and national trade policies/world events.

Management factors include the alignment and flexibility of different policies, legislations, and regulations in response to slow variables and fast feedback responses of the SES.
Approaches that can support complex adaptive thinking include:

- Community projects that are holistic and interdisciplinary (e.g. lobster and aquaculture research that includes both social and ecological components);
- Stakeholders opportunities to access, analysis, and discuss different ways of knowing, forms of data and knowledge relating to the Bay;
- Interdisciplinary studies and inter-professional development that feed into an integrated management approach to SES;

- Professional training for individuals and community organizations e.g. business skills, organizational project management, project risk management training, and data interpretation.

Drawing from the literature, one successful study demonstrated a collaborative project that included representatives from federal and provincial governments, fishermen, environment NGOs, and the aquaculture industry to discuss and identify solutions to address the risk of stationary marine debris in the Bay of Fundy (Rehn et al., 2018). This three-year study brought participants together to document different participant's perceptions of debris sources and threats, and to place large non-mobile debris into GIS layers so as to identify mitigation priorities (Rehn et al., 2018). Initially, the process started with a high-level degree of distrust between the fishermen and aquaculture representatives. Contentious issues included what was debris, who was responsible for it, and which ones should be prioritized for removal (Rehn et al., 2018). The introduction of the GIS map, with physical data points being added, introduced a level of stability to the discussions. One influence on stakeholder involvement was the fear of walking away from the process, which might also remove their influence over the map, and its future outcomes, e.g. potential to influence government and the public (Rehn et al., 2018). As participants became more engaged with the project and were being held accountable to the data they were providing, polarized positions changed, with compromises made on who was responsible, and what mitigation actions could be taken.

Other factors that may have contributed to the success of this project included involving just the fishermen in the first stage of the project (to document their perspectives on sources, types, and risks of marine debris in the Bay), followed by including other stakeholders during the second phase, including government and solid waste commissions. Given the ongoing conflicts around chemical pollution and loss of space between fishermen and aquaculture, taking this approach may have given fishermen a greater sense of control in their contribution to the project and the desire for it to succeed (Rehn et al., 2018). Another factor was framing the project around a greater good, in that the area of concern had been designated an ecological and biologically significant area by DFO, as it contained several species at risk, including the right whale (Buzuta & Singh, 2008). Many of the participants lived in the area, and knew each other from daily encounters both at the work place and in the community. Focusing on the risks that large debris fixed to the ocean floor and floating in the water column posed to humans, whales and other marine species, shifted the attention away from each other, as they collectively sought ways to address these problems. A third factor, which probably did not have as much influence as the ones mentioned above, was the incentive of a small amount of funding available to remove high priority debris that was within their capacity to address (Rehn et al., 2018). Additional context relating to the issues between the Aquaculture industry and traditional fisheries is provided in **Appendix 3**.

9.4.2 Polycentric governance

Similar to adapting complex thinking, polycentric governance builds upon the principles of learning and participation. Within the social system, encouraging learning requires establishing resources to support timely and proactive learning (e.g. different levels of learning – classroom, experiential, online, and intergenerational), providing a safe space to ask critical questions and discuss issues constructively, and creating knowledge that is shared and accessed among different communities and groups (e.g. native and non-native communities, industry sectors). Encouraging learning within management systems requires an openness to shift and/or adapt conceptual models such as integrating and sharing of different ways of knowing, providing resources to support different forms of learning and monitoring and evaluating different approaches and processes for knowledge generation and dissemination.

Broader participation requires resources and a process for equitable participation among different communities and stakeholders. This includes identifying groups/sectors who potentially may be less powerful at the table, providing opportunities for their participation and a process to better understand and communicate their perspectives, in the context of broader issues and the policy environment. The question though is which groups are most at risk (and why), and how is this process made equitable? One approach might be to identify groups that are the most vulnerable (or resilient) using indicators that need not always be based on economics (e.g. digital access and literacy)

Approaches that can support polycentric governance include:

- Processes established to identify issues, opportunities and cross scale interactions at different spatial and temporal scales (e.g. Marine Advisory Committee, BoFEP);
    - Ability and willingness to learn from experiences (e.g. SWNB planning committee) and adapt and/or transform governance strategies in response to unexpected events (e.g. climate change);
- Process to prioritize issues and opportunities in a fair and equitable manner that considers specified and unexpected risks to the SES;
    - Ability to monitor and evaluate different approaches and processes for flexible governance that can adapt to changes, without compromising future opportunities or creating/enhancing risks to the SES;
- Process to understand different perspectives, issues and their interactions at different scales and match the governance system to the issues and opportunities (current and future), with the appropriate resources.

The SWNB Marine Advisory Committee is a good example of an attempt to establish a form of polycentric governance. Parlee & Wiber (2018) provide a comprehensive overview of the formation and processes involved in establishing the SWNB initiative. Beginning in 2004, the formation of the committee was based on an interest in protecting the future of the Bay. During the first phase, provincial and federal department of fisheries representatives formed a government secretariat that provided support to the group, which included 12 members representing industries, first nation communities and NGO's (nominations were provided to the government prior to membership being approved). With the committee established, the second phase was the development of a community values criteria framework (CVC) tool using a bottom-up approach to gather feedback from communities in the area. The purpose of this tool was to better understand how local values would come into play when assessing management plans and development processes. The third phase was a refinement of the CVC, and recommendations on the structure and function of the committee going forward (e.g. to assess and provide advice on issues relating to coastal development and management using the CVC as guide). The Secretariat, however considered this a duplication of resources, with additional bureaucratic layers, and during the fourth phase the committee was officially dismantled in 2017 by the government leads (Parlee & Wiber, 2018).

In a subsequent post mortem (Marine Advisory Committee, October 2017), one of the main reasons for the disbandment was that government agencies deemed that in its current form the committee was not functional (Marine Advisory Committee, October 2017). As such, there would need to be a review and refinement of the committees' mandate, purpose and operating procedures. These minutes also highlighted that the committee did not reach its full potential, including the fact that the CVC was never used in practise despite the resources and time it had taken to develop the tool (Marine Advisory Committee, October, 2017). An earlier committee report had emphasized the challenges and complexity of government agencies when dealing with ecosystem change, trade-offs and overlapping interests and standards, which makes the integration of multiple activities difficult in the context of diverse ecological, social, and economic objectives (Marine Advisory Committee, June 2017).

Other areas of the minutes suggested that DFO did not bring issues to the table that required advice, the process for providing advice was unclear, and one to two meetings per year was not enough for maintaining momentum and interest. Another issue noted in the minutes was also highlighted by Parlee & Wiber (2018). This involved the 'hats off the door' protocol, which was initiated to allow people to step away from their daily professional roles so that interests and perspectives could be discussed and consensus reached. Yet this was difficult to achieve because some people were attending during their work hours (and were thus considered representing their organisations/agencies) and often the expertise and experience that members bought to the table came from the work they did (Marine Advisory Committee, October 2017).

The role of government agencies, as the Secretariat was to mainly facilitate and provide administrative support (Marine Advisory Committee, October, 2017). It was felt that true collaboration and the value of this process requires all members to be fully engaged in the process and discussions. An acknowledged issue indicated that as public servants, government members were required to support the priorities and mandates of their departments, which restricts what they can say and do during these types of forums. Lastly, although the MAC had been reviewed on a number of occasions, the most recent being the 2012-2015 period by the Secretariat, none of the recommendations had been implemented (Marine Advisory Committee, October 2017).

Members agreed that what worked was the relationships built through on-going engagement, and that the MAC provided a form for community members to discuss important issues (MAC, October 2017). Local projects such as dealing with marine debris (see Rehn et al., 2018) were easier to implement and support as there was less conflict involved. Bigger issues such as chemical use in aquaculture farming needed a broader national approach as it involved stakeholders and issues beyond the local and SWNB level. Suggestions for next steps included a shift from consensus reaching to sharing information and perspectives, and longer and more frequent meetings that had the right people at the table. The FRCC was also suggested as a potential model for engagement (Marine Advisory Committee, October 2017).

This section has discussed two examples that illustrate complex adaptive thinking and polycentric governance in the context of building general resilience. Both examples provide interesting lessons relating to challenges and opportunities faced by the proponents. For the SWNB area, these examples provide an opportunity to continue the learning momentum and trust that has already been established.

9.5 Summary

This chapter focused on understanding general resilience factors though the lens of the seven resilience principles. Based on the analysis, the three principles with objectives that appeared to be most at risk of not being achieved were: (a) understanding slow variables and fast feedbacks, (b) fostering complex adaptive thinking, and (c) establishing polycentric governance. Diversity and redundancy provide a buffer that allows for different choices to be considered and prioritized. Yet, one of the issues with transferring ecological concepts to social-economic systems is that too many choices/perspectives can prevent decisions being made in a timely manner, not everyone will be in agreement and/or setting priorities creates conflicts among members due to different opinions, conceptual models (including values), behaviors and attitudes.

Principle 4 (foster adaptive complex thinking) is a focal point between principles that represent important components and processes that build SES resilience (P1-3), and those that provide support towards the governance of the system (P5-7). As such, it would be important to work towards this principle so as to better understand and deal with current known and future unknown threats and uncertainties. A helpful start might be to build on the opportunities centered on the principle of learning as this has highest percentage of positive comments. Yet, as many examples have shown, ongoing conflicts, individual personalities, and distrust among fishermen, the aquaculture industry and government, challenge the development of an enabling learning and collaborative environment. Nevertheless, this approach might be considered the first step towards meeting the goals of effective participation and the development of polycentric governance.

Chapter 10: Conclusions

10.1 Introduction

The four objectives of this study were to:

1. Conduct a literature review on risk and resilience concepts and frameworks in the current literature of SESs;
2. Explore how these concepts and frameworks provide insights for one of the largest fisheries (groundfish) collapses in the world, which occurred in Atlantic Canada;
3. Understand the roles of risk and resilience concepts in stressed Atlantic Canadian fishing communities using a case study of the New Brunswick coastal communities; and
4. Present and discuss overall approaches that contribute to a better understanding of the role and interactions between risk and resilience concepts in coastal community SESs.

The following sections summarize how each objectives was addressed, and the key insights that have emerged.

Objective 1: Findings from the literature review highlight the strengths and limitations of each approach. For example, both risk and resilience approaches take a holistic and systematic perspective that recognises the interactions between systems, acknowledges the need to focus on capacities and has an objective of better preparing systems to deal with uncertainty, surprises and change. However, within the management field, risk is an older approach with defined principles, objectives, frameworks, measures and process, and is often an accepted approach in standard management practices. Resilience (in the context of resilience management for SES) is a newer approach and has yet to be considered a standard approach in the day to day management of a SES.

Incorporating a specified resilience (what to what/whom) approach with traditional risk management provides opportunities for adding elements that may address the complexity and inter-linkages of different risks. Yet, focusing on the system (rather than a single risk) could help strengthen existing interconnecting pathways by unpacking key elements such as power relations that may prevent the development of a resilient system. Furthermore, taking a general resilience perspective might better prepare an SES to address areas of uncertainty and change by exploring how long-term trends from stressors can change the nature and impact of shocks in the future (OECD, 2014a-b).

Both resilience and risk approaches have similar critiques in their methods, including the limited and narrow ability to conceptualize the social system and a reliance on scientific interpretations (as the prioritized knowledge system), based on models and frameworks. Consequently, from an applied perspective, any approach to conceptualize integrated risk and resilience management approaches will need to consider both the limitations and strengths of these two approaches.

Using a resilience approach may help to better prepare a SES in situations of uncertainty and unexpected shocks as risk management has traditionally been more focused on identifying and preparing for known shocks and hazards. From a resilience perspective, Biggs et al., (2015), draws from the earlier work of the Resilience Alliance and examines the linkages among principles, objectives and applied frameworks in an SES context. Two integrated risk and resilience frameworks drawing from the disaster (DROP model) and port security (Brooks and Pelot model) are explored as a means to better understand how these concepts could contribute to an integrated risk and resilience management approach for coastal community SESs.

Objective 2: Applying the seven resilience principles (Biggs et al., 2015) to the groundfish fishery literature provided important insights into the potential relationships between risk and resilience concepts in this context. As a contribution towards identifying an approach that can be used at the community level to better understand the interactions between these two concepts, a simple scoring tool was applied to the literature to assess how well the objectives of the resilience principles was achieved at two time frames (prior to the event, 1992 and post event, up to 2018).

Based on this subjective scoring assessment, all principles scored very poorly prior to 1992, but there were small increments post event. Encourage learning (Principle 5) scored the highest post event due to the plethora of research articles and reports that were produced. However, the application of changes based on this new knowledge, especially in the management context still faces challenges due to political and economic pressures.

Resilience characteristics were also identified that could either enhance resilience or create risks to a specific component of the SES. Components of risk and resilience are dynamic, and what might be one person's risk is another's opportunity to build their resilience. Furthermore, risks and resilience attributes change over time, and what once might have been a coping/adaptive strategy has led to unexpected risks to the same entity/individual when SES conditions change. Future exploration of these risk and resilience characteristics and interconnections could provide the foundation to better support coastal communities strategically address slow creaping threats, such as climate change.

Objective 3: In the SWNB case, the closure of the groundfish fishery triggered a number of coping/adaptive strategies including fishermen leaving the fishery but finding other forms of local employment, securing other employment opportunities outside SWNB/province, and switching to different fisheries, including lobstering or starting small scale aquaculture farms. These strategies had future consequences to coastal communities including a decline in populations and the loss of public services. Compared to the groundfish fishery, it appeared that participants were able to refocus on the lobster fishery, which had always been part of their inshore fisheries. Aquaculture was also another option. Although the industry was subsidised by government, fishermen were able to get out of the fishery, in comparison with the groundfish fishery case, where many fishermen remained, relying on these financial benefits despite there being no more fish.

Similar, to findings from the groundfish fishery study, what may have initially been an adaption strategy for a community or individual has the potential to become a risk factor at a later date. Although, this could be considered true in many situations, the focus on short-term management strategies to address a crisis may often overlook the need to plan and manage for other potential risks that emerging from current interventions. In this context the bow-tie visualisation tool is a useful approach to identifying different threats and building in strategies to either prevent or mitigate the consequences of these events. Another contribution to the risk and resilience literature builds on the Brooks and Pelot (2015) risk and resilience model, by drawing insights from Cutter et al., (2008). Here, resilience factors could potentially be built into a risk management framework to help strengthen the SES, both prior to, and following an event.

Objective 4: Chapters four, and specifically, eight and nine combine research results with the theoretical literature in order to discuss the factors that could increase specified and/or general resilience to better support risk management approaches. Chapter four used secondary data to reconstruct the key elements that contributed to the collapse of the groundfish fishery, and to explore how risk and resilience concepts could be used to frame an approach to better understand their individual roles and interactions in the context of this SES. Having the advantage of an extensive library of literature and being able to observe what has happened since 1992, provides for some key insights into the interactions between risk and resilience concepts. Firstly, there were opportunities to prevent the collapse as the risks and consequences of continuing to fish at that level were known to both managers and fishermen. Yet, due largely to political and socio-economic influencers, actions to prevent these risks were not undertaken. Secondly, mitigating economic and management actions following the collapse, allowed coastal communities to cope with the moratorium, with some adapting by leaving the area/fishery to work in other sectors/locations, or switched to another fishery. The government continued to subsidies the fishermen (but also taking other measures such as re-training), despite there being no more fish. This in turn created an environment of complacency and reliance on government funding, as opposed to finding other means of earning a livelihood. Hence, although these actions allowed communities to be resilient, it perhaps did not really consider the new risks that may have emerged i.e. remaining focused on the fisheries and expecting that they would be able to return to this nature base resource (and at the same level of intensity) in the future.

Cod stocks have slowly recovered and recently the fishery was recently opened as a pilot due to pressure from the fishermen, but then closed as stock levels dropped again. The fact that fishermen are still focusing on this species, even when international prices are low, is problematic, as it indicates that there could be problems with the current fisheries (e.g. snow crab and shrimp) hence requiring another shift in fisheries focus. The work being done by the Ocean Frontier Institution[72] is conducting sustainable fisheries and aquaculture research, but they could also explore employment options in other coastal and ocean employment sectors as a pathway towards diversifying the current reliance by coastal communities on natural resources.

[72] https://oceanfrontierinstitute.com/

Drawing from the groundfish fishery case, Chapter eight presents a bow-tie visual assessment tool as a means to identifying potential risks to a specific entity from a known hazard, and to make connections between threat drivers, consequences, and preventive/mitigating actions. This approach also allows for a discussion around escalating factors that could enhance or create barriers to interventions being proposed as a means to address the issue. Including a resilience perspective on both sides of the bow-tie is an opportunity to think more deeply about the consequences of preventive and mitigating actions (including policies) that may escalate the issue and/or create new threats in the future. As such the integrated risk and resilience bow-tie approach offers communities a flexible tool that can be used to create a discussion around a specific threat or to brainstorm different threats to prioritize the ones that could have the most impact on their livelihoods, areas or interest/value, and/or geographic location.

Chapter 9 takes another approach to understanding the roles and interactions of risk and resilience concepts by using the resilience principles as a lens to assess the baseline status of the SES. The concept being proposed here is that risk management in the context of specified resilience helps identify threats to a specific entity (inshore fisheries sector) from a known hazard (aquaculture sector), however, as shown in Figure 17, there are many other environmental, economic and social threats that could apply to both sectors (e.g. climate change) and the synergies and/or accumulation are future unknown threats could have a serious consequences for coastal communities. Understanding who (and which community/sectors) might be the most vulnerable to current and future changes will be important management areas to monitor

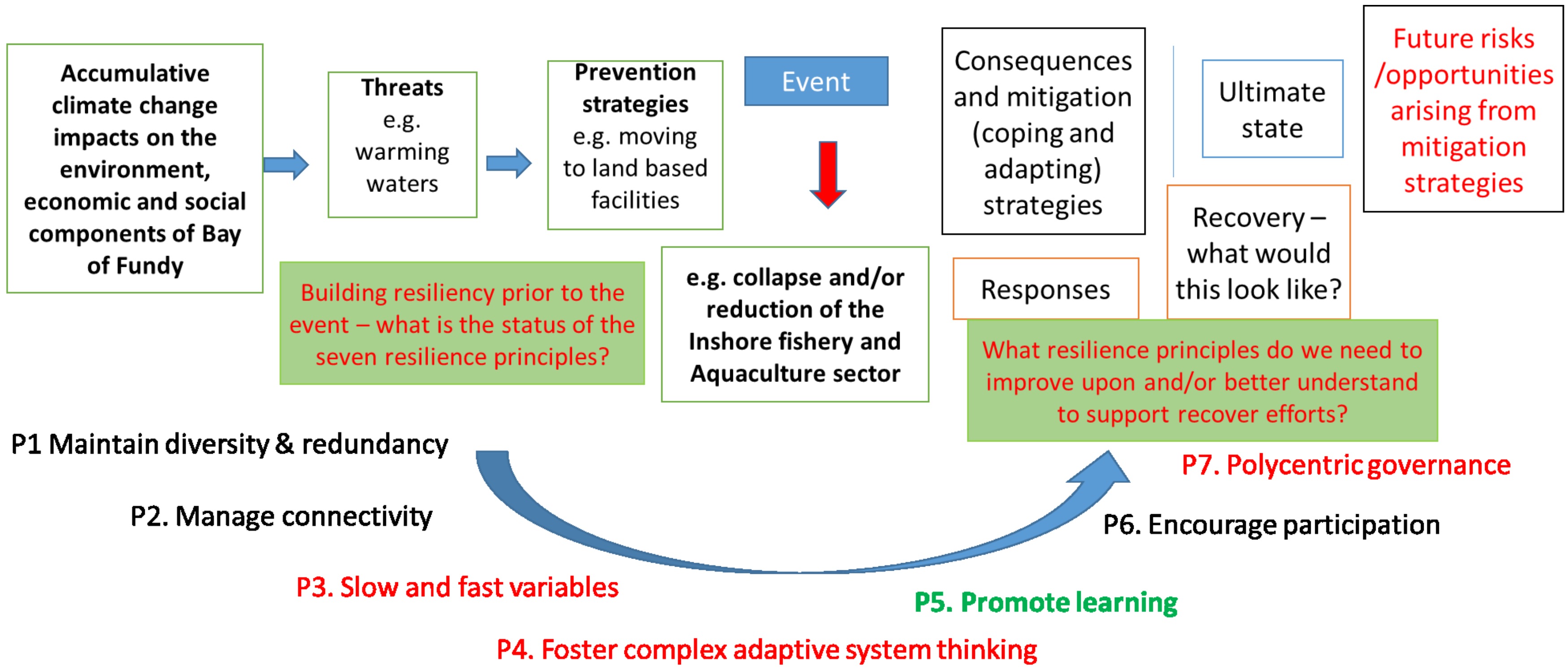
Concepts of risk and resilience are used in a more typical form, in that the objectives of the resilience principles are being assessed to determine which principles may be most risk of not being achieved. Applying a simple scoring tool, the three principles most at risk appeared to be: (a) understanding slow variables and fast feedbacks, (b) fostering complex adaptive thinking, and (c) establishing polycentric governance. Principle 4 (foster adaptive complex thinking) is a focal point between principles that represent important components and processes that build SES resilience (P1-3), and those that provide support towards the governance of the system (P5-7).

A helpful start could be to build on the opportunities centered on the principle of learning as this has the highest percentage of positive comments. Many examples have shown ongoing conflicts, individual personalities, and distrust among fishermen, the aquaculture industry and government challenge the development of an enabling learning and collaborative environment. Yet, there are also examples which show that sectors are able to work together around a common cause, and produce tangible results. As such, building around the principle of learning could be considered the first step towards meeting the goals of effective participation and the development of polycentric governance, which in turn contributes towards achieving Principles 1-3, and lessens the risk of these principles not being achieved.

Although the bow-tie visual tool, and scoring assessment used in this thesis maybe considered simple, one of the underpinning objectives of this research was to identify ways in which theoretical concepts relating to risk and resilience can be applied in a community environment. As SES are extremely complex and dynamic, with many unknown risks and opportunities, having these discussions in a way that is not overwhelming will be an important element for a meaningful polycentric governance structure. This is especially so, given that mental and conceptual models often have a more influencing role in underpinning the actions, responses, behaviors, and attitudes of different stakeholders. As such, managing for resilience as a process, provides an opportunity to build complementary risk management tools to both strengthen current strategies, but also consider future risks that may not be so evident in the moment.

Another contribution of my research is demonstrated here with this hypothetical example (Figure 22). Here we are trying to develop general resilience for the broader SES, that includes both the aquaculture industry and inshore fisheries – and we would want to do this because community members work in both industries, which in turn are reliant on natural resources and environmental supporting factors (e.g. water temperature and conditions). Known risks can be better managed using the integrated specified resilience and risk management approach. Adding general resilience into a SES as proposed though the application of these seven resilience principles provides buffering options for adapting or mitigating the impacts of unknown threats.

Figure 22: Building the general resilience in SWNB SES: A hypothetical example



A deeper understanding of the connectivity within and across a SES requires stepping away from silo management and taking on a more integrated approach that addresses the complexity of the whole SES, including both its risk and resilience. Understanding the roles of specified and general resilience provides an opportunity to conceptually explore interactions between these two concepts. Applying complex thinking requires learning in its many forms of knowledge generation and transformation, the ability to apply that knowledge in a timely manner to decision making process, and maintain forums that allow for participation in management decisions, by participants that have the resources and experience at different spatial and temporal scales.

Figure 23 provides a two perspectives on how risk may be considered in the context of resiliency and a SES. The inner circle focuses on the risk of the phenomena (whom/what is being affected, and by what). How resilient the SES (as a state property) can then be considered based on the impact the phenomena has on different parts of the SES, and the efforts made for the system to cope or adapt in order to continue to function. The outer circle (risk to SES principles) considers resilience as a management process, and here the perspective is to assess how well the resilience principles are being met, and which ones are at risk (and from what) so that interventions can be applied at a broader level. This approach is based on the assumption that by building general resilience through these principles, the resilience of the SES becomes stronger as takes into consideration both known phenomena but also events that may not be so evident or are unexpected.

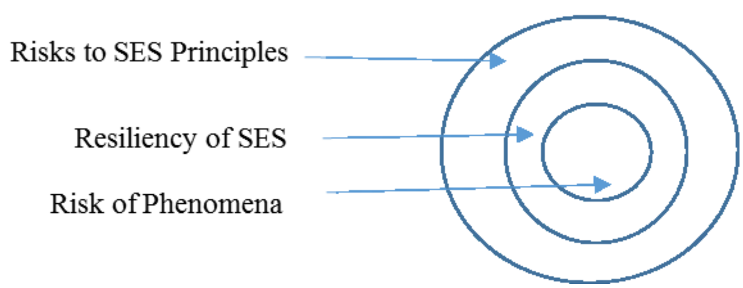


Figure 23: Two perspectives on risk and resilience interactions

10.2 Contributions and Future Work

The theoretical contributions of this research provided a different perspective on an integrated approach to understanding the specified resilience and risk. Another contribution was the conceptualization of how resilience principles could contribute towards building general resilience as a buffer for unknown threats within a SES. Applied contributions include proposed tools to visualize and discuss different aspects of risks and resilience that can be used in a community environment to enhance their ability to cope or adapt to changes.

Two areas for future work include:

- Testing the integrated risk and resilience approach in other contexts - threats (or opportunities) from known and unknown climate change impacts
- Developing a better understanding of risk and resilience concepts and interactions by expanding to other stakeholders in SWNB e.g. government, aquaculture industry, and other industries

10.3 Reflections and Final Comments

The approach taken in this study provided a subjective assessment on how well the seven resilience principle objectives were met. Yet, perspectives change based on personal and afar experiences, and individuals wear many hats (e.g. inshore fishermen are business owners, unionists, community members, fishermen associations etc.). Hence, the interpretation of what is a risk (or resilient) can change over short and long time frames, and in response to different issues/opportunities and perceived crisis. Thus, not everyone would agree that these principles are the most important to them, and support the application of a few or all. As a broad guide, these principles as applied in a linked risk-resilience approach provide an opportunity to better understand what/who is being made resilience and by what, and the risks that might be associated with the process for making something resilient and/or the consequences of not anticipating a specific risks or preparing for an unexpected event. This process is made stronger by understanding what the specific risks are to different stakeholders and then determining how resilient they are to unexpected events.

Known risks can be managed, but building general resilience into a SES as proposed though the application of these seven resilience principles provides buffering options for adapting or mitigating the impacts of unknown threats. Environmental impacts including climate change (e.g. warming oceans, lobsters migrating to deeper colder waters, intensity and frequency of storms, ocean acidification) are already being felt. Yet, the connectivity and understanding of slow and fast variables and feedback loops, both within systems and across a SES (which often has spatial and temporal considerations), requires stepping away from silo management and taking on a more integrated approach that addresses the complexity of the whole SES. The knowledge gained as a result of the research conducted for this thesis contributes to an understanding of the need and consequences for this integration.

Policies that guide both fisheries and aquaculture may not always be complementary. The ongoing issues of climate change may in fact hinder the ability of sectors to adapt to changes and/or fail to address/cover the broader environmental and social pressures (including economics) on the Bay. On the brighter side, this could be an opportunity to shift towards a more transformative from of governance as it first requires a shift in conceptual thinking from a silo/individualist model to one that encompasses a SES that is above an individual /agency/organization's current familiarity/comfort and mandate. This approach will require commitment and deliberate action from agencies, fishermen, and other industries to conceptualize, restructure, and allocate resources to create a governance system that moves beyond sector interests, agency jurisdictions/mandates, and organization/association obligations to their members. However, as illustrated from this research, the consequences of not doing so further exacerbates the risks and minimizes the opportunities to build appropriate forms of resilience.

As presented in Chapter eight, when this study was conducted the aquaculture industry was considered a major threat to the traditional fisheries. Yet, one of the biggest multinational company in the area started off as a local business following the collapse of the groundfish fishery. The company is still based in SWNB, and provides some employment and economic benefits to communities and the province. As communities comprise of fishermen and aquaculture workers and other stakeholders, impacts that are occurring because of climate change will affect the SES with potentially similar (e.g. services and employment losses) and unique impacts (vulnerability will be dependent on how resilient the industry and workers are) for both industries. The fact that both industries rely so heavily on the environment (and economic markets) could be a considerable threat in the future.

An observation from the collapse of the cod fishery was the heavy reliance upon government agencies to financially assist fishermen and communities post event. Although, this provides short-term solutions and allows the fishermen to cope and/or adapt to the crisis, it may also prolong the reliance of fishermen and communities on this sort of funding. Stenek et al., (2010) study highlights the importance of livelihood diversification. This is also important from a governance system perspective and may lead to a transformation in the fishery (e.g. a SES approach) before a crisis becomes apparent. Polycentric governance is one such approach, however as noted earlier, this process also requires coordination, conflict management, and the ability to make decisions, and the resources for implementation.

General resilience could be further explored in the context of the different policies, mandates, and regulations that are implemented across SWNB, but also at the national and international levels. Given the possibility of overlaps and/or gaps in the legislation, it would be important to know which policies (e.g. environment, social development, conservation, economic development, and climate change) may create new risks (or opportunities) or make specific elements of a sector or the overall sector more vulnerable to unknown impacts emitting from changes in the environmental, social, economic, and technological domains.

The knowledge generated from the research conducted for this thesis in terms of a novel integrated approach for understanding the linked risk and resilience of SES provide an invaluable contribution to enhancing the responses from all stakeholders in an SES. Following such an approach not only flags current and future unknown risks, but allows opportunities for adaptation through coping strategies that have the potential to build resilience within the SES.

References

Adger, W. N., & Kelly, P. M. (2012). Social vulnerability and resilience. In *Living with Environmental Change* (pp. 41-56). Routledge.

Alverson, D. L. (1987). *A study of trends of cod stocks off Newfoundland and factors influencing their abundance and availability*. Ottawa, Ontario, Canada: Department of Fisheries and Oceans.

Andersson, K. P., & Ostrom, E. (2008). Analyzing decentralized resource regimes from a polycentric perspective. *Policy sciences*, *41*(1), 71-93.

Armitage, D., & Johnson, D. (2006). Can resilience be reconciled with globalization and the increasingly complex conditions of resource degradation in Asian coastal regions?.

Audzijonyte, A., Kuparinen, A., Gorton, R., & Fulton, E. A. (2013). Ecological consequences of body size decline in harvested fish species: positive feedback loops in trophic interactions amplify human impact. *Biology letters*, *9*(2), 20121103.

Aven, T. (2016). Risk assessment and risk management: Review of recent advances on their foundation. *European Journal of Operational Research*, *253*(1), 1-13.

Bakun, A. (1996). *Patterns in the ocean: ocean processes and marine population dynamics*. California Sea Grant, in cooperation with Centro de Investigaciones Biologicas del Noroeste, La Paz, Mexico.

Barnett, A. J., Wiber, M. G., Rooney, M. P., & Maillet, D. G. C. (2016). The role of public participation GIS (PPGIS) and fishermen's perceptions of risk in marine debris mitigation in the Bay of Fundy, Canada. *Ocean & coastal management*, *133*, 85-94.

Bavington, D. (2009). Managing to endanger: Creating manageable cod fisheries in Newfoundland & Labrador, Canada. *Maritime Studies, 7(2)*, 99-119.

Bavington, D. (2010). From hunting fish to managing populations: fisheries science and the destruction of Newfoundland cod fisheries. *Science as Culture, 19(4*), 509-528.

Baxter, P., & Jack, S. (2008). Qualitative case study methodology: Study design and implementation for novice researchers. *The qualitative report*, *13*(4), 544-559.

Becker, E. (2012). Social-ecological systems as epistemic objects. In Human-Nature Interactions in the Anthropocene (pp. 55-77). Routledge.

Béné, C. (2006). *Small-scale fisheries: assessing their contribution to rural livelihoods in developing countries*. FAO fisheries circular, 1008, 46.

Béné, C., Wood, R. G., Newsham, A., & Davies, M. (2012). *Resilience: new utopia or new tyranny? Reflection about the potentials and limits of the concept of resilience in relation* *to vulnerability reduction programmes*. IDS Working Papers, 2012(405), 1-61.

Berkes, F. (2007). Community-based conservation in a globalized world. *Proceedings of the National academy of sciences*, *104*(39), 15188-15193.

Berkes, F., & Folke, C. (1998). Linking sociological and ecological systems: management practices and social mechanisms for building resilience.

Berkes, F., & Ross, H. (2013). Community resilience: toward an integrated approach. *Society & Natural Resources*, *26*(1), 5-20.

Berkes, F., Arce-Ibarra, M., Armitage, D., Charles, A., Loucks, L., Makino, M., ... & Berdej, S. (2016). Analysis of social-ecological systems for community conservation. *Community Conservation Research Network, Halifax Canada Available online at:. http://www. communityconservation. net/resources/social-ecological-systems*.

Berkes, F., Colding, J., & Folke, C. (Eds.). (2008). *Navigating social-ecological systems: building resilience for complexity and change*. Cambridge University Press.

Bieg, C., McCann, K. S., McMeans, B. C., Rooney, N., Holtgrieve, G. W., Lek, S., ... & Fraser, E. (2018). Linking humans to food webs: a framework for the classification of global fisheries. *Frontiers in Ecology and the Environment*, *16*(7), 412-420.

Biggs, R., Schlüter, M., & Schoon, M. L. (2015). An introduction to the resilience approach and principles to sustain ecosystem services in social–ecological systems. Principles for building resilience: Sustaining ecosystem services in social–ecological systems, 1-31.

Biggs, R., Schlüter, M., Biggs, D., Bohensky, E. L., BurnSilver, S., Cundill, G., ... & Leitch, A. M. (2012). Toward principles for enhancing the resilience of ecosystem services. *Annual review of environment and resources*, *37*, 421-448.

Binder, C., Hinkel, J., Bots, P., & Pahl-Wostl, C. (2013). Comparison of frameworks for analyzing social-ecological systems. Ecology and Society, 18(4).

Blackmore, J. M., & Plant, R. A. (2008). Risk and resilience to enhance sustainability with application to urban water systems. *Journal of Water Resources Planning and Management*, *134*(3), 224-233.

Bodin, Ö., & Prell, C. (Eds.). (2011). *Social networks and natural resource management: uncovering the social fabric of environmental governance*. Cambridge University Press.

Boholm, A. (1998). Comparative studies of risk perception: a review of twenty years of research. *Journal of risk research*, *1*(2), 135-163.;

Boholm, Å. (2003). The cultural nature of risk: Can there be an anthropology of uncertainty?. *Ethnos*, *68*(2), 159-178.

Boholm, Å., & Corvellec, H. (2011). A relational theory of risk. *Journal of risk research*, *14*(2), 175-190.

Borrego, M., & Newswander, L. K. (2010). Definitions of interdisciplinary research: Toward graduate-level interdisciplinary learning outcomes. *The Review of Higher Education*, *34*(1), 61-84.

Bowd, R. (2015). *Risk, resilience and social-ecological systems in natural resource-based development in South Africa* (Doctoral dissertation).

Brand, F., & Jax, K. (2007). Focusing the meaning (s) of resilience: resilience as a descriptive concept and a boundary object. *Ecology and society*, *12*(1).

Breuer, A., Janetschek, H., & Malerba, D. (2019). Translating Sustainable Development Goal (SDG) interdependencies into policy advice. *Sustainability, 11(7*), 2092.

Brondizio, E. S., Ostrom, E., & Young, O. R. (2009). Connectivity and the governance of multilevel social-ecological systems: the role of social capital. *Annual review of environment and resources, 34*, 253-278.

Brooks, M. R., & Pelot, R. (2008). Port security: a risk based perspective. *Maritime safety, security and piracy. Informa, London*, 195-216.

Brown, K. (2014). Global environmental change I: A social turn for resilience?. *Progress in human geography, 38(1)*, 107-117.

Brown, K., & Westaway, E. (2011). Agency, capacity, and resilience to environmental change: lessons from human development, well-being, and disasters. *Annual review of environment and resources*, *36*, 321-342.

Brubaker, E. (2000). Unnatural Disaster: How Politics Destroyed Canada's Atlantic Groundfisheries. *Political Environmentalism: Going Behind the Green Curtain*, 161-210.

Buzeta, I & Singh, R. (2008). Identification of ecologically and biologically significant areas in the Bay of Fundy, Gulf of Maine Volume 1 Areas identified for review, and assessment of the Quoddy Region, Fisheries and Oceans Canada (2008)

Canadian Science Advisory Secretariat Science Advisory (CSASSA) Report (2012/2010). Assessment of scallops (*Placopecten Magellanicus*) in scallop production areas 1-6 in the Bay of Fundy. Retrieved from: https://waves-vagues.dfo-mpo.gc.ca/Library/345680.pdf

Carpenter, S., Arrow, K., Barrett, S., Biggs, R., Brock, W., Crépin, A. S., ... & Li, C. Z. (2012). General resilience to cope with extreme events. *Sustainability, 4(12)*, 3248-3259.

Carpenter, S., Walker, B., Anderies, J. M., & Abel, N. (2001). From metaphor to measurement: resilience of what to what?. *Ecosystems*, *4*(8), 765-781.

CGE Risk Management Solutions B.V. (2015) Bowtie Methodology Manual. Revision 15 (27-Mar-2015). Retrieved from https://www.icao.int/safety/SafetyManagement/SMI/Documents/BowTieXP%20Methodology%20Manual%20v15.pdf

Chang, B. D., Coombs, K. A., & Page, F. H. (2014). The development of the salmon aquaculture industry in southwestern New Brunswick, Bay of Fundy, including steps toward integrated coastal zone management. *Aquaculture Economics & Management*, *18*(1), 1-27.

Charles, A. T. (1995). The Atlantic Canadian groundfishery: roots of a collapse. *Dalhousie LJ*, *18*, 65.

Charles, A. T. (1997). Fisheries management in Atlantic Canada. *Ocean & Coastal Management*, *35*(2-3), 101-119.

Charles, A. T. (1998). Living with uncertainty in fisheries: analytical methods, management priorities and the Canadian groundfishery experience. *Fisheries Research*, *37*(1-3), 37-50.

Colding, J., & Barthel, S. (2019). Exploring the social-ecological systems discourse 20 years later. *Ecology and Society*, *24*(1).

Conservation Council of New Brunswick, & Milewski, I. A. (2002). *Two hundred years of ecosystem and food web changes in the Quoddy region, outer Bay of Fundy*. Fredericton, NB: Conservation Council of New Brunswick.

Coon, D. (1999). *An ecological sketch of some Fundy fisheries*. Conservation Council of New Brunswick, Fredericton, New Brunswick, Canada.

Corbin, J. S., & Strauss, A. A. 2008. *Basics of qualitative research: Techniques and procedures for developing grounded theory*, 3rd ed. Los Angeles, Calif. : Sage Publications.

Cormier, R. J., Savoie, F., Godin, C., & Robichaud, G. (2016). *Bowtie analysis of avoidance and mitigation measures within the legislative and policy context of the Fisheries Protection Program*. Fisheries and Oceans Canada= Pêches et océans Canada.

Coulthard, S., & Britton, E. (2015). Waving or drowning: an exploration of adaptive strategies amongst fishing households and implications for wellbeing outcomes. *Sociologia Ruralis*, *55*(3), 275-290.

Cutter, S. L. (2016). The landscape of disaster resilience indicators in the USA. *Natural hazards*, *80*(2), 741-758.

Cutter, S. L., Barnes, L., Berry, M., Burton, C., Evans, E., Tate, E., & Webb, J. (2008). A place-based model for understanding community resilience to natural disasters. *Global environmental change*, *18*(4), 598-606.Cutter, 2016

Cutter, S. L., Burton, C. G., & Emrich, C. T. (2010). Disaster resilience indicators for benchmarking baseline conditions. *Journal of homeland security and emergency management*, *7*(1).

Davies, R. W. D., & Rangeley, R. (2010). Banking on cod: Exploring economic incentives for recovering Grand Banks and North Sea cod fisheries. *Marine Policy*, *34*(1), 92-98.

Dawes, R. M., & Kagan, J. (1988). *Rational choice in an uncertain world*. New York: Harcourt Brace Jovanovich.

Department of Post-Secondary Education, Training and Labour, (2012-2013). Annual Report. Reterived from: https://www2.gnb.ca/content/dam/gnb/Departments/petl-epft/PDF/AnnualReport-RapportAnnuel2012-2013.pdf

Desplanque, C., & Mossman, D. J. (2004). Tides and their seminal impact on the geology, geography, history, and socio-economics of the Bay of Fundy, eastern Canada.

DeYoung, B., & Rose, G. A. (1993). On recruitment and distribution of Atlantic cod (Gadus morhua) off Newfoundland. *Canadian Journal of Fisheries and Aquatic Sciences*, *50*(12), 2729-2741.

Douglas, M (1992). *Risk and Blame: Essays in Cultural Theory*. London: Routledge

Drinkwater, K. F. (2005). The response of Atlantic cod (Gadus morhua) to future climate change. *ICES Journal of Marine Science*, *62*(7), 1327-1337.

Eero, M., MacKenzie, B. R., Köster, F. W., & Gislason, H. (2011). Multi-decadal responses of a cod (Gadus morhua) population to human-induced trophic changes, fishing, and climate. *Ecological Applications, 21(1)*, 214-226.

Elmqvist, T., Folke, C., Nyström, M., Peterson, G., Bengtsson, J., Walker, B., & Norberg, J. (2003). Response diversity, ecosystem change, and resilience. *Frontiers in Ecology and the Environment, 1(9)*, 488-494.

Erickson, V. (1978). *Maliseet-Passamaquoddy*. In Handbook of North American Indians Volume 15, Northeast. (Ed) Bruce Trigger, pp. 123-136. SmithsDnian Institution, Washington.

Fabinyi, M., L. Evans, & S. J. Foale. (2014). Social-ecological systems, social diversity, and power: insights from anthropology and political ecology. *Ecology and Society 19(4)*: 28. Retrieved from http://dx.doi.org/10.5751/ES-07029-190428

Fanning, L. (2002). Reviews of George A. Rose, Cod: The Ecological History of the North Atlantic Fisheries. *International Journal of Maritime History, 20(1)*, 293-338.

Fanning, L. (2007). Evaluating community fish quota management in Atlantic Canada: Lessons from the Start-Up Years. *MAST 5(2):*27-54

Fergus, S., & Zimmerman, M. A. (2005). Adolescent resilience: A framework for understanding healthy development in the face of risk. *Annu. Rev. Public Health*, *26*, 399-419.

Finkbeiner, E. M. (2015). The role of diversification in dynamic small-scale fisheries: Lessons from Baja California Sur, Mexico. *Global Environmental Change*, *32*, 139-152.

Finlayson, A. C. (1994). Fishing for truth: a sociological analysis of northern cod stock assessments from 1977 to 1990. St. John's, Newfoundland: Institute of social and economic research, Memorial University of Newfoundland.

Fisheries Resource Conservation Council (2000-2001), Conseration requirments for groundfish stocks in the Gulf of St. Lawrence. Report to the Minster of Fisheries and Oceans. Retrieved from: https://waves-vagues.dfo-mpo.gc.ca/Library/346601.pdf

Flach, F. F. (1997). *Resilience: How to bounce back when the going gets rough*. New York: Hatherleigh Press

Fletcher, W. R. J. (2014). Review and refinement of an existing qualitative risk assessment method for application within an ecosystem-based management framework. *ICES Journal of Marine Science, 72(3)*, 1043-1056.

Flyvbjerg, B. (2006). Five misunderstandings about case-study research. Qualitative inquiry, 12(2), 219-245.

Folke, C. (2006). Resilience: The emergence of a perspective for social–ecological systems analyses. *Global environmental change*, *16*(3), 253-267.

Folke, C. (2016). Resilience (republished). *Ecology and Society*, *21*(4).

Folke, C., Carpenter, S., Elmqvist, T., Gunderson, L., Holling, C. S., & Walker, B. (2002). Resilience and sustainable development: building adaptive capacity in a world of transformations. *AMBIO: A journal of the human environment*, *31*(5), 437-441.Folke et al., 2010

Folke, C., Carpenter, S., Walker, B., Scheffer, M., Chapin, T., & Rockström, J. (2010). Resilience thinking: integrating resilience, adaptability and transformability. *Ecology and society*, *15*(4).

Folke, C., Colding, J., & Berkes, F. (2003). Synthesis: building resilience and adaptive capacity in social-ecological systems. *Navigating social-ecological systems: Building resilience for complexity and change*, *9*(1), 352-387.

Frank, K. T., Petrie, B., Choi, J. S., & Leggett, W. C. (2005). Trophic cascades in a formerly cod-dominated ecosystem. *Science, 308(5728)*, 1621-1623.

Gardner, M. & MacAskill, G. (2010). Economic Impact of the New Brunswick Ocean Sector 2003-2008. Prepared for the Government of Canada. Retrieved from https://www2.gnb.ca/content/dam/gnb/Departments/10/pdf/Publications/Fish-Peches/ocean.pdf

Glaser, B. G., & Strauss, A. L. (1967). The constant comparative method of qualitative analysis. *The discovery of grounded theory: Strategies for qualitative research,* 101, 158.

Government of New Brunswick (2017). *New Brunswick agrifood and seafood export highlights 2017*. Retrieved from: https://www2.gnb.ca/content/dam/gnb/Departments/10/pdf/Publications/Aqu/ExportHighlightsforNewBrunswickAgrifoodandSeafood2017.pdf

Grant, J., Simone, M., & Daggett, T. (2019). Long-term studies of lobster abundance at a salmon aquaculture site, eastern Canada. *Canadian Journal of Fisheries and Aquatic Sciences, (999)*, 1-7.

Halliday, R. G., & Fanning, L. P. (2006). A history of marine fisheries science in Atlantic Canada and its role in the management of fisheries. *Proceedings of the Nova Scotian Institute of Science*.

Hamilton, L. C., & Butler, M. J. (2001). Outport adaptations: Social indicators through Newfoundland's cod crisis. *Human Ecology Review*, 1-11.

Hamilton, L. C., Haedrich, R. L., & Duncan, C. M. (2004). Above and below the water: social/ecological transformation in northwest Newfoundland. *Population and Environment*, *25*(6), 195-215.

Hanna, S. S. (2008). Institutions for managing resilient salmon (*Oncorhynchus spp*.) ecosystems: the role of incentives and transaction costs. *Ecology and Society, 13(2)*. Retrieved from: https://www.jstor.org/stable/26267959?seq=1#metadata_info_tab_contents.

Happer, C., & Philo, G. (2013). The role of the media in the construction of public belief and social change. *Journal of social and political psychology*, *1*(1), 321-336.

Harvey, J.& Milewski, I. (2007). *Salmon Aquaculture in the Bay of Fundy: An Unsustainable Industry*. Conservation Council of New Brunswick, Fredericton, New Brunswick, Canada

Hattam, C., Atkins, J. P., Beaumont, N., Börger, T., Böhnke-Henrichs, A., Burdon, D., ... & Sastre, S. (2015). Marine ecosystem services: linking indicators to their classification. *Ecological Indicators*, *49*, 61-75.

Haya, K., Burridge, L. E., & Chang, B. D. (2001). Environmental impact of chemical wastes produced by the salmon aquaculture industry. *ICES Journal of Marine Science, 58(2)*, 492-496.

Higgins, J. (2018). Economic impacts of the cod moratorium. *Newfoundland and Labrador Heritage Web Site*. Retrieved from https://www.heritage.nf.ca/articles/economy/moratorium-impacts.php

Hirschman, A. O. (1970). *Exit, voice, and loyalty: Responses to decline in firms, organizations, and states* (Vol. 25). Harvard university press.)

Holling, C. S. (1973). Resilience and stability of ecological systems. *Annual review of ecology and systematics*, *4*(1), 1-23.IRGC, 2006

Holling, C. S. (1986). The resilience of terrestrial ecosystems: local surprise and global change. *Sustainable development of the biosphere*, *14*, 292-317.Holling, 2001;

Holling, C. S., & Gunderson, L. H. (2002). Resilience and adaptive cycles. *In: Panarchy: Understanding Transformations in Human and Natural Systems, 25-62*.

Holm, P. (2001) *The invisible revolution: the construction of institutional change in the fisheries*, Doctoral dissertation, Norwegian College of Fisheries Science, University of Tromso, Norway

Homeland and Security Studies and Analysis Institute (2010). *Risk and Resilience: Exploring the relationship*. Prepared for Department of Homeland Security Directorate of Science and Technology. Retrieved from: http://www.anser.org/docs/reports/RP10-01.03.16-01.pdf

Huffman, J. (2018, June 13). Canada cuts quota in its biggest Atlantic cod fishing area by 25%. *Undercurrent News*. Retrieved from https://www.undercurrentnews.com/2018/06/13/canada-cuts-quota-in-its-biggest-atlantic-cod-fishing-area-by-25/

Hutchings, J. A. (1996). Spatial and temporal variation in the density of northern cod and a review of hypotheses for the stock's collapse. *Canadian Journal of Fisheries and Aquatic Sciences*, *53*(5), 943-962.

Hutchings, J. A., & Myers, R. A. (1994). What can be learned from the collapse of a renewable resource? Atlantic cod, Gadus morhua, of Newfoundland and Labrador. *Canadian Journal of Fisheries and Aquatic Sciences*, *51*(9), 2126-2146.

Hutchings, J. A., & Reynolds, J. D. (2004). Marine fish population collapses: consequences for recovery and extinction risk. *BioScience*, *54*(4), 297-309.

Hutchinson, W. F. (2008). The dangers of ignoring stock complexity in fishery management: the case of the North Sea cod. *Biology letters*, *4*(6), 693-695.

Iles, TD. (1980). The natural history of fisheries management. *Proc N S Inst Sci (30):*3–19

IRGC. (2017). *Introduction to the IRGC Risk Governance Framework, revised version*. Lausanne: EPFL International Risk Governance Center.

Ivanitskaya, L., Clark, D., Montgomery, G., & Primeau, R. (2002). Interdisciplinary learning: Process and outcomes. *Innovative higher education*, *27*(2), 95-111.Kennedy, 1976).

Jackson, J. B. C., et al. (2001). Historical overfishing and the recent collapse of coastal ecosystems. *Science 293*:629–638.

Jasanoff, S. (1993). Bridging the two cultures of risk analysis 1, 2. *Risk analysis*, *13*(2), 123-129. Kirby report, 1982;

Jentoft, S. (2000). Legitimacy and disappointment in fisheries management. *Marine policy*, *24*(2), 141-148.

Kasperski, S., & Holland, D. S. (2013). Income diversification and risk for fishermen. *Proceedings of the National Academy of Sciences*, *110*(6), 2076-2081.

Keats, D., Steele, D.H., and Green, J.M. 1986. *A review of the recent status of the northern cod stock (NAFO Divisions 2J, 3K, and 3L) and the declining inshore fishery*. A report, to the Newfoundland Inshore Fisheries Association, on Scientific Problems in the Northern cod controversy, St. John's, Nfld.

Kelman, I., Mercer, J., & Gaillard, J. C. (Eds.). (2017). The Routledge handbook of disaster risk reduction including climate change adaptation. Routledge.

Klein, J. T., & Newell, W. H. (1997). Advancing interdisciplinary studies. *Handbook of the undergraduate curriculum: A comprehensive guide to purposes, structures, practices, and change*, 393-415.Lather, 1992).

Klein, R. J., Nicholls, R. J., & Thomalla, F. (2003). Resilience to natural hazards: How useful is this concept? *Global environmental change part B: environmental hazards, 5(1)*, 35-45.

Knott, C., & Neis, B. (2017). Privatization, financialization and ocean grabbing in New Brunswick herring fisheries and salmon aquaculture. *Marine Policy*, *80*, 10-18.

Kurlansky, M. (1998). A biography of the fish that changed the world. Vintage Canada.

Lambin, E. F., & Meyfroidt, P. (2011). Global land use change, economic globalization, and the looming land scarcity. *Proceedings of the National Academy of Sciences*, *108*(9), 3465-3472.Lebel et al., 2006;

Lavell, A., Oppenheimer, M., Diop, C., Hess, J., Lempert, R., Li, J., ... & Cardona, O. D. (2012). Climate change: new dimensions in disaster risk, exposure, vulnerability, and resilience. In *Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation: Special Report of the Intergovernmental Panel on Climate Change* (pp. 25-

64). Cambridge University Press.

Lebel, L., Anderies, J. M., Campbell, B., Folke, C., Hatfield-Dodds, S., Hughes, T. P., & Wilson, J. (2006). Governance and the capacity to manage resilience in regional social-ecological systems.

Leeder, J., (2018, March 23). Newfoundland cod stocks suffer serious and surprising decline. *The Globe and Mail*. Retrieved from https://www.theglobeandmail.com/canada/article-newfoundland-cod-stocks-suffer-serious-decline-report/

Lemmen, D & Warren, F. ed. (2004) Climate change impacts and adaptation: a Canadian perspective. Natural Resources Canada, Ottawa, Ontario. 174 p

Leveson, N., Dulac, N., Zipkin, D., Cutcher-Gershenfeld, J., Carroll, J., & Barrett, B. (2006). Engineering resilience into safety-critical systems. *Resilience engineering: Concepts and precepts*, 95-123.

Lewis, S., & Smith, K. (2010, March). Lessons learned from real world application of the bow-tie method. In *6th Global Congress on Process Safety* (pp. 22-24). American Institute of Chemical Engineers San Antonio, Texas.

Lincoln, Y., & Gubba, E. (1985). *Naturalistic inquiry*. London, SageLipset et al. (1956),

Liu, Y., Chuenpagdee, R., & Sumaila, U. R. (2013). Salmon aquaculture in Canada and Norway–appraising governability. In *Governability of Fisheries and Aquaculture* (pp. 201-218). Springer, Dordrecht.

Lotze, H. K., & Milewski, I. (2004). Two centuries of multiple human impacts and successive changes in a North Atlantic food web. *Ecological applications, 14*(5), 1428-1447.

Luthar, S. S., Lyman, E. L., & Crossman, E. J. (2014). Resilience and positive psychology. In *Handbook of developmental psychopathology* (pp. 125-140). Springer, Boston, MA.

MA. (2005). *Ecosystems and human well-being* (Vol. 5). Washington, DC:: Island press.

Maillet, D. G. C., Wiber, M. G., & Barnett, A. (2019). Actions towards the joint production of knowledge: the risk of salmon aquaculture on American Lobster. Journal of Risk Research, 22(1), 67-80.

Manyena, S. B. (2006). The concept of resilience revisited. *Disasters*, *30*(4), 434-450.

Marine Advisory Committee (2017). *Meeting minutes: Reflections and Next Steps*. St. George Community Centre (Magaguadavic Place) 10 J.O. Spinney Street, St George, NB.

Marshall, J. (2001). Landlords, leaseholders & sweat equity: changing property regimes in aquaculture. *Marine Policy, 25(5)*, 335-352.

Martin, N., Forrester, J., & Ensor, J. (2018). What is equitable resilience?. *World development, 109*, 197-205.

Mason, C. M., Lim-Camacho, L., Scheepers, K., & Parr, J. M. (2015). Testing the water: understanding stakeholder readiness for strategic coastal and marine management. *Ocean & Coastal Management, (104)*, 45-56.

Mason, F. (2002). The Newfoundland cod stock collapse: a review and analysis of social factors. *Electronic Green Journal*, *1*(17).

Masten, A. S. (2007). Resilience in developing systems: Progress and promise as the fourth wave rises. *Development and psychopathology*, *19*(3), 921-930.

Mather, C. (2013). From cod to shellfish and back again? The new resource geography and Newfoundland's fish economy. *Applied Geography*, *45*, 402-409.

Mather, C., & Fanning, L. (2019). Social licence and aquaculture: Towards a research agenda. *Marine Policy*, *99*, 275-282.

McCay, B. J., & Finlayson, A. C. (1995, November). The political ecology of crisis and institutional change: the case of the northern cod. In *annual meeting of the American Anthropological Association, Washington, DC* (pp. 15-19).

McClure, C. A., Hammell, K. L., & Dohoo, I. R. (2005). Risk factors for outbreaks of infectious salmon anemia in farmed Atlantic salmon, Salmo salar. *Preventive veterinary medicine, 72(3-4)*, 263-280.

McGinnis, M. D. (2017). The IAD Framework in Action: Understanding the Source of the Design Principles in Elinor Ostrom's Governing the Commons. *Elinor Ostrom and the Bloomington Schools of Political Economy, 3*, 87-108.

McLeod, R. W., & Bowie, P. (2018). Bowtie Analysis as a prospective risk assessment technique in primary healthcare. *Policy and Practice in Health and Safety*, *16*(2), 177-193.

Merriam, S. B. (1988). *Case study research in education: A qualitative approach*. Jossey-

Miles, M. B., and Huberman, M. A. 1994. Qualitative Data Analysis.

Milewski, I. (2001). *Impacts of salmon aquaculture on the coastal environment: a review*. In MF Tlusty, DA Bengston, HO Halvorson, SD Oktay, JB, Pearce and RB Rheault Jr.,(eds). Marine aquaculture and the environment: A meeting for stakeholders in the Northeast. Cape Cod Press, Falmouth, MA (pp. 166-197).

Milewski, I., & Smith, R. E. (2019). Sustainable aquaculture in Canada: Lost in translation. *Marine Policy*, *107*, 103571.

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

Milich, L. (1999). Resource mismanagement versus sustainable livelihoods: the collapse of the Newfoundland cod fishery. *Society & Natural Resources*, *12*(7), 625-642.

Millar, C. and Aiken, D.E. (1995). *Conflict Resolution in Aquaculture: A matter of trust. In: ColdWater Aquaculture in Atlantic Canada* (ed. by A. Boghen), pp.619-645. The Canadian Institute for Research on Regional Development. Université de Moncton. Tribune Press, Sackville.

Mitchell, T., & Harris, K. (2012). R*esilience: A risk management approach. ODI background note*, 1-7. Retrieved from: https://www.odi.org/sites/odi.org.uk/files/odi-assets/publications-opinion-files/7552.pdf

Molinos, J. G., Halpern, B. S., Schoeman, D. S., Brown, C. J., Kiessling, W., Moore, P. J., ... & Burrows, M. T. (2016). Climate velocity and the future global redistribution of marine biodiversity. *Nature Climate Change*, *6*(1), 83.

Moore, O. (21 October 2011). *Cod 'ranching' offers snapshot of lost traditions*. Globe and Mail. Retrived from: https://www.theglobeandmail.com/news/national/cod-making-a-comeback-in-newfoundland-research-shows/article4385506/

Moran, D. (2002). *Introduction to phenomenology*. Routledge.

Mouland, N.E., K.J. Clark, G.D. Melvin, & L.M. Annis. (2003). *A summary of herring tagging in 4VWX, 1998 to 2003*. Can. Sci. Advis. Sec. Res. Doc. 2003/043: 28p

Murray, G., Neis, B., & Johnsen, J. P. (2006). Lessons learned from reconstructing interactions between local ecological knowledge, fisheries science, and fisheries management in the commercial fisheries of Newfoundland and Labrador, Canada. *Human Ecology*, *34*(4), 549-571.

Murray, G., Neis, B., Palmer, C. T., & Schneider, D. C. (2008). Mapping cod: fisheries science, fish harvesters' ecological knowledge and cod migrations in the Northern Gulf of St. Lawrence. *Human Ecology*, *36*(4), 581-598.

Myers, R. A., Hutchings, J. A., & Barrowman, N. J. (1996). Hypotheses for the decline of cod in the North Atlantic. *Marine ecology progress series*, *138*, 293-308.

Myers, R. A., Hutchings, J. A., & Barrowman, N. J. (1997). Why do fish stocks collapse? The example of cod in Atlantic Canada. *Ecological applications*, *7*(1), 91-106.

Nasmith, L., Hubley, B, Smith, S.J., & Glass, A. (2013). *Scallop Production Areas in the Bay of Fundy: Stock status for 2012 and forecast for 2013*. DFO Can. Sci. Advis. Sec. Res. Doc. 2013/004. vii + 112 p

Neis, B., & Williams, S. (1997). *The new right, gender and the fisheries crisis: local and global dimensions*. Atlantis: Critical Studies in Gender, Culture & Social Justice.

Neis, B., Felt, L., Schneider, D. C., Haedrich, R., Hutchings, J., & Fischer, J. (1996). Northern Cod stock assessments: what can be learned from interviewing resource users. *Canadian Journal of Fisheries and Aquatic Science*, *56*, 1944-63.

Neis, B., Power, N. G., & Gerrard, S. (2013). Women and Children First: the Gendered and Generational Socialecology of Smaller-scale Fisheries in Newfoundland and Labrador and Northern Norway. *Ecology and Society*, *18*(4).

Neis, B., Schneider, D. C., Felt, L., Haedrich, R. L., Fischer, J., & Hutchings, J. A. (1999). Fisheries assessment: what can be learned from interviewing resource users?. *Canadian Journal of Fisheries and Aquatic Sciences*, *56*(10), 1949-1963.

Nelson, D. R., Adger, W. N., & Brown, K. (2007). Adaptation to environmental change: contributions of a resilience framework. *Annu. Rev. Environ. Resour.*, *32*, 395-419. 419.ODI, 2016

New Brunswick Department of Agriculture, Fisheries and Aquaculture (NBDAFA) (2000) Bay of Fundy Marine Aquaculture Site Allocation Policy . NBDAFA , Fredericton , New Brunswick , Canada . Retrieved from https://www2.gnb.ca/content/gnb/en/departments/10/aquaculture/content/site_allocation_policy.html

Newell, D., Ommer, R. E., & Ommer, R. (Eds.). (1999). *Fishing places, fishing people: traditions and issues in Canadian small-scale fisheries*. University of Toronto Press.

Norris, F. H., Stevens, S. P., Pfefferbaum, B., Wyche, K. F., & Pfefferbaum, R. L. (2008). Community resilience as a metaphor, theory, set of capacities, and strategy for disaster readiness. *American journal of community psychology, 41(1-2)*, 127-150.

OECD (2014a). *2014 Report on the Implementation of the OECD Strategy on Development. Retrieved from* http://www.oecd.org/mcm/C-MIN(2014)14-ENG.pdf

OECD. (2014b). *Guidelines for resilience systems analysis*, OECD Publishing. Retrieved from https://www.oecd.org/dac/Resilience%20Systems%20Analysis%20FINAL.pdf

Olsson, P., Folke, C., & Hahn, T. (2004). Social-ecological transformation for ecosystem management: the development of adaptive co-management of a wetland landscape in southern Sweden. *Ecology and Society*, *9*(4).

Ommer, R. E. (2007a). *Coasts under stress: restructuring and social-ecological health*. McGill-Queen's Press-MQUP.

Ostrom, E. (2007b). A diagnostic approach for going beyond panaceas. *Proceedings of the national Academy of sciences, 104(39)*, 15181-15187.

Ostrom, E. (2009). A general framework for analyzing sustainability of social-ecological systems. *Science, 325(5939)*, 419-422.

Pahl-Wostl, C. (2009). A conceptual framework for analysing adaptive capacity and multi-level learning processes in resource governance regimes. *Global environmental change*, *19*(3), 354-365.

Palmer, C., & Sinclair, P. (1997). *When the fish are gone: Ecological disaster and fishers in Northwest Newfoundland*. Halifax, Nova Scotia, Canada: Fernwood Publishing...

Park, J., Seager, T. P., Rao, P. S. C., Convertino, M., and Linkov, I. (2013): Integrating Risk and Resilience Approaches to Catastrophe Management in Engineering Systems, *Risk Anal., 33*, 356–367, doi:10.1111/j.1539-6924.2012.01885.x, 2013.

Parlee, C., & Wiber, M. (2018). Using conflict over risk management in the marine environment to strengthen measures of governance. *Ecology and Society*, *23*(4).

Pasteur, K. (2011). *From Vulnerability to Resilience, a framework for analysis and action to build community resilience*. Practical Action Publishing.

Pauly, D., Christensen, V., Dalsgaard, J., Froese, R., & Torres, F. (1998). Fishing down marine food webs. *Science*, *279*(5352), 860-863.

Planque, B., Fromentin, J. M., Cury, P., Drinkwater, K. F., Jennings, S., Perry, R. I., & Kifani, S. (2010). How does fishing alter marine populations and ecosystems sensitivity to climate?. *Journal of Marine Systems, 79(3-4)*, 403-417.

Preiser, R., Biggs, R., De Vos, A., & Folke, C. (2018). Social-ecological systems as complex adaptive systems: organizing principles for advancing research methods and approaches. *Ecology and Society, 23(4).* Retrieved from: https://doi.org/10.5751/ES-10558-230446

Ramsden, M., Taylor, M., Steer, R., & Bennett, R. (2013, April). *Ten Golden Rules for Developing Robust Bowties*. In European HSE Conference and Exhibition. Society of Petroleum Engineers.

Rangeley, R. W., & Davies, R. W. (2012). Raising the "Sunken Billions": Financing the transition to sustainable fisheries. *Marine Policy, 36(5)*, 1044-1046

Reed, M., Evely, A. C., Cundill, G., Fazey, I. R. A., Glass, J., Laing, A., ... & Stringer, L. (2010). What is social learning?. *Ecology and society*.

Rehn, A. C., Barnett, A. J., & Wiber, M. G. (2018). Stabilizing risk using public participatory GIS: a case study on mitigating marine debris in the Bay of Fundy, Southwest New Brunswick, Canada. *Marine Policy, 96,* 264-269.

Renn, O. (2006). Risk communication–Consumers between information and irritation. Journal of *Risk Research, 9(8)*, 833-849.

Renn, O. (2008). White paper on risk governance: Toward an integrative framework. In *Global risk governance* (pp. 3-73). Springer, Dordrecht. Resilience Alliance, 2007

Renn, O., Klinke, A., & Van Asselt, M. (2011). Coping with complexity, uncertainty and ambiguity in risk governance: a synthesis. *Ambio*, *40*(2), 231-246.

Repko, A. F. (2008). *Interdisciplinary research: Process and theory*. Sage.

Resilience Alliance (2007) A*ssessing resilience in social-ecological systems: a workbook for scientists* (Version 1.1: Draft for testing and evaluation). Retrieved from http://www.resalliance.org/3871.php

Resilience Alliance. (2010). Assessing resilience in social-ecological systems: workbook for practitioners (revised version 2.0). Retrieved from: https://www.researchgate.net/publication/284030932_Assessing_Resilience_in_Social-Ecological_Systems_Workbook_for_Practitioners_Version_2

Roberts, T. (2017, March 31). Gutting of quota 'nail in the coffin' for inshore shrimp industry, says FFAW. Retrieved from: https://www.cbc.ca/news/canada/newfoundland-labrador/shrimp-quota-cuts-1.4049205

Rose, G. A. (2004). Reconciling overfishing and climate change with stock dynamics of Atlantic cod (Gadus morhua) over 500 years. *Canadian Journal of Fisheries and Aquatic Sciences*, *61*(9), 1553-1557.

Rose, G. A., & Rowe, S. (2015). Northern cod comeback. *Canadian Journal of Fisheries and Aquatic Sciences*, *72*(12), 1789-1798.

Rose, G. A., Bradbury, I. R., DeYoung, B., Fudge, S. B., Lawson, G. L., Mello, L. G. S., ... & Windle, M. J. S. (2008). Rebuilding Atlantic cod: lessons from a spawning ground in coastal Newfoundland. *Resiliency of gadid stocks to fishing and climate change*, 197-220.

Sandeman, S. (2002). Presentation to the FRCC on DFO vessels. Mimeo. FRCC, Ottawa

Saunders, B., Sim, J., Kingstone, T., Baker, S., Waterfield, J., Bartlam, B., ... & Jinks, C. (2018). Saturation in qualitative research: exploring its conceptualization and operationalization. *Quality & quantity, 52*(4), 1893-1907.

Schrank, W. E. (2005). The Newfoundland fishery: ten years after the moratorium. *Marine Policy*, *29*(5), 407-420.

Schrank, W. E., & Roy, N. (2013). The Newfoundland fishery and economy twenty years after the Northern Cod Moratorium. *Marine Resource Economics*, *28*(4), 397-413.

Schrank, W. E., & Skoda, B. (2002). The Cost of Marine Fishery Management in Eastern Canada: Newfoundland, 1989/1990-1997/1998. *International Journal of Maritime History, 14(1)*, 33-61.

Schrank, W. E., Skoda, B., Parsons, P., & Roy, N. (1995). The cost to government of maintaining a commercially unviable fishery: the case of Newfoundland 1981/82 to 1990/91. *Ocean Development & International Law*, *26*(4), 357-390.

Sheard, S. (2008, June). 11.2. 2 a framework for system resilience discussions. In *INCOSE International Symposium* (Vol. 18, No. 1, pp. 1243-1257).

Shertzer, K. W., & Prager, M. H. (2006). Delay in fishery management: diminished yield, longer rebuilding, and increased probability of stock collapse. *ICES Journal of Marine Science, 64(1)*, 149-159.

Simms, S (2017). Newfoundland and Labrador's northern cod fishery: charting a new sustainable future. House of Commons Report of the Standing Committee on Fisheries and Oceans, 42nd Parliament (1st Session), Ottawa, Canada,42pp.

Sinclair, P. R. (1992). *Atlantic Canada's fishing communities: The impact of change*. In D. A. Hay, & G. S. Basran (Eds.), Rural sociology in Canada. Don Mills, Ontario, Canada: Oxford University Press

Sinclair, P. R., Johnsen, J. P., & Ripley, P. (2009). Power and the production of science. Assessing cod stocks as the mechanistic fishery collapses.

Southwest New Brunswick Marine Resource Planning Committee (MRP) (2005) Southwestern Bay of Fundy Marine Resource Planning Process Initiative: Phase 1 Final Report

Southwest New Brunswick Marine Resource Planning Committee (MRP) (2009) The Preferred Future of the Bay: Recommendations Toward a community Based Plan for the Management of Marine Activities and Spaces in SW NB Bay of Fundy.

Southwest New Brunswick Marine Resource Planning Committee (MRP) (2011) Report on Phase 3 of the Marine Resource Planning Initiative: Towards Community-Based Planning of Marine Activities in SWNB Bay of Fundy.

Stake, R. E. (1995). *The art of case study research*. Sage.

Standards Australia. (2009). *AS/NZS ISO31000:2009 Risk management - Principles and guidelines*. Sydney: Standards Australia.

Statistics Canada. (2017). *Campobello Island, RCR [Census subdivision], New Brunswick and Yukon [Territory] (table)*. Census Profile. 2016 Census. Statistics Canada Catalogue no. 98-316-X2016001. Ottawa. Released November 29, 2017.

S
tatistics Canada. (n.d.) *Table 32-10-0107-01 Aquaculture, production and value*. Retrieved from https://doi.org/10.25318/3210010701-eng

Stephenson, R. (1990). Multiuse conflict: aquaculture collides with traditional fisheries in Canada's Bay of Fundy. *World Aquaculture, 21(3)*, 34-45.

Stewart, L. (2001). *Salmon aquaculture in New Brunswick: natural development of our marine heritage*. Aquaculture Strategies Inc.

Stockholm Resilience Center (n.d.). Advancing complex adaptive systems and resilience thinking. Retrieved from https://www.stockholmresilience.org/research/research-streames/complex-adaptive-systems.html

Stojanovic, T., McNae, H., Tett, P., Reis, J., Smith, H. D., & Dillingham, I. (2016). The "social" aspect of social-ecological systems: a critique of analytical frameworks and findings from a multisite study of coastal sustainability. *Ecology and Society*.

Stoll, J. S., Beitl, C. M., & Wilson, J. A. (2016). How access to Maine□ s fisheries has changed over a quarter century: The cumulative effects of licensing on resilience. *Global Environmental Change*, *37*, 79-91.

Stoll, J. S., Fuller, E., & Crona, B. I. (2017). Uneven adaptive capacity among fishers in a sea of change. *PloS one, 12(6)*, e0178266.

Stringer, L., Dougill, A., Fraser, E., Hubacek, K., Prell, C., & Reed, M. (2006). Unpacking "participation" in the adaptive management of social–ecological systems: a critical review. *Ecology and society*, *11*(2).

Sutterlin, A. M (1981). Salmonid rearing trials at Deer Island, New Brunswick, with some projections on economic viability. St. Andrews, NB: *Government of Canada, Fisheries and Oceans.*

Torraco, R. J. (2005). Writing integrative literature reviews: Guidelines and examples. *Human resource development review*, *4*(3), 356-367.

Tuler, S., Agyeman, J., Agyeman, J., da Silva, P. P., LoRusso, K. R., & Kay, R. (2008). Assessing vulnerabilities: Integrating information about driving forces that affect risks and resilience in fishing communities. *Human Ecology Review*, 171-184.

United Nations General Assembly (2015) United Nations Sustainable Development Summit 2015. Retrieved from https://sustainabledevelopment.un.org/post2015/summit

United Nations International Strategy for Disaster Reduction (UNISDR). (2009). *Terminology on disaster risk reduction*. Geneva, Switzerland.

Uusi-Heikkilä, S., Lindström, K., Parre, N., Arlinghaus, R., Alós, J., & Kuparinen, A. (2016). Altered trait variability in response to size-selective mortality. *Biology letters*, *12*(9), 20160584.

Waddy, S. L., Mercer, S. M., Hamilton-Gibson, M. N., Aiken, D. E., & Burridge, L. E. (2007). Feeding response of female American lobsters, *Homarus americanus*, to SLICE®-medicated salmon feed. *Aquaculture, 269(1-4)*, 123-129.

Walker, B., & Salt, D. (2006). *Resilience thinking: sustaining ecosystems and people in a changing world*. Island press.

Walker, B., & Salt, D. (2012). *Resilience practice: building capacity to absorb disturbance and maintain function*. Island Press.

Walker, B., Abel, N., Anderies, J., & Ryan, P. (2009). Resilience, adaptability, and transformability in the Goulburn-Broken Catchment, Australia. *Ecology and society*, *14*(1).

Walker, B., Carpenter, S., Anderies, J., Abel, N., Cumming, G., Janssen, M., ... & Pritchard, R. (2002). Resilience management in social-ecological systems: a working hypothesis for a participatory approach. *Conservation ecology, 6(1)*. Retrieved from: http://www.consecol.org/vol6/iss1/art14/

Walker, B., Gunderson, L., Kinzig, A., Folke, C., Carpenter, S., & Schultz, L. (2006). A handful of heuristics and some propositions for understanding resilience in social-ecological systems. *Ecology and society, 11(1)*. Retrieved from: http://www.ecologyandsociety.org/vol11/iss1/art13/

Walker, B., Holling, C. S., Carpenter, S., & Kinzig, A. (2004). Resilience, adaptability and transformability in social–ecological systems. *Ecology and society*, *9*(2).

Walsh-Dilley, M., Wolford, W., & McCarthy, J. (2016). Rights for resilience: food sovereignty, power, and resilience in development practice. *Ecology and Society*, *21*(1).

Walters, B. B. (2007). Competing use of marine space in a modernizing fishery: salmon farming meets lobster fishing on the Bay of Fundy. *The Canadian Geographer/Le Géographe canadien*, *51*(2), 139-159.

Walters, C., & Maguire, J. J. (1996). Lessons for stock assessment from the northern cod collapse. *Reviews in fish biology and fisheries*, *6*(2), 125-137.

Wamsler, C., & Brink, E. (2014). Moving beyond short-term coping and adaptation. *Environment and Urbanization, 26(1), 86-111.*

Wappel, T. (2005). *Northern cod: a failure of Canadian fisheries management*. Report to the Standing Committee on Fisheries and Oceans, Ottawa.

Waters, C. L., & Clark, K. J. (2005). *Summary of the weir herring tagging project, with an update of the HSC/PRC/DFO herring tagging program*. Canadian Science Advisory Secretariat Research Document, 25, 31.

Weitzman, J., & Bailey, M. (2019). Communicating a risk-controversy: Exploring the public discourse on net-pen aquaculture within the Canadian media. *Aquaculture*, *507*, 172-182.

Westley, F., Carpenter, S. R., Brock, W. A., Holling, C. S., & Gunderson, L. H. (2002). Why systems of people and nature are not just social and ecological systems. *In: Gunderson, LH and CS Holling (eds.). Panarchy: Understanding Transformations in Human and Natural Systems, 103-119*.

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

Wiber, M., Charles, A., & Kearney, J. (2008). A Participatory Approach to Identifying Research Needs for Community-Based Fishery Management.

Wiber, M., Charles, A., Kearney, J., & Berkes, F. (2009). Enhancing community empowerment through participatory fisheries research. *Marine policy*, *33*(1), 172-179.

Wilson, L., & Wiber, M. G. (2009). Community perspectives on integrated coastal management: Voices from the Annapolis Basin area, Nova Scotia, Canada. *Ocean & Coastal Management*, *52*(11), 559-567.

Withers, P. (April 28, 2018). Halibut flourishing, cod struggling, says DFO stock assessment. Retrieved from: https://www.cbc.ca/news/canada/nova-scotia/fish-stocks-halibut-cod-1.4639551

Woodrow, M. (1998). A case study of fisheries reduction programs during the Northern Cod Moratorium. *Ocean & coastal management*, *39*(1-2), 105-118.

Yin, R. (2017). *Case Study Research and Applications: Design and Methods*. SAGE Publications.

Yin, R. K. (2011). *Applications of case study research*. Sage.

Zimmerman, M. A., & Brenner, A. B. (2010). *Resilience in adolescence: Overcoming neighborhood disadvantage*.

Appendices

Interview script

Understanding the relationship between risk and resilience in a small–scale coastal social-ecological fishery system: Southwest New Brunswick and South Western Cape area, South Africa

Introduction

Thank you for agreeing to be interviewed and I really appreciate the time you are taking to share your experiences about your fishery and community. I am a graduate student from Dalhousie University in Halifax, Canada and this is part of my research for my PhD. I am interested in learning more about how fishermen are coping / dealing with past and current changes in their fishery (resilience) and what future changes you think are coming. Changes may be either good or bad. I will ask about five types of changes: economic (e.g. lower prices, higher operating costs), technological (e.g. new types of gear), ecological (e.g. problems in fish habitats), political (e.g. stakeholder conflict, management plans and regulations), and social (e.g. changes to your communities, collaborative projects). What I am interested in finding out is how current conditions and coping skills can help to prepare for future threats or opportunities. I will also be doing a similar study in the South Western Cape Town region in South Africa (July, 2011). Information from both studies will help in understanding and encouraging community driven approaches that could hopefully address and reduce threats in small scale fisheries.

Your responses will be kept in confidence and I will not be recording names or details that may lead others to identify you. This study is voluntary and you may withdraw from this interview or any other parts of this study at any time. With your permission I will record this interview mainly to check my notes to ensure that I have captured correctly your responses. Only I will have access to the tape recording and the audio tape will be deleted at the end of the study.

I would like to first start off with some general questions about your occupation, then move on to more specific questions about changes that you have experienced in the fishery over the last 20 years and what you are experiencing now. We will then move on to some questions about what you think might happen in the next ten years to your fishery, your community and yourself.

Lastly I would like to discuss the role of management plans, policies and legislations that are and could affect your fishery, community or you. This will also include community based projects.

Section 1: Profiles

I would like to start off asking some general questions about your fisheries, followed by some questions on your livelihoods and then yourself.

Number of years in the fishery________________

Occupations-roles (e.g. license holder, captain, crew, buyer etc.___________________

Type of fisher y: (species) Sp. 1:___________ Sp. 2 __________; Sp. 3 ___________________;

Gear type, Sp. 1:___________________; Sp. 2 ___________________; Sp. 3 ___________________;

Bait: Sp. 1:___________________; Sp. 2 ___________________; Sp. 3 ___________________;

Time at sea: Sp. 1:___________________; Sp. 2 ___________________; Sp. 3 ________

Home port____

Technology used: Sp. ____

Can you please give me some examples of how wide your markets are?

Species 1: Local___________Provincial______________National________________International__________

Species 2: Local______Provincial________National__________International__________

Species 3: Local___________Provincial______________National________________International__________

I would now like to move on to a few questions about your livelihoods please:

Could you please give me some examples of how you are dependent on the fisheries (e.g. fisher, buyer, factory worker, office)?

Based on your examples could you please tell me how dependent you are on the fishery for your livelihood: 0%_____25%___50%___75%____100%__

Could you please tell me if you have any other occupations that contribute to your livelihood?

____

Are there other family members involved in the fishery and if so what are their roles:

____

Besides fishing are there any other ways that you use the coastal and marine environments

Are there any other ways that you see the marine and coastal environments providing benefits for your fishery, community, yourself?

Lastly a couple of questions about yourself:

Age (category)>20: _________21-30: __________31-40:_________41-50:_________51-60:___________60>:_________

Education level: Primary school_______High School____University____Graduate__Trade school___Community Collage_______Other________________________________

Which community do you live in____

How long have you lived in this community/____________________________

Where did you live before moving to this community?

____

What made you move?

____

Thank you, for your information, this ends the first section of the interview. I would now like to move on to some questions about how changes have affected your fishery, your community and yourself over the last 20 years. I will also like to get your thoughts on some of the future threats and opportunities to your fishery/business or community over the next 10 years.

Section 2

Environmental changes

Can you please give me some examples of **environmental changes** that you have noticed in the areas that you have fished (how, why, when, who)

- How you were able to cope with these changes or events?

- What were some of the challenges that you faced in coping with these changes or events?
- Were there any opportunities that helped you cope with these changes or events? Please explain?
- Can you please give me some examples on how successful you thought these coping strategies were?

Environmental threats

Can you give me some examples please of what you think will be the most important **environmental threats** to your fishery or business in the next 10 years? (Prompt for 2, 5, 10), (how, why, when, who)?

- How certain are you that these threats could happen? **(a)** 0% __ **(b)** 25% ___**(c)** 50%__ **(d)** ___75% **(e)** 100%__**(f)** Don't know__
- What affect do you think these threats would have on your fishery? **(1)**__e.g. No effect on your current fishing practice); **(2)** ___e.g. Some effect but would still encourage family members to stay in the fishery or business; **(3)**___e.g. Large effect e.g. greatly reduce fishing effort, discourage family members to stay in the fishery or business; **(4)**___e.g. Leave the fishing industry; **(5)** Don't know_____

- Can you please give me some examples of what you think might be future environmental opportunities available to your fishery over the next 10 years

Information on planning for threats and opportunities

- Can you please give me some examples of the types of plans you would make to address these threats or make use of the opportunities that you have mentioned?
- Can you please give me some examples of resources that you think you will need to carry out your plans successfully?
- Can you please give me some examples of where you might be able to get or develop these resources?
- When would you need these resources (before, during or after the event) and in what form will you need them?

- Can you please give me some examples of who else might be involved to help make your plans successful?

I would now like to ask some questions about technological changes:

- Can you please give me some examples of **technological changes** that have affected your fishery (how, why, when, who)
    - o How you were able to cope with these changes or events?
    - o What were some of the challenges that you faced in coping with these changes or events?
    - o Were there any opportunities that helped you cope with these changes or events? Please explain?
    - o Can you please give me some examples on how successful you thought these coping strategies were?

Can you give me some examples please of what you think will be the most important **technological threats** to your fishery in the next 10 years? (Prompt for 2, 5, 10), (how, why, when, who)?

- How certain are you that these threats could happen? **(a)** 0% __ **(b**) 25% ___**(c)** 50%__ **(d)** ___75% **(e)** 100%__**(f)** Don't know__
- What affect do you think these threats would have on your fishery? **(1)**__e.g. No effect on your current fishing practice); **(2)** ___e.g. Some effect but would still encourage family members to stay in the fishery); **(3)**___e.g. Large effect e.g. greatly reduce fishing effort, discourage family members to stay in the fishery); **(4)**___e.g. Leave the fishing industry; **(5)** Don't know_____
- Can you please give me some examples of what you think might be future technological opportunities available to your fishery over the next 10 years

Information on planning for threats and opportunities

- Can you please give me some examples of the types of plans you would make to address these threats or make use of the opportunities that you have mentioned?

- Can you please give me some examples of resources that you think you will need to carry out your plans successfully?
- Can you please give me some examples of where you might be able to get or develop these resources?
- When would you need these resources (before, during or after the event) and in what form will you need them?
- Can you please give me some examples of who else might be involved to help make your plans successful?

Thank you for this information. I would now like to move on and ask about social changes that you have noticed in you fishery or community.

- Can you please give me some examples of **social changes** that have affected you, your community or your fishery? (how, why, when, who)
    - How you were able to cope with these changes or events?
    - What were some of the challenges that you faced in coping with these changes or events?
    - Were there any opportunities that helped you cope with these changes or events? Please explain?
    - Can you please give me some examples on how successful you thought these coping strategies were?

I would now like to ask some questions on what you think will be the most important social threats to your fishery/business or community.

Can you give me some examples please of what you think will be the most important social threats to your fishery in the next 10 years? (Prompt for 2, 5, 10), (how, why, when, who)?

- How certain are you that these threats could happen? (a) 0% __ (b) 25% ___(c) 50%__ (d) ___75% (e) 100%__(f) Don't know__
- What affect do you think these threats would have on your fishery? (1)__e.g. No effect on your current fishing practice); (2) ___e.g. Some effect but would still encourage family members to stay in the fishery); (3)___e.g. Large effect e.g.

greatly reduce fishing effort, discourage family members to stay in the fishery); (4)___e.g. Leave the fishing industry; (5) Don't know_____

Information on planning for threats and opportunities

- Can you please give me some examples of the types of plans you would make to address these threats or make use of the opportunities that you have mentioned?
- Can you please give me some examples of resources that you think you will need to carry out your plans successfully?
- Can you please give me some examples of where you might be able to get or develop these resources?
- When would you need these resources (before, during or after the event) and in what form will you need them?
- Can you please give me some examples of who else might be involved to help make your plans successful?

Thank you for sharing this information. I would now like to ask some questions about economic changes that you may have noticed in the last 20 years

- Can you please give me some examples of **economic changes** that have affected you, your community or your fishery? (how, why, when, who)?
    - How you were able to cope with these changes or events?
    - What were some of the challenges that you faced in coping with these changes or events?
    - Were there any opportunities that helped you cope with these changes or events? Please explain?
    - Can you please give me some examples on how successful you thought these coping strategies were?

I would now like to ask some questions on what you think will be the most important economic threats to your fishery/business or community.

Can you give me some examples please of what you think will be the most important **economic threats** to your fishery in the next 10 years? (Prompt for 2, 5, 10), (how, why, when, who)?

- How certain are you that these threats could happen? **(a)** 0% __ **(b**) 25% ___**(c)** 50%__ **(d)** ___75% **(e)** 100%__**(f)** Don't know__
- What affect do you think these threats would have on your fishery? **(1)**__e.g. No effect on your current fishing practice); **(2)** ___e.g. Some effect but would still encourage family members to stay in the fishery); **(3)**___e.g. Large effect e.g. greatly reduce fishing effort, discourage family members to stay in the fishery); **(4)**___e.g. Leave the fishing industry; **(5)** Don't know_____

Information on planning for threats and opportunities

- Can you please give me some examples of the types of plans you would make to address these threats or make use of the opportunities that you have mentioned?
- What resources do you think you will need to carry out your plans successfully?
- Where you might be able to get these resources (or develop them)?
- When would you need these resources (before, during or after the event) and in what form will you need them?
- Who else might be involved to help make your plans successful?

Thank you for this information. I would now like to finish this section with some questions on your observations around political changes (e. g management or regulations).

- Can you please give me some examples of **political changes** that have affected you, your community or your fishery? (how, why, when, who)?
  - How you were able to cope with these changes or events?
  - What were some of the challenges that you faced in coping with these changes or events?
  - Were there any opportunities that helped you cope with these changes or events? Please explain?
  - Can you please give me some examples on how successful you thought these coping strategies were?

Can you give me some examples please of what you think will be the most important **political threats** to your fishery in the next 10 years? (Prompt for 2, 5, 10), (how, why, when, who)?

- How certain are you that these threats could happen? **(a)** 0% __ **(b**) 25% ___**(c)** 50%__ **(d)** ___75% **(e)** 100%__**(f)** Don't know__
- What affect do you think these threats would have on your fishery? **(1)**__e.g. No effect on your current fishing practice); **(2)** ___e.g. Some effect but would still encourage family members to stay in the fishery); **(3)**___e.g. Large effect e.g. greatly reduce fishing effort, discourage family members to stay in the fishery); **(4)**___e.g. Leave the fishing industry; **(5)** Don't know_____

Information on planning for threats and opportunities

- Can you please give me some examples of the types of plans you would make to address these threats or make use of the opportunities that you have mentioned?
- What resources do you think you will need to carry out your plans successfully?
- Where you might be able to get these resources (or develop them)?
- When would you need these resources (before, during or after the event) and in what form will you need them?
- Who else might be involved to help make your plans successful?

End this section with some general questions:

- Can you please give me some examples of how you were able to identify (e.g. observations, experiments, govt. or academic reports etc.) the changes to your: (a) fishery________________(b) community ________________________
- Could you please give me some examples of opportunities that you fishery may provide for other fisheries/fishermen/stakeholders/industries/organizations?
- Can you give me examples of threats that your fishery may pose to other fisheries /fishermen /stakeholders/industries/organizations?

Thank you, for your information this has been very helpful for the study. This now ends the second section of the interview. I would now like to finish off with some questions on the role of policies, legislations and management plans!

Section 3

Role of polices, legislations management plans

- Can you give me some examples of the types of legislations, policies or management plans that affect your fishery?
- Are there any examples of legislations, policies or management plans that have helped your fishery?
- Can you give me some examples of policy, legislation or management plans that you think would benefit the future of your fishery?
- Which of these policies etc. would you see as the most important ones for dealing with threats to your fishery? (1-3 rank)
- Which of these policies etc. would you see as the most important ones for providing opportunities for your fishery (1-3 rank)

We have talked a little bit about government approaches; I would now like to ask some questions about community based approaches to coastal and ocean management.

- Can you please give me some examples of community type projects, committees or initiatives that you have been involved with recently?
- What were some of the reason for starting these initiatives/ projects and how did you get involved?
- Can you please tell me who else was involved and what were their roles?
    - Can you please give me some examples of successful outcomes of these projects/initiatives?
    - What changes did they make for a) the fishery; b) you community, c) yourself
- Can you please give me some examples of the challenges of implementing these projects/initiatives?
- Can you please give me some examples of other things that could have been done (who, when, how)

This now concludes our interview. This has been a very valuable experience for me. Thank you so much for your time. Now do you have any questions for me?

Question for lobster buyers

(a) Could you please tell me if you have heard of the traceability tag program?

(b) If so, do you think it is a good thing or do you have any concerns about it?

Please could you explain with examples?

General and specified resilience attributes.

Attributes in this context are defined as a quality or feature regarded as a characteristic or inherent part of developing resilience. Resilience attributes described below include ones that are well documented in the resilience literature and were coded from the interviews (e.g. species diversity, redundancy, livelihoods diversity, connectivity between fluctuating economics, and international events, and environmental crisis, information generation and sharing, and conceptual models). Attributes from the interviews that are more specific to this study are italicized and bolded. Attributes that could be explored further are noted as un-bolded italics.

<table>
<tr><th>Principle</th><th>System component</th><th>General resilience</th><th>Specified resilience</th></tr>
<tr><td rowspan="3">P1. Maintain diversity and redundancy</td><td>Environmental</td><td colspan="2">• Understanding of overall industry impacts across the Bay and their historical and future growth patterns
• Understanding of the pressures that drives social-economic needs, and aligning these with changes in environmental and ecological processes</td></tr>
<tr><td>Socio-economic</td><td>• Livelihoods diversity and opportunities (across sectors)
• Community values and identity: intergenerational shifts (fisheries, technology, skills, education, status etc.)
• Community composition/demographics and future shifts
• Community cooperation (social capital)</td><td>• Fisheries sector e.g. livelihoods diversity and redundancy, work flexibility, different /alternative fisheries, skills and training opportunities, land hatcheries
• Aquaculture sector: e.g. on-land facilities, feed and medication application process, rotation of sea pens</td></tr>
<tr><td>Management</td><td colspan="2">• Understanding of sector, provincial, and federal management policies and decisions and their interactions, gaps, and overlaps that may build the resilience of one sector at the expense of another and/or the ecosystem of the Bay
• Ability to reconcile the differences and conflicting objectives of relevant policies and regulations</td></tr>
</table>

Principle	System component	General resilience
P2. Manage connectivity	**Environmental**	• Population recruitment monitoring and evaluation • Spawning habitats (herring, lobster - offshore and inshore) • Trophic levels and food chains (temporal and spatial shifts in predator - prey species) • Physical, biological, chemical processes • Environmental and other temporal and spatial changes
	Socio-economic	• Community – livelihoods reliance on the natural environment and surrounding resources e.g. fisheries, aquaculture, tourism, transportation • Economic and global events: (e.g. fluctuating markets, fuel costs, security, diseases, natural and human caused disasters) • ***Family connections and values (fisheries vs aquaculture)*** • Fishermen's groups and communities (geographical), priorities and spatial utilisation • Community trust and rapport with government agencies and large corporations (***Historical legacy and current events)***
	Management	• ***Connectivity between regulating /management agencies (silo vs integrated species management, economic development etc.)*** • ***Voters power and elections: federal provincial, municipality (4 years); and shifting mandates*** • *_International influences (e.g. international disputes, wars, disasters), that have an impact on trade agreements and policies_
P3. Manage slow variables and feedbacks	**Environmental**	• Shifts in species and predator-prey interactions food chains • Migration patterns (deep waters-colder), abundance and distribution (lobster), • ***Shifts in species health (quality) in response to environmental and temporal changes***
	Socio-economic	• ***Community conceptual model*** - seven years of good fishing, followed by an equal number of bad years (e.g. herring and scallops) • International markets and events that influence national and local sectors
	Management	• ***Alignment and flexibility across different policies, legislations, and regulations in responses to slow variables and fast feedback responses within and across different components of the SES*** • Understanding of risks and opportunities (within and across sectors and agency mandates) catalysed by past, current and future policies, regulations, and legislations • ***Resources to be able to prepare and respond to changes***

Principle	System component	General resilience
P4. Foster complex adaptive thinking (CAS)	**Socio-economic**	• ***Professional training e.g. business applications, organisational project management (including M&E), project risk management assessment, clean technology, data systems that feed into an integrated approach for better understanding complex systems across the Bay*** • *Community projects that are holistic and interdisciplinary (e.g. lobster and aquaculture research that includes both social and ecological components) • Stakeholders opportunities to access, analysis, and discuss different ways of knowing, forms of data and knowledge relating to the Bay • Interdisciplinary studies and inter-professional development that feed into an integrated management approach to SES
	Management	• *Inclusion of both hard and soft skills development for new employees* • **Digital skills level and technology infrastructure support* • **Studies on the policy-science interface within and across different agencies and government levels* • Collecting analysing and sharing different forms of data and information that introduces and fosters the capacity for CAS • Maintenance of different forms of data and information that can be used and accessed by other stakeholders to initiative CAS

Principle	System component	General resilience/Specified resilience
P5. Encourage learning	**Socio-economic**	• ***Establishing frameworks and resources to support timely and proactive learning (e.g. different levels of learning – classroom, experiential, online, intergenerational)*** • *Safe space to ask critical questions and discuss issues - exploring creative conflict with a process to distil innovative objectives* • ***Knowledge creation and sharing across and within different communities - native and non-native communities***
	Management	• **Shift in management values: Inclusion, acceptance and sharing of different knowledge sources* • Accessible and collaborative information management and dissemination processes (issues identification, research design, data collection, analysis, compilation, sharing, discussion, feedback /evaluation) • ***Resources to support different forms of learning*** • ***Monitor and evaluate different approaches and processes for learning***

Principle	System component	General resilience/Specified resilience
P6. Broaden Participation	**Socio-economic**	• Resources for broader and equitable participation among different communities and stakeholders • *Identify gaps and overlaps (e.g. stakeholders, issues) and opportunities (temporal and spatial) for stakeholder participation in management decisions*
	Management	• *Identify groups/sectors (transparently) who potential may be less powerful at the table, provide opportunities for their participation and a process to better understand and communicate their perspectives, in the context of broader issues and the policy environment* • Building diversity and effective redundancy into the governance system
P7. Promote polycentric governance	**Socio-economic**	• *Process to understand issues, opportunities and cross scale interactions at different spatial and temporal scales* • *Overall process to prioritize issues and opportunities in a fair and equitable manner that considers potential risks to the SES from adaptive or mitigating actions* • *Equitably match diverse stakeholders' values and priorities to flexible governance systems*
	Management	• Process to understand different perspectives, issues and their interactions at different scales and match the governance system to the issues and opportunities (current and future), with the appropriate resources • Ability to monitor and evaluate different approaches and processes for flexible governance that can adapt to changes, without compromising future opportunities or creating/enhancing risks to the SES • *Ability and willingness to learn from experiences (e.g. SWNB planning committee) and adapt and/or transform governance strategies in response to unexpected events (e.g. climate change)*

Aquaculture perspectives

It would appear that fishermen are more likely to work with trusted government officials (who they have had a long-term good working relationship with and/or are vouched for by a trusted association) than with the aquaculture industry. Maillet et al.'s (2018) study on joint production of knowledge centered on better understanding the impacts of salmon cages on egg bearing lobsters. The research team included academics, DFO social and natural scientists and local fishermen. A member of the team had raised the question of inviting aquaculture representatives to help inform certain aspects of the research design, but fishermen noted concerns citing previous failed collaborative attempts and their lack of trust with the industry. The team opted to accommodate the fishermen's preference as the risk of alienating their participation (which was essential for the study) and the acceptance of the study findings by the fishing community had greater consequences than approaching the aquaculture industry for input (Maillet et al., 2018). The risk that the findings would be heavily critiqued by the industry as they were not at the table was considered to be of lesser consequence to the success of the project than not having the fishermen participate. Another example of selected participation is provided by Milewski & Smith (2019), where DFO excluded national and regional environmental, fisher, consumer, and social/community development organizations from the process to identify indicators for monitoring and evaluating sustainable aquaculture.

Maillet et al., (2018) propose that perceptions about the inshore fisheries by the aquaculture industry center on the belief that commercial fishing has caused the collapse of many fisheries, and that the industry can prevent further overexploitation by increasing food security and providing opportunities for employment, especially in rural areas. With the growth and success of the lobster fishery, the industry considers that any impact they may have in local areas would be insignificant (Maillet et al., 2018). Alternatively, fishermen consider that because they are geographically limited to a specific fishing area, other users should not compromise local habitats for important fisheries they rely on for their livelihoods (Maillet et al., 2018). The paper concludes that despite recommendations from the literature (e.g. Stirling, 2012) with regards to approaches to address risk and uncertainty (e.g. fostering collaboration, learning, and understanding the values and priorities of stakeholder) it would be very difficult to incentivize this here, given the degree of distrust by both sides (Maillet et al., 2018).

A study that engaged with communities across five Nova Scotia counties indicates that distrust is fostered through perceived and observed impacts upon environmental and social components (Gervais & Kaouass, 2015). Environmental impacts included pollution from discarded feed and feces creating dead waters under the cages, pesticides, pests, and antifouling agents impacting nearby waters, the uncertainty of benthic and habitat recovery, farm debris and noise from feeding equipment, and the compatibility between different users and their impact on habitats. Fishermen considered shellfish aquaculture (e.g. oysters and seaweed) as being greener, less invasive, and not as threatening as the salmon industry (Gervais & Kaouass, 2015). Political, social, and economic concerns included perceptions of the industry (i.e. it was big) and only concerned about making a profit, even if it was impacting the environment and causes conflicts within communities. Another concern related to the inability of government regulators to monitor and deal with infringements, and that it is more biases towards the industry because they are providing financial support. Other comments related to limited job opportunities and support for local economics, and that government and the industry ignored the historical, social, and economic contributions of the lobster industry. Rumors speculating about compensation being given to the industry by government for loss gear/stock, which were not provided to fishermen created further distrust and suspicion (Gervais & Kaouass, 2015).

A third study (Boaler, 2014) focused on perceived inter-sectoral conflicts with developing aquaculture on the Eastern Shore of Nova Scotia. The author noted seven categories of concern: environment, governance and information issues, nature of the industry and its practices, economics, industry etiquette and ethics, opposition tactics, and human health. Similar environmental concerns were recorded, but also included the threat to wild salmon from escapees. Governance and information issues in addition to the ones already mentioned noted biased information and misinformation. Economic concerns were on the potential collapse of one or both industries, and a decrease in coastal property values. Etiquette and ethical issues described a lack of community engagement, entailment, lack of transparency, and misinformation. Misinformation was mentioned under opposition tactics, which also included fear mongering. A couple of interviewees also noted concerns for unknown impacts on human health (Boaler, 2014).

These examples shed light on community and fishermen perspectives of the aquaculture industry. Yet, with the exception of Maillet et al., (2018) extrapolation on the aquaculture industry's perspectives towards inshore fisheries there appears to be limited studies from that angle. Although an extensive review of the literature, including specific aquaculture journals could reveal additional studies, a quick search notes two articles of interest. Osmundsen et al., (2017) study of fish farmers and regulators coping with the wickedness of aquaculture and Weitzaman & Bailey (2019) research on the public discourse of the industry through media platforms. Osmundsen et al., (2017) study consisted of interviews with the industry and regulators to determine the challenges with governing aquaculture, and what the characteristics of good governance would entail. This study found that there is a great extent of uncertainty of the externalities around production, and dynamics as new solutions emerge that make established knowledge and information irrelevant. The authors propose a governance approach that focuses on building competence, collaboration, and adaptability, which is also flexible and cost efficient (Osmundsen et al., 2017).

Weitzaman & Bailey (2019) research provides general insights on how aquaculture is represented in the media. Their findings suggested that the media presents aquaculture in a mostly negative tone but with variation across regions and specific attributes. The study also found that risk factors were focused on environmental challenges and management responses, while positive aspects describe scientific and technological advances and economic benefits (Weitzaman & Bailey (2019). Despite the good news stories describing community engagement, support, good environmental practices, etc. it would be safe to conclude that the perception of the industry by the public is fairly low. As such it might be interesting to explore the aquaculture industry's perspectives on these issue, going beyond the information that is posted on their public relations websites and other public channels.

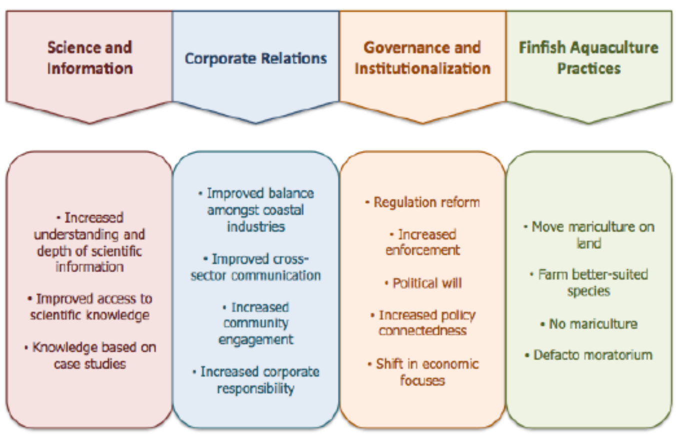
Exploring solutions towards reducing fishermen and aquaculture industry conflicts

One successful study demonstrating a collaborative project that included representatives from federal and provincial governments, fishermen, ENGos, and the aquaculture industry, used public participatory GIS to determine the locations of marine debris in the SWNB area (Rehn et al., 2018). The three year study bought participants together to document different participant's perceptions of debris sources and threats, and to place large non-mobile debris into GIS layers so as to identify mitigation priorities (Rehn et al., 2018). Initially, the process started with a high-level degree of distrust between the fishermen and aquaculture representatives. Contentious issues included what was debris, who was responsible for it, and which ones should be prioritized for removal. The introduction of the GIS map, with physical data points being added, introduced a level of stability to the discussions. The fear of walking away from the process, might also remove their influence over the map, and its future outcomes e.g. potential to influence government and the public (Rehn et al., 2018). As participants became more engaged with the project and were being held accountable to the data they were providing, polarized positions changed, with compromises made on who was responsible, and what mitigation actions could be taken.

Factors that may have contributed to the success of this project included involving just the fishermen in the first stage of the project (to document their perspectives on sources, types, and risks of marine debris in the Bay), followed by the other stakeholders during the second phase. Given the ongoing conflicts around chemical pollution and loss of space between these two groups, taking this approach may have given fishermen a greater sense of control in their contribution to the project, and the desire for it to succeed (Rehn et al., 2018). Another factor, was framing the project around a greater good, in that the area of concern had been designated an ecological and biologically significant area by DFO, as it contained several species of risk, including the right whale (Buzuta & Singh, 2008). Many of the participants lived in the area, and knew each other from daily encounters both at the work place and in the community. Focusing on the risks that large debris fixed to the ocean floor, and floating in the water column posed to humans, whales and other marine species, shifted the attention away from each other, as they collectively sought ways to address these problems. A third factor, which probably did not have as much influence as the ones mentioned above was that a small amount of funding was available from the project to remove high priority debris that was within their capacity to address (Rehn et al., 2018).

Gervais & Kaouass, (2015) study noted a couple of areas where fishermen indicated interested in doing further research. Research topics included impacts from chemical, feed etc. on the environment, reproductive ability and health of lobsters near salmon farms, wild salmon reproduction and mortality, and the proliferation of fish and shellfish, and human pathogens in nearby aquatic waters. Other research needs highlighted were an evaluation of standard operating procedures for site management, and a socio-economic evaluation of aquaculture in Nova Scotia (Gervais & Kaouass, 2015). This study does not indicate whether the aquaculture industry would be involved in the research and how, and who would do it, but it does note that participants were tired of being involved in studies, which were often disregarded by the government and the industry. There is also no indication whether the involvement of the industry, and/or the results from the studies would contribute to a better understanding of perspectives and relationships between the two industries, or cause further conflicts.

Interviewees from Boaler, (2014) also provided some suggestions on how conflicts might be alleviated and are presented in the diagram below. However, the study does not expand upon the implementation or feasibility of these recommendations.



Suggested pathways towards alleviating conflicts (Boaler, 2014)

Two other papers are of notable consideration. Liu et al., (2013) suggest three approaches towards mitigating some of the conflicts between the two industries that could also improve governability. Recent technological improvements include the development of vaccines, feed formulation, and a closed containment system (either on land, or sea based using a sea-bag system). The development of vaccines has largely reduced the use of antibiotics (Tveteras, 2002) and feed efficiency has increased with these new procedures (Asche, 2008). Although closed containment systems reduce the risk to the environment, with the fluctuating market prices for salmon in many situations it would not be economically feasible to implement (Liu et al., 2013). The application of an integrated production system that would include other species such as mussels, and seaweed, may also help reduce environmental impacts and increase employment opportunities (Liu et al., 2013). Liu et al., (2013) list market based instruments such as taxes, tradable permits, performance bonds (deposit-refund) and eco-labeling to force producers and consumers to take environmental concerns into account. Governance measures include a strong streamlined regulatory process (especially in the case of Canada, where two government levels have authority, with involvement by a multiple number of agencies, regulations and polices) that is accountable, and balances social, economic, and environmental concerns, an integrated costal management framework, and international governance given that salmon production is a global industry (Liu et al., 2013).

Mather and Fanning (2019) explore the potential of a social license approach being applied by the aquaculture industry. Emerging as a concept and practice for the mining industry, a social license approach facilitates access to natural resources by establishing open communications and effective relationships between the industry and communities in the area (Mather & Fanning, 2019). The review highlighted key operational factors in the implementation of this concept, but also noted some critiques of this approach. Examples of these critiques include: the marginal role that it may play in community-company relationships as it is often used as a last resort to gaining access to natural resources, and the difficulty of having fair and meaningful dialogue when power relations are asymmetrical (Mather & Fanning, 2019). There is still a lot of uncertainty as to how a social license approach could be applied/useful in the context of an industry other than mining, but based on the review findings, the interest is growing by both the industry and academics on its potential to be adapted and reshaped to support a societally endorsed, sustainable aquaculture sector (Mather & Fanning, 2019).

This sampling of studies was conducted as a means to better understand the most important tensions between fishermen and the aquaculture industry, and how they might be addressed to enhance general resilience of a broader SES. From this brief overview, in the context of SWNB it would seem that more academic studies have focused on the perspectives of fishermen and the impacts of aquaculture, than from the perspectives of the aquaculture industry. Acknowledging the tensions between the two industries in this area, especially after the lobster impacts from pesticides, and the potential asymmetrical power relationship between fishermen, and the industry/government, this is not too surprising. Other studies have noted similar concerns, but draw attention to the role of media, and misinformation in contributing to these tensions. Aquaculture technology has also been identified as potentially playing a crucial part in either escalating or mitigating these tensions. Alternatively, one study has demonstrated the feasibility of having both sides collaboratively work on a shared project. As noted above, key factors played a role in the successful outcome of this project.

Other studies have suggested areas of research that might shed more light on how to bridge these relationships, but given the nature of these studies, may be more challenging, depending on how they are framed. A couple of studies have alluded to the issue of multiple policies, regulations and agencies both regulating and developing fisheries and aquaculture industries, and the need to streamline these processes so that proper accounting, monitoring, and evaluation programs can be established. As noted from the interviews and these studies, one of the driving forces behind distrust, was the issue of management fairness, with fishermen indicating that they were often given the short straw when it came to aquaculture considerations, despite their considerable contribution to provincial and national social, economic and environmental goals. As described earlier, learning and participation opportunities can be created among fishermen, industry, and government, and are mostly likely to succeed if centered on win-win situation, such as marine debris. There is still more progress needed regarding contentious areas like chemical pollution and fish arm expansion, but this experience is a good start towards building trust and fostering complex, adaptive systems thinking among different stakeholders.