CASTING A WIDER NET: ENGAGING COMMUNITIES TO ENHANCE FISHERIES SCIENCE AND INFORM MANAGEMENT IN ATLANTIC CANADA

by

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

DEDICATION

In loving memory of Emma Kate
(1990-2014)

Table of Contents

LIST OF TABLES vii

LIST OF FIGURES ix

ABSTRACT xiii

LIST OF ABBREVIATIONS USED xiv

ACKNOWLEDGEMENTS xv

CHAPTER 1 - Introduction 1

1.1 Analysing fishery systems 1

1.2 Fisheries in Atlantic Canada 9

1.3 Building upon previous work 14

1.4 Thesis objectives 17

1.5 Approach and methodology 19

1.5.1 Positionality 19

1.5.2. Pragmatism 23

1.5.3. Mixed methods 24

1.6 Statement of co-authorship 26

1.7 Summary 27

CHAPTER 2 – Look who's talking: contributions to evidence-based decision-making for commercial fisheries in Atlantic Canada 28

2.1 Introduction 28

2.2 Methods 35

2.2.1 Canadian Science Advisory Secretariat 35

2.2.2 Stock selection 37

2.2.3 Defining information and knowledge types 39

2.2.4 Identifying contributions from diverse knowledge types within stock assessment reports 40

2.2.5 Rightsholder and stakeholder engagement in peer review of stock assessments 43

2.2.6 Briefing notes to decision-makers 44

2.3 Results 45

2.3.1 Stocks selected 45

2.3.2 Integrated Fisheries Management Plans 46

2.3.3 Stock assessment content 48

2.3.4 Stock assessment peer review 51

2.3.5 Briefing notes ... 54
2.4 Discussion ... 56
2.4.1 Stock assessment content: use of information from rights / stakeholders ... 57
2.4.2 Stock assessment peer review: bringing diverse groups to the table ... 60
2.4.3 Briefing notes: consolidating advice for decision makers ... 62
2.4.4 Addressing challenges ... 63
2.5 Conclusion ... 67
CHAPTER 3 – Exploring catch patterns in the data-deficient recreational mackerel fishery ... 68
3.1 Introduction ... 68
3.2 Methods ... 73
3.2.1 Dockside observations ... 73
3.2.2 Harvester-collected data ... 75
3.2.3 Analysis ... 75
3.3 Results ... 76
3.3.1 Summary statistics – Dockside observations ... 76
3.3.2 Patterns on longer time scales – angler data ... 77
3.4. Discussion ... 80
3.4.1 Patterns in mackerel catch and landings ... 80
3.4.2 Working towards estimating mackerel removals in the recreational sector ... 81
3.4.3 Engaging local users and their data ... 86
3.5 Conclusion ... 88
CHAPTER 4 - "The people's fish": Sociocultural dimensions of recreational fishing for Atlantic mackerel in Nova Scotia ... 90
4.1 Introduction ... 90
4.2 Methods ... 95
4.2.1 Data collection ... 95
4.2.2 Analysis ... 99
4.3 Results ... 101
4.3.1 Demographics of Survey Respondents ... 101
4.3.2 Benefits from Fishing ... 103
4.3.3 Covariates of Fishing Benefits ... 105
4.4.4 Management and Conservation ... 108
4.4 Discussion ... 112

4.4.1 Benefits from Fishing 112
4.4.2 Access to Fishing 114
4.4.3 Methodological Reflections 116
4.4.4 Management and Conservation Implications 117
4.5 Conclusion 120
CHAPTER 5 – Community knowledge as a cornerstone in fisheries management 122
5.1 Introduction 122
5.2 Methods 127
5.2.1 Literature search 127
5.2.2 Literature review 128
5.2.3 Data analysis 129
5.3 Results 130
5.3.1 Summary of literature 130
5.3.2 Management context 132
5.3.3 Exploring 'community' 135
5.3.4 Examining 'knowledge' 137
5.3.5 The role of community across dimensions of sustainability 137
5.3.6 Setting the stage for success 141
5.3.7 Recommendations 145
5.4 Discussion 149
5.4.1 A community or an industry? 150
5.4.2 From inputs to engagement 153
5.4.3 Overcoming challenges 156
5.4.4 Moving forward together 157
5.5 Summary 159
CHAPTER 6 - Conclusion 161
6.1 Major findings 161
6.2 Reckoning with different forms of knowledge 166
6.3 Considering wellbeing and sustainable livelihoods 175
6.4 Decentralization vs. unification 180
6.5 Complexity vs. efficiency 183
6.6 Practical recommendations 186
REFERENCES 192

APPENDIX 232
Appendix 1 – Mackerel angler questionnaire 232
Appendix 2 – Copyright release 238

LIST OF TABLES

Table 2.1: Decision-making considerations cited by the Canadian *Fisheries Act* pertaining to the goal of full-spectrum sustainability..32

Table 2.2: Definitions for traditional knowledge systems used by Fisheries and Oceans Canada in Integrated Fisheries Management Plans (IFMPs)..................41

Table 2.3: Presence (1) / Absence (0) of various stakeholder engagement types evident in DFO stock assessment Science Advisory Reports for commercial species in Atlantic Canada, including scientific information (fishery-dependent data collected in collaboration with rights/stakeholders, fishery-independent data collected in collaboration with rights/stakeholders), Indigenous knowledge, and community knowledge..47

Table 2.4: References to rightsholder/stakeholder knowledge described in Integrated Fisheries Management Plans for a selection of marine commercial stocks in Atlantic Canada...49

Table 2.5: Summary on content pertaining to stakeholder and rightsholder concerns included in briefing notes for fisheries management decisions regarding Total Allowable Catch (TAC) for Atlantic halibut (Fisheries and Oceans Canada, Maritimes Region, 2014-2020)...55

Table 2.6: Information and knowledge contributions by rightsholders/stakeholders to evidence-based decision-making identified based on considerations stipulated in Canada's *Fisheries Act (2019)*............................57

Table 3.1: History of recreational restrictions for Atlantic mackerel.................71

Table 4.1: Prevalence of motivations for anglers fish for Atlantic mackerel or Amalamaq (*Scomber scombrus*) in Nova Scotia / Mi'kma'ki for recreational purposes. Values are posterior means and standard deviations (SD), with lower (HPD 3%) and upper (HPD %97) 94% uncertainty intervals, given by the highest posterior density (HPD) from an intercept-only Bayesian model......................105

Table 4.2: Additional species of fish caught by recreational Atlantic mackerel fishers in Nova Scotia / Mi'kma'ki...107

Table 5.1: Information collected during scoping review for community knowledge in fisheries management...129

Table 5.2: Enablers and barriers to community engagement, participation, and leadership in fisheries management...146

LIST OF FIGURES

Figure 1.1: Conceptual diagram of a social-ecological system (adapted from Virapongse 2016)..2

Figure 1.2: Timeline of key events influencing fisheries management in Atlantic Canada..6

Figure 1.3: Doughnut model of economics (adapted from Raworth 2017).........7

Figure 1.4: Map of regional units managed by Fisheries and Oceans Canada, with Atlantic Canada approximately located within the black box indicated (i.e., Gulf, Maritimes, Quebec, and Newfoundland and Labrador Regions). Sources: Esri, Garmin, FAO, NOAA, © OpenStreetMap contributors, and the GIS User Community. Government of Canada, Open Government: DFO-MPO_Regions2021 (https://open.canada.ca/data/en/dataset/3862c9fa-dbeb-4f00-ac03-c5da6551bf00)..11

Figure 1.5: Updated DFO Maritimes Ecosystem Approach Framework (2020 Workshop), adapted from Bundy et al. 2021...17

Figure 1.6: Typologies of common mixed methods research approaches (adapted from Halcomb and Hickman 2015; Shorten and Smith 2017).............26

Figure 2.1: Processes of science advising and decision-making conducted by DFO Fisheries Management, adapted from Soomai et al. 2017. Three key engagement opportunities for rightsholders and stakeholders are highlighted, with red boxes indicating the key documents analyzed in the present study to evaluate their participation and contributions..36

Figure 2.2: Flow chart of methods used to investigate participation of, and contributions from, rightsholders and stakeholders in fisheries management in Atlantic Canada...37

Figure 2.3: Map of regional units managed by Fisheries and Oceans Canada. Regional units involved in the present case study are indicated by the black box (i.e., Gulf, Maritimes, Quebec, and Newfoundland and Labrador). Sources: Esri, Garmin, FAO, NOAA, © OpenStreetMap contributors, and the GIS User Community. Government of Canada, Open Government: DFO-MPO_Regions2021 (https://open.canada.ca/data/en/dataset/3862c9fa-dbeb-4f00-ac03-c5da6551bf00)..38

Figure 2.4: Number of stock assessment meeting attendees from various rightsholder and stakeholder groups identified within stock assessment documents for commercial fisheries in Atlantic Canada (Acad = academic scholars, Fed-Mn = federal management authorities, Fed-Sci = federal science staff, Indig = representatives of Indigenous communities or organizations, Industry = non-Indigenous fish harvesters or fishing associations, NGO = representatives of non-governmental organizations, Prov = provincial government authorities, USA = American [typically National Oceanic and Atmospheric Administration - NOAA] representatives).......................................53

Figure 3.1: Map of Atlantic mackerel (Amalamaq, *Scomber scombrus*) recreational fishing sites visited as part of a dockside monitoring study in Halifax Regional Municipality / Kjipuktuk. EPassage indicates a beach fishing location at Fisherman's Cove, Eastern Passage; Bedford indicates Bedford Wharf, Mill Cove, Bedford; Dingle indicates 'The Dingle', Sir Sandford Fleming Park, Halifax; SMB represents Bay Lookout Provincial Park, Boutiliers Point....................................74

Figure 3.2: A) Number of recreational mackerel anglers fishing per sampling site per 1-h observation period over time, B) Number of mackerel landed (i.e., caught and retained) by anglers in a 1-h observation period over time, C) Maximum number of Atlantic mackerel retained by an angler per 1-hr observation period over time, D) Proportion of Atlantic mackerel caught and retained by anglers as opposed to discarded over time.......................................77

Figure 3.3: A) Boxplot of mackerel landed per angler per fishing day in a given year, where the box represents the interquartile range, the horizontal line indicates the median, B) Number of mackerel landed per angler per fishing day over the course of a season from 2012-2022...79

Figure 4.1: Summary of fishery types targeting Atlantic mackerel or Amalamaq (*Scomber scombrus*) in Atlantic Canada...93

Figure 4.2: Map of Nova Scotia, the province in eastern Canada (located within the traditional and unceded territory of the Mi'kmaq and Wolastoqey) which compromised the geographic scope of recruitment for a research study on recreational mackerel fishing in the region. Solid lines delineate county borders within the province (Nova Scotia Geographic Data Directory, https://nsgi.novascotia.ca/gdd/)..96

Figure 4.3: Odds ratio plots for reasons anglers fish for Atlantic mackerel or Amalamaq (*Scomber scombrus*) in Nova Scotia / Mi'kma'ki for recreational purposes as a function of selected key covariates. Points are highest posterior density (HPD) odds ratios for conditions listed at the bottom of each panel, with grey bars representing 50% HPD intervals. Grey bars not spanning unity (vertical 1:1) are considered to have clear evidence of differences between groups. Colours shaded for magnitude of the odds ratio for conditions on the left (blue) and right (red)..106

Figure 4.4: Summary of current restrictions and angler perspectives on current management measures for recreational Atlantic mackerel or Amalamaq (*Scomber scombrus*) fishing in Nova Scotia / Mi'kma'ki...................................109

Figure 5.1: Flow chart summary of scoping review protocol for community knowledge in fisheries management..128

Figure 5.2: Number of academic journal articles published in a given time period from a scoping literature review on community knowledge in fisheries management..131

Figure 5.3: Number of academic studies based in or focusing on a given geographic region in a scoping literature review on community knowledge in fisheries management (Note: CAmerica = Central America, Caribb = Caribbean, NAmerica = North America, SAmerica = South America)..................................132

Figure 5.4: Groups identified as 'community members' engaged in fisheries management based on a scoping literature review...136

Figure 5.5: Ecological, social, institutional, and economic outcomes from community contributions to fisheries management...141

Figure 5.6: Recommendations from community engagement, participation, and leadership in fisheries management from a scoping review of the academic literature..........147

Figure 6.1: Sustainable Livelihoods Approach framework (adapted from Serrat 2017)..........177

ABSTRACT

In many contexts around the world, fisheries management remains a 'wicked problem', plagued by complexity in efforts to obtain credible information upon which to make decisions, establish legitimacy in governance processes, and achieve diverse objectives. Understanding how different actors in the fisheries governance process may work together to combine sources of information and bridge knowledge types is foundational to enhancing 'evidence-based' decision-making toward full-spectrum sustainability. Full-spectrum sustainability encompasses not only the ecological considerations that form the basis of conventional fisheries assessments, but is more expansive to encompass economic, social, and governance pillars. With a focus on fisheries in Atlantic Canada, the goal of my thesis was to explore approaches to scientific inquiry that result in both a more holistic assessment of the fishery system and more transparency and inclusion in decision-making processes, setting the stage for 'win-win' scenarios for both human communities and the natural world in which they are embedded.

I first explored recent *Fisheries Act* amendments regarding "Decision-making criteria" to assess recent stakeholder and rightsholder contributions to current science-policy and advisory processes at Fisheries and Oceans Canada. In subsequent chapters, I used recreational fishing of Atlantic mackerel (*Scomber scombrus*) as a case study for engaging with fishery stakeholders. First, I estimated patterns and volumes of catch using unconventional data sources from the recreational sector to address gaps in understanding for this data-deficient fishery. Next, I characterized the social and cultural dimensions of the fishery by surveying the angling community to describe their demographic characteristics, motivations for recreational mackerel fishing, and perceptions of management. Finally, my exploration of current DFO advising practices, combined with my practical experience learning from fish harvesters, led to the need to craft a potential working definition of 'community knowledge' for decision-making, as referenced in the *Fisheries Act*.

A common thread throughout my research is the unrealized (potential) value of community knowledge in fisheries science and management. I describe how engaging with stakeholders and rightsholders need not 'dilute' the role of science in decision-making, but can enrich it, partly by forcing us to confront the multifaceted objectives we seek to achieve through fishing.

LIST OF ABBREVIATIONS USED

ATK	Aboriginal Traditional Knowledge
CFRN	Canadian Fisheries Research Network
CSAS	Canadian Science Advisory Secretariat
DFO	Fisheries and Oceans Canada
EBM	Ecosystem-based management
FAO	Food and Agricultural Organization of the United Nations
FSC	Food, Social, and Ceremonial (Indigenous fishing)
HRM	Halifax Regional Municipality
IFMP	Integrated Fisheries Management Plan
LEK	Local Ecological Knowledge
LFA	Lobster Fishing Area
OCAP©	First Nations principles of Ownership, Control, Access, Possession
NCR	National Capital Region
NGO	Non-governmental organization
NL	Newfoundland and Labrador
RDG	Regional Director General (of Fisheries and Oceans Canada)
SDGs	Sustainable Development Goals
SFGAC	Scotia-Fundy Groundfish Advisory Committee
SLA	Sustainable Livelihoods Approach
TAC	Total Allowable Catch
TEK	Traditional Ecological Knowledge
UN	United Nations
UNDRIP	United Nations Declaration on the Rights of Indigenous Peoples

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CHAPTER 1 - Introduction

1.1 Analysing fishery systems

Fisheries management is, in a word, complex. This is largely because a given fishery is composed of numerous subsystems (Garcia and Charles 2007), involving both human actors and dynamics, and aspects and processes of the 'natural world' (Charles 1994). Since the Enlightenment period beginning in 17th century Europe, the dominant paradigm within both natural and social Western sciences has been to treat 'humans' and 'nature' as separate entities (Liboiron 2021). This has contrasted with historically more holistic conceptions of these intertwined systems, and in contrast to ongoing ideas of 'nature' held by other cultures around the world, including enduring Indigenous cultures (Liboiron 2021). As a result, to this day, Western ecologists tend to consider social systems only in so far as they may act as external drivers of ecosystem dynamics (Carpenter et al. 2012, Cumming 2014). On the other hand, economists and other social scientists may consider natural systems only in the extent to which they offer resources for extracting capital or providing a basis for livelihoods (Biggs et al. 2021).

However, recently there is greater public and academic appreciation of the coupled nature of environmental and social challenges (e.g., Breslow et al. 2017), and this is happening while there is growth in the fields of systems science and complexity thinking. The result is that in recent years there has been a renewed recognition that human systems are fundamentally interdependent and inseparable from ecosystems, representing seamless "social-ecological systems" (**Figure 1.1**). Conceptualized in a scholarly sense in the 1990s by researchers working in interdisciplinary areas of ecological economics (e.g., Berkes et al. 1989; Ostrom 1990; Costanza 1991; Berkes and Folke 1998), social-ecological systems are not merely social plus ecological systems, but rather are cohesive, integrated systems greater than a sum of their parts. Investigating fisheries as social-ecological systems, and the implications this has for fishery assessments and objective-setting for fisheries management, has formed a base upon which to explore ideas within my thesis research.

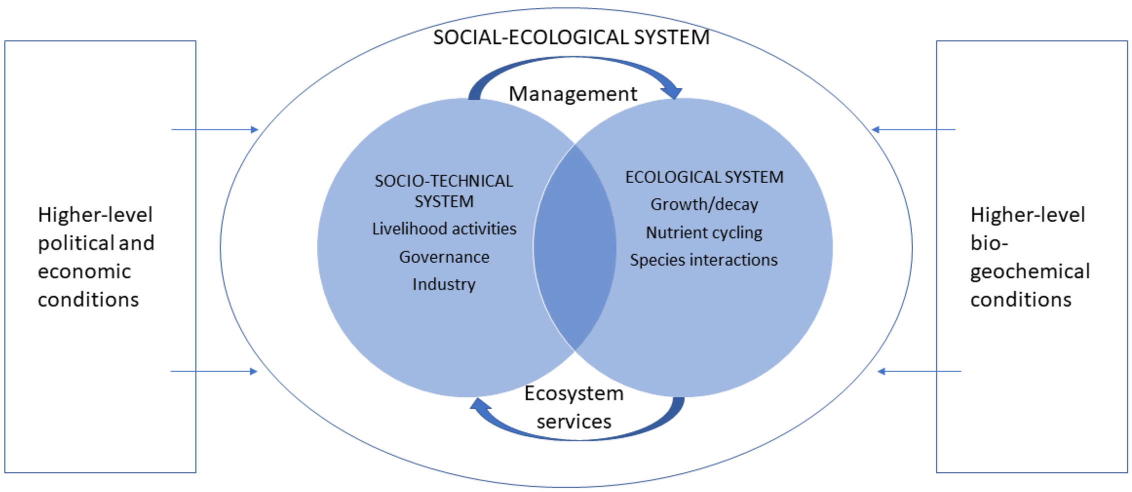

Figure 1.1: Conceptual diagram of a social-ecological system (adapted from Virapongse et al. 2016)

For humans, fisheries are both (often simultaneously) an economic industry and a sociocultural practice (Charles 1994). As such, in many contexts around the world, fisheries management remains a 'wicked problem' (Jentoft and Chuenpagdee 2009), firstly because it is difficult to delineate from other ecological and societal challenges. In addition, it involves numerous interdependencies and non-linear, multi-causal relationships. Furthermore, the questions demanded of fisheries management (e.g., "how many fish should we catch?") are often normative as opposed to technical, meaning that there are no clear right or wrong answers, or at least no right answers that can be determined scientifically (Jentoft and Chuenpagdee 2009).

Ultimately, the goal of so-called ‘resource management science’ (Gulland 1977) is thus determining an appropriate balance between and among a diverse range of short-term benefits and longer-term rewards (Beverton and Holt 1957; FAO 1983; Schaefer 1991). With this in mind, a number of paradigms have been articulated with which to guide fisheries management (Charles 1992). There has been a “conservation” paradigm advocated for largely by biological scientists, wherein ‘sustainability’ is defined as long-term conservation of a fish ‘stock’, leading to the prioritization of fish stock protection regardless of human objectives (at least in theory) (Charles 1994). Alternative perspectives on sustainability have included a “rationalization” paradigm (Clark 1990; Anderson and Seijo 2015), which instead offers the use of bioeconomic models to achieve sustainability in the form of optimal (maximal) resource rent. Additionally, there is a “social / community” paradigm (Charles 1992), in which sustainability is achieved via small-scale and community-based fisheries and management regimes, which prioritize resilience and diversity.

Within the conservation paradigm, a ‘single species’ focus and lack of attention to interactions between species and within ecosystems is believed to have hindered the goal of sustainable fishing to date (e.g., Stephenson and Lane 1995; Andrew et al. 2007; Tolotti et al. 2022). Failures in fisheries management (see e.g., Charles 2001; Garcia and Grainger 2005) have also been attributed to the neo-classical economic argument that fisheries operate as common-pool resources without the property rights necessary to incentivize stewardship, leading to the prioritization of the rationalization paradigm. The social/community paradigm largely emerged in response to management failures linked to the centralization of management regimes outside fishing communities and a failure to incorporate local knowledge and traditional management approaches (Charles 2001). Ultimately, there are limitations in any technocratic approaches that fail to capture the complexity of fishery systems to meet biological, social, and economic objectives (Serchuk and Smolowitz 1990, Caddy and Cochrane 2001). There is also always inherent uncertainty in managing fisheries stemming from random fluctuations, uncertainty in parameter estimates, and a basic lack of knowledge about the nature of the fishery system (Magnuson 1991, Stephenson and Lane 1995, Larkin 1996, Charles 1998, Caddy and Cochrane 2001). However, the paradigm within which fisheries management structures are designed will inform who participates in fisheries management, which types of information or knowledge are deemed important to inform decisions, and which objectives will be pursued or achieved.

Operating from the point of view that fisheries function as social-ecological systems, and recognizing that the goal of natural resource management is generally considered to be 'sustainability', here I define sustainability using a 'multiple pillars of sustainability' framework which combines aspects of the three paradigms outlined above (see Charles 1994; Purvis et al, 2019). Specifically, I use the 'four pillars of sustainability' framework per Foley et al. (2020), which asserts that a comprehensive understanding of sustainability must address ecological, economic, social, and institutional aspects of a fishery. Frameworks of this nature were first developed nearly 30 years ago, partly in reaction to fisheries failures under post-WWII management regimes guided by limited entry, catch restrictions, territorial jurisdiction, and property rights (Charles 1994, Stephenson and Lane 1995). Examples include the collapse of California sardine (Radovich 1981), Peurvian anchoveta stocks (Hilborn and Walters 1992), North Sea (Burd 1991) and Georges Bank (Anthony and Waring 1980) herring stocks, and groundfisheries in Atlantic Canada, primarily Atlantic cod (Fisheries

Resource Conservation Council 1993; Parsons 1993). The alternative pursuit of an ‘integrated’ fisheries management system seemed necessary to many. While the specific pillars have varied over time, (e.g., operational, social, and economic, Stephenson and Lane 1995; ecological, social, economic, and community, e.g., Charles 1994), these “full-spectrum” approaches generally involve the simultaneous pursuit of a healthy ecosystem, viable economic activity, social equity and cultural vitality, and fair, resilient governance systems. Furthermore, there is recognition that these different dimensions can be overlapping and interdependent.

On an international scale, a variety of agreements and conventions have been formulated to address some of the diverse demands of achieving a holistic version of ‘sustainability’ (**Figure 1.2**; Garcia and Charles 2007), including the United Nations Convention on the Law of the Sea (UNCLOS; UN General Assembly 1982), the Brundtland Report (Brundtland Commission 1987), the United Nations Conference on Environment and Development (UNCED 1992), and the Code of Conduct for Responsible Fisheries (FAO 1995). Indeed, the full-spectrum sustainability definition used in modern fisheries management can trace its roots to the domain of international development.

Figure 1.2: Timeline of key events influencing fisheries management in Atlantic Canada

Most recently, the UN Sustainable Development Goals (SDGs) encapsulate these multi-faceted social-ecological objectives (UN General Assembly 2015). Additionally, the UN Decade for Ocean Science initiative (UNESCO 2020) has charted a course by which marine researchers may contribute to achieving the SDGs, although this allegedly straightforward path from scientific research to sustainable development has been rightfully criticized (see e.g., Singh et al. 2021; Polejack 2023). These high-level initiatives largely aim to balance the goals of poverty alleviation, food security, and sustainable livelihoods with those of conservation and environmental health. A conceptual framework that helps to operationalize these goals is the doughnut model of economics (**Figure 1.3**; Raworth 2017), within which one must balance meeting social minima (the inside of the doughnut), without exceeding environmental maxima (i.e., planetary boundaries, represented by the outside of the doughnut). Within fisheries management specifically, a move towards ecosystem-based management to address complexity (McLeod and Leslie 2009), the use of the precautionary approach to guard against uncertainty (Garcia 1994), and co-management to decentralize decision-making are guiding more recent efforts (Puley and Charles 2022).

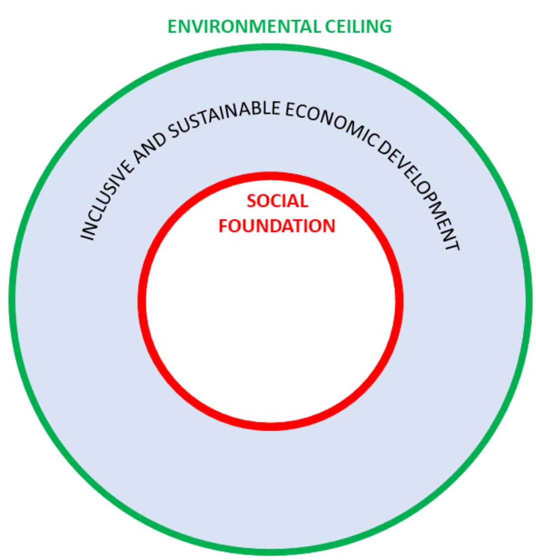

Figure 1.3: Doughnut model of economics (adapted from Raworth 2017)

Throughout this thesis, I explore the interaction of two key aspects of fisheries: fisheries science (i.e., research or monitoring conducted to support management of fisheries) and fisheries management (i.e., administration of fishing activities to achieve societal objectives) (Halliday and Fanning 2006). At its core, fisheries management is about making decisions – about who can fish, where they can fish, what they can fish, how they can fish, and ultimately, why we are fishing in the first place. Generally, best practices in fisheries management centre on the concept of 'evidence-based decision-making', i.e., that information must be gathered to assess the state of a fishery to determine management options and select an optimal path forward to achieve the desired objectives (Cooke et al. 2017). This may include knowledge of both ecosystem and human dynamics across space and time (Long et al. 2015). To date, most of the 'evidence' informing such decisions in modern fisheries management has been scientific data in line with the 'conservation' paradigm (Su et al. 2021), but here I consider 'evidence' to be any form of knowledge which may inform a decision. This may represent information from the natural sciences, social sciences and humanities, and local or traditional knowledge.

Such a conceptualization of 'evidence' is in line with increasing efforts across sectors to engage rightsholders and stakeholders in the "advice-giving landscape" in recent decades, leading to more "fluid, pluralized, and polycentric" science-policy systems (Craft and Howlett 2013). Here, stakeholders are defined as those with involvement or vested interest in a fishery, whereas rightsholders refer to those with legal or inherent rights to fishery access (i.e., in Canada, rightsholders are Indigenous Peoples). One must also recognize that each group engaged in evidence-gathering brings unique perspective and expertise to the process, which might influence perceptions of management options or alternatives (Ommer et al. 2012). Assessing and explaining how different actors in the fisheries governance process may work together to combine sources of information and bridge knowledge types to solve problems is foundational to enhancing 'evidence-based' decision-making toward full-spectrum sustainability (Bodin 2017). This represents a cornerstone of the present thesis.

1.2 Fisheries in Atlantic Canada

While fisheries are important to diverse communities around the world, fishing has formed a particularly strong cornerstone of the history, culture, and socioeconomics in Atlantic Canada (Andersen 1978, DFO 2022), a region comprising the ancestral and, in many cases, unceded territory of the Mi'kmaq, Wolastogey, Peskotomuhkati, Innu, Beothuk, and Inuit. For Indigenous Peoples in the region, fishing has always been a critical means of obtaining nutritious food for community wellbeing and an essential cultural practice, guided by traditional principles related to sustainable use such as the Mi'kmaw concept of *Netukulimk* (Denny and Fanning 2016, McMillan and Prosper 2016, Reid et al. 2021, 2022). Furthermore, the harvest and export of fish was a primary motivation for European colonizers to develop settlements throughout the region (Campling and Colas 2021), leading to the establishment of rural fishing communities with hundreds of years of fishing heritage to date (Ommer 1994, Castañeda et al. 2020, Schijns et al. 2021).

Within the scope of this thesis, the marine environment of Atlantic Canada is considered here to span three principle ecological zones: the Grand Banks, Gulf of St. Lawrence, and Scotian Shelf / Bay of Fundy (Charles 1997). The adjacent coastline covers five provinces in present-day Canada: Nova Scotia, New Brunswick, Prince Edward Island, Newfoundland and Labrador, and Quebec. Notably, while fish processing and sale is under provincial jurisdiction, marine fisheries are managed under federal jurisdiction, via Fisheries and Oceans Canada (DFO). While headquartered in Ottawa, the work of DFO is largely administered via regional offices, and those working within Atlantic Canada involve the Maritimes Region, Gulf, Newfoundland and Labrador Region, and Quebec Region branches of DFO (**Figure 1.4**). Fish populations in Canadian waters are divided into management units (i.e., stocks), which are then assigned to an appropriate regional DFO branch, where staff of the relevant branch(es) are thus tasked with the activities of managing the fishery, in line with higher-level policies, directives, and frameworks developed by staff in the National Capital Region (NCR; i.e., DFO headquarters).

Despite the value of fish in Atlantic Canada, socioculturally and economically, this region was nonetheless the site of one of the most notorious examples of fisheries management failure globally. The collapse of the groundfishery and subsequent fishing moratorium for Atlantic cod in the early 1990s had monumental impacts on marine ecosystems and devastating effects on the economic viability of coastal communities in the region; these stocks have for the most part failed to recover to this day (Charles 1995a, 1997, Hutchings and Reynolds 2004, Hutchings 2022).

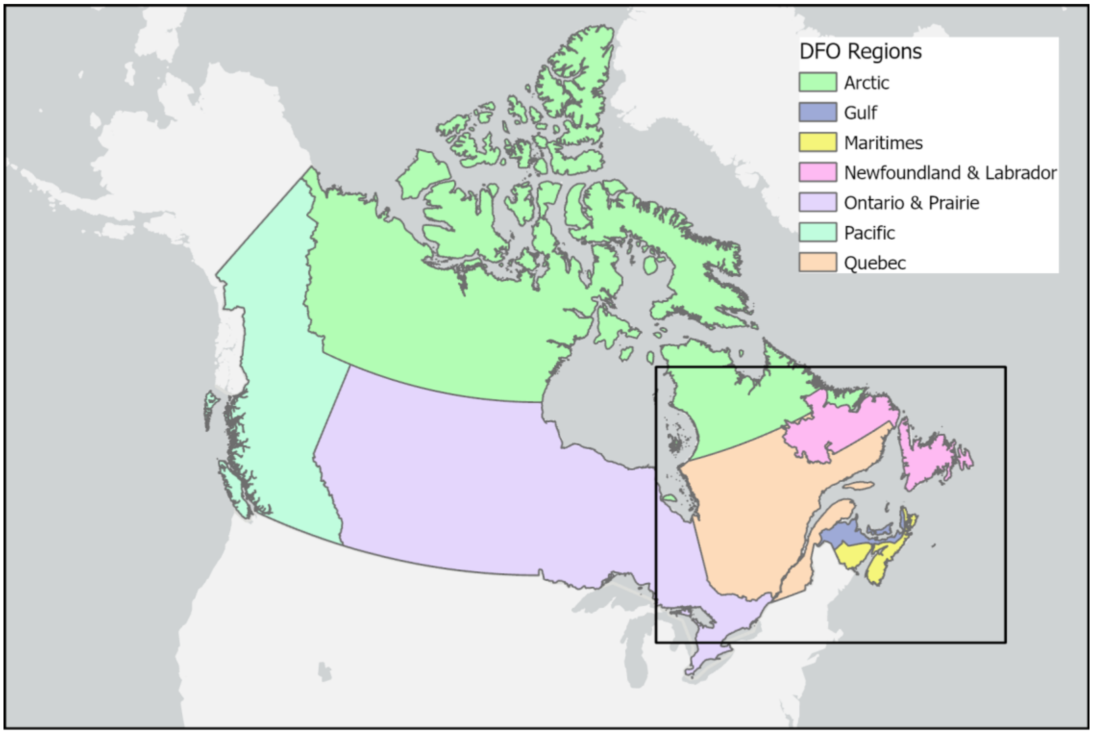

Figure 1.4: Map of regional units managed by Fisheries and Oceans Canada, with the scope of Atlantic Canada indicated by the black box (i.e., Gulf, Maritimes, Quebec, and Newfoundland and Labrador). Sources: Esri, HERE, Garmin, FAO, NOAA, © OpenStreetMap contributors, and the GIS User Community. Government of Canada, Open Government: DFO- MPO_Regions 2021 (Government ofCanada 2021b; https://open.canada.ca/data/en/dataset/3862c9fa-dbeb-4f00-ac03-c5da6551b f00).

In response to both local and global examples of fisheries failures, the Government of Canada has put in place a Sustainable Fisheries Framework (2009), largely dedicated to achieving ecological sustainability for fisheries guided by the precautionary approach[1] (**Figure 1.2**). Here, the precautionary approach refers to "being cautious when scientific information is uncertain, unreliable, or inadequate and not using the absence of adequate scientific information as a reason to postpone or fail to take action to avoid serious harm to the resource"[2]. The overall approach consists of a specific decision-making

[1] https://www.dfo-mpo.gc.ca/reports-rapports/regs/sff-cpd/overview-cadre-eng.htm
[2] https://www.dfo-mpo.gc.ca/reports-rapports/regs/sff-cpd/precaution-eng.htm

framework to implement a harvest strategy based on the precautionary approach, with varying degrees of success in practice (see Winter and Hutchings 2020; Archibald et al. 2021a), in combination with a suite of policies related to other issues such as bycatch.

At a higher level, the *Fisheries Act* is the primary piece of legislation governing fisheries in Canada and was initially enacted to secure federal jurisdiction for marine fisheries by the new settler-colonial state immediately after confederation in 1868 (Casteneda 2020; Silver et al. 2022). The *Act* has since been modified over the years by various governments in response to shifting political priorities (e.g., Hutchings and Post 2013), with the most recent amendments coming into force in 2019, representing a so-called 'modernized' *Fisheries Act*. The stated goals for these changes to the *Act* were to restore lost habitat protections following changes made in 2012, provide better certainty for industry, advance reconciliation with Indigenous Peoples, ensure the long-term sustainability of marine resources, and instill strong and meaningful protection for fish and waters in Canada[3]. The Minister of Fisheries, Oceans, and the Canadian Coast Guard at the time of implementation, MP Jonathan Wilkinson, stated, "It raises the bar in making sure that decision-making is based on science and evidence" (Hakai 2019), through enshrining the precautionary approach, an ecosystem approach, and mandated rebuilding plans for stocks, among numerous other changes.

However, this new reality has broadened the number of components and constraints to be considered in fishery assessments and management procedures, leading to more management complexity. Indeed, the stated mandate of the Canadian government in managing fisheries is three-fold: to sustainably manage fisheries and aquaculture; to work with fishers, coastal, and Indigenous

[3] https://www.dfo-mpo.gc.ca/campaign-campagne/fisheries-act-loi-sur-les-peches/introduction-eng.html

communities; and to ensure that Canada's oceans and other aquatic ecosystems are protected from negative impacts[4]. In what ways do these roles support or refute one another? How does research into fisheries and fisheries management support win-win-win outcomes? And how can this be done during an unprecedented time of global change?

An ongoing challenge in fisheries management is ultimately finding a balance between realism and simplicity in building conceptual and analytical models used to inform fisheries (Garcia and Charles 2007). Meanwhile, urgent new issues are at the fore requiring action – for example, the current climate crisis is impacting both human communities and broader natural systems at a quickening pace that will bring unprecedented, perhaps unanticipated, and certainly irreparable changes to our world. Indeed, as I write these words on an unseasonably warm 30°C+ day in May 2023, ~16 000 residents of my city are displaced by record-setting wildfires as 10 000s of hectares of one of Canada's wettest provinces are burning to the ground. It has been noted that enhanced understanding of social-ecological systems and engagement with rights/stakeholders are needed for successful fishery adaptation to climate change (Woods et al. 2022).

On the governance side, the present-day conversation is full of concerns about equity and access within fisheries, amid calls for "just transformations toward sustainability" (Avelino et al. 2016, Avelino 2017, Bennett et al. 2019, Österblom et al. 2020). This is particularly true in the context of a push toward the development of a so-called 'blue economy', where it is unclear who will benefit from such investments and how, and who might be left behind (Jouffray et al. 2020, Farmery et al. 2021, Cisneros-Montemayor et al. 2021, Bennett et al. 2022). Equity and access are particularly relevant to the need for ongoing decolonization of institutions, including fisheries management bodies, in settler-

[4] https://www.dfo-mpo.gc.ca/about-notre-sujet/mandate-mandat-eng.htm

colonial states such as Canada. Here, the federal government has recognized the United Nations Declaration on the Rights of Indigenous Peoples and a "Nation to Nation relationship" (United Nations Declaration on the Rights of Indigenous Peoples Act, SC 2021, c 14; **Figure 1.2**) has been declared a priority, amidst ongoing conflicts between Indigenous and non-Indigenous harvesters in Atlantic Canada and elsewhere (Williams and Wien 2022). From tackling the uncertainty imposed by climate change, to embracing a move toward 'decolonizing' our institutions, fisheries management is arguably getting more contentious over time.

1.3 Building upon previous work

Entering the fisheries management space in Canada as a researcher has involved interfacing with a variety of ideas and initiatives in the region upon which my work builds, led by a variety of notable leaders in Canadian fisheries science over the past decades. For example, based in Newfoundland post-cod collapse, Dr. Barbara Neis was among the first in the region to conduct fisheries research using social science methodologies to engage with fishers' knowledge, in a way that has not been done with the same level of detail and dedication since (Neis et al. 1999, Neis and Felt 2000, Johannes and Neis 2007). In doing so, she demonstrated the underappreciated value of fishers' knowledge research in fisheries management at that time, and this partially inspired the exploration done in this thesis regarding more recent uses and implications of fishers' knowledge to inform the pursuit of full-spectrum sustainability. Similarly, Dr. Rosemary Ommer drew from expertise in the history of rural economies to delve into social-ecological systems change in marine ecosystems, including in Newfoundland in light of the groundfishery collapse (Ommer 1994, Ommer and Perry 2022, Ommer and Turner 2023).

Using lessons learned from the collapse, Dr. Anthony Charles also developed a research program as a pioneer in the field of community-based fisheries management and community-based science and monitoring globally, and specifically in Atlantic Canada. Furthermore, Charles contributed significantly to ideas around integrated, community-based approaches to 'full-spectrum sustainability' for fisheries in his early and ongoing work, which served as the conceptual framing for many of my research questions (Charles 1994, 1995a, 1997, 1998, 2002, Wiber et al. 2009, Charles et al. 2020). The work of Dr. Jeff Hutchings (notably a co-supervisor of this work) was also heavily influenced by his observations of fisheries management during and following the groundfishery closure, leading to decades of advocacy for transparency and accountability in science informing fisheries management (Hutchings et al. 1997, 2016, VanderZwaag et al. 2011, Hutchings 2022). More recently, Dr. Suzette Soomai (Soomai 2017a, 2017b) mapped and evaluated aspects of evidence-based decision-making policies and pathways within Fisheries and Oceans Canada, and with a focus on Atlantic Canada, paving the way for further exploration of current procedures and protocols. Additionally, while I consider fishing communities more broadly in the present thesis, scholarship from Indigenous fisheries governance in Atlantic Canada / Mi'kma'ki specifically (e.g., Denny and Fanning, 2016; Giles et al., 2016) has offered important critiques of conventional approaches to fisheries science and management which have informed research questions here.

Furthermore, in recent years, Dr. Robert Stephenson led the formation of the Canadian Fisheries Research Network (CFRN), a cross-sectoral, interdisciplinary team consisting of government, NGO and fishing industry partners. The network (among other things) developed a set of fisheries objectives for Atlantic Canada, envisioning multi-criteria decision-making for multiple pillars of sustainability (Stephenson et al. 2018, 2019, Foley et al. 2020). These objectives, already co-developed by local representatives from various fishing-related agencies, provided a starting point for me to envision what fisheries management could or should achieve in Atlantic Canada.

Finally, the Maritimes Region branch of Fisheries and Oceans Canada is in the process of implementing an ecosystem-based management (EBM) framework, which will for the first time attempt to expand upon single-species fisheries stock assessments to consider multiple species, oceanographic and ecosystem-level components (Pepin et al. 2019, 2022), and human components of the fishery system. Currently, fisheries management planning in DFO Maritimes Region is guided by both conservation objectives (productivity, biodiversity, habitat, per the 2012 Maritimes Region Ecosystem Approach to Management framework; Curran et al. 2012), as well as social, cultural, and economic objectives (culture and sustenance, and prosperity) (Bundy et al. 2021). This initial ecosystem-approach framework, combined with the objective-setting work conducted by the transdisciplinary CFRN (e.g., Stephenson et al. 2019), has led to more recent efforts led by Dr. Alida Bundy to develop a more holistic DFO Maritimes Region EBM Framework that fits with the goal of full-spectrum sustainability (Foley et al. 2020), i.e., addresses ecological, social, economic, and governance objectives (**Figure 1.5**). While in early stages of development, it served as inspiration for an arena within which ideas explored in this thesis may be operationalized.

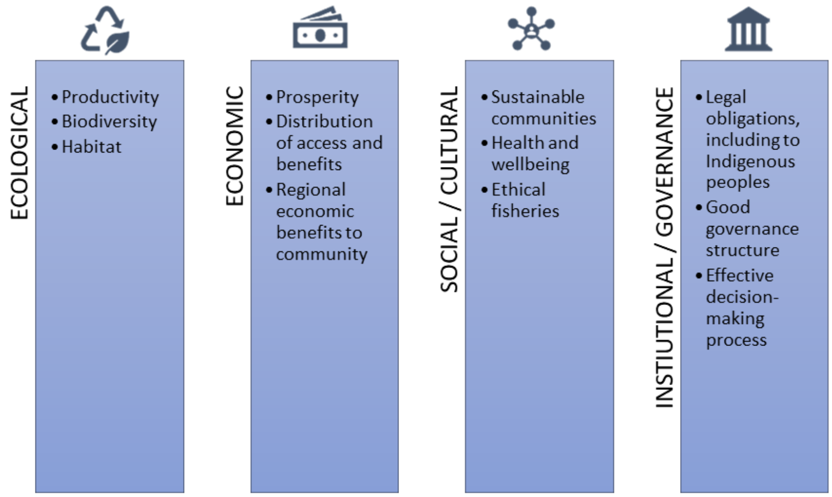

Figure 1.5: Updated DFO Maritimes Ecosystem Approach Framework (2020 Workshop), adapted from Bundy et al. (2021).

1.4 Thesis objectives

With a focus on fisheries in Atlantic Canada, the goal of this thesis was to explore approaches to conducting more holistic assessments of the fishery system and to achieving more transparency and inclusion in decision-making processes toward the goal of full-spectrum sustainability. Specifically, the following questions guided my research chapters:

1) How do rightsholders and stakeholders currently contribute to the evidence base informing fisheries management?

2) How might one partner with fishing community members in new ways to yield data needed for fishery assessments?

3) How might engaging with fishing community members facilitate socioeconomic assessments of fisheries?

4) What is an appropriate working definition and scope for the "community knowledge" that can inform fisheries management?

I began my investigation in Chapter 2 by assessing recent *Fisheries Act* amendments and current practices in the science-policy space at Fisheries and Oceans Canada with respect to inclusion of decision-making criteria informed by rightsholders and stakeholders. Using a variety of science advising documents and briefs for decision-makers I described and identified opportunities for information and knowledge contributions in DFO fisheries management processes and explored the limitations of current practices on mobilization of information contributed during consultative processes.

In subsequent chapters, I used recreational fishing of Atlantic mackerel (known in Mi'kmaw as Amalamaq, i.e., *Scomber scombrus*) as a case study for engaging with rights/stakeholders to conduct socioeconomic fisheries assessments and combine unconventional sources of catch and effort data to address data gaps in this data-poor fishery. This species is also significant because the lack of research and monitoring of forage fish, like mackerel, has been identified to be a significant barrier to operationalizing ecosystem system-based management efforts in Canada, in which predator-prey dynamics should be made explicit (Boldt et al. 2022). In Chapter 3, I developed and tested a dockside monitoring protocol, in combination with data collected and self-reported by mackerel angler collaborators, to document operational dimensions of the fishery such as catch, effort, and discards. In Chapter 4, I conducted a questionnaire with mackerel anglers around Nova Scotia to document demographics, fishing practices, and preferences and priorities for this under-engaged stakeholder group.

With these experiences in mind, to conclude the thesis, I revisited some ideas from my exploration of current science advising practices. I had an interest in delving further into a potential working definition of 'community knowledge' for decision-making (as specified in the *Fisheries Act*). Using a global literature review, I explored the many groups and methods involved in operationalizing community knowledge in fisheries management, which serves as Chapter 5.

Fisheries management decisions arguably operate at three levels: 1) strategic (choice of overall framework), 2) operational (choice of direct management measures), and 3) behavioural (response to regulations) (Charles 1995a). While here I investigated both operational and behavioural components of decision-making, the overall objective is for my results to inform choices at the strategic level, which ultimately influence downstream options. These results would ideally set the stage for 'win-win' scenarios for both human communities and the natural world in which they are embedded.

1.5 Approach and methodology

1.5.1 Positionality

While standard in the social sciences, it remains uncommon to describe researcher positionality in the natural sciences, likely owing to the expectation that natural science requires objectivity, such that one's personal background or characteristics do not affect the research undertaken (Jamieson et al. 2023). However, O'Brien (1993) argues that the very nature of the scientific process (i.e., asking questions about the universe) is emmeshed in sociocultural context: "Asking certain questions means not asking other questions, and this decision has implications for society, for the environment, and for the future. The decision to ask any question, therefore, is necessarily a value-laden, social, political decision as well as a scientific decision." Indeed, decisions about questions to ask and methods to use in this thesis may seem quite different from a standard biology PhD thesis, in which the research objectives might typically seek to assess and explain strictly ecological phenomena. In addition to providing theoretical background informing this thesis, here I share some personal history, through which I aim to clarify how my experiences, motivations, and perspectives led to this interdisciplinary approach.

While I may not have been cognizant of it at the time, my awareness of coastal communities as social-ecological systems began in childhood. I was born in Midland, Ontario, a small town on the shores of Georgian Bay. While I am a white woman descended from French settlers in Canada, I recognize that I was born in the homeland of the Huron-Wendat Nation and of the Anishinaabek people (now referred to as the Chippewa Tri-Council – comprising Beausoleil First Nation, Rama First Nation, and the Georgina Island First Nation). I would not have conceived of my hometown as a 'coastal community' in the past, but there has been recent discussion of the role the Great Lakes play as Canada's "fourth coast" and as a critical component of the stream-to-sea continuum (Glithero 2020). Midland has a working waterfront with a grain elevator and other industries servicing commercial shipping, in addition to a plethora of tour boats and personal pleasure crafts. Spending summers hiking around and swimming in the Bay instilled an environmental ethic from a young age, but my conception of the 'environment' was never one devoid of people.

After a visit to New Brunswick and Prince Edward Island (Mi'kma'ki), my interest in water systems expanded to include the ocean, leading to my undergraduate studies in marine biology and oceanography at Dalhousie University and a Master of Science focused on aquatic ecology at McGill University. My early research interests centred on the influence of environmental conditions on animal distributions and behaviours, particularly conditions created or impacted by humans. My academic instruction largely framed humans as distinct and antagonistic to 'nature', but a formative early field experience living and working with fish harvesters in northern Cape Breton (Unama'ki) on an oceanographic sampling project broadened my view to appreciate that marine resource users are experts and ocean advocates in their own right.

My interest in these human dimensions of environmental problem-solving flourished after my MSc during a period of employment at the Canadian Sea Turtle Network, an environmental not-for-profit based in Halifax / Kjipuktuk dedicated to studying and protecting endangered sea turtles in Canadian waters. Led by executives with academic experience in the social sciences and humanities, the network was founded as a successful partnership between scientists, fish harvesters, and other coastal community members. Biological monitoring work aboard fishing vessels alongside harvesters taught me the power of patiently establishing trust to facilitate productive research and stewardship partnerships. These experiences fuelled my desire to conduct research involving harvester participants or collaborators, as well as my interest in how groups with different or even seemingly opposing interests can find common ground to work together.

I was also inspired by the bottom-up (i.e., not government-led or policy-mandated) work done by fellow turtle conservationists working together in networks worldwide, particularly grassroots, community-led projects such as Natureseekers in Trinidad and Tobago. My Trinidadian colleagues sought to synergize local marine research, ecotourism, and rural economic development initiatives, demonstrating that there need not be large trade-offs between environmental initiatives and livelihoods. Seeing such projects in action motivated me to investigate other win-win opportunities, in this case within the fisheries sector. Finally, I was responsible for leading 'citizen' or 'community' science projects to collect data on endangered turtle species in Atlantic Canada, and this provided me with practical experience co-developing monitoring programs with members of the public to yield information useable by scientific agencies. This work confirmed for me the vast underappreciated expertise held by those not formally trained as scientists, but with experiential or local knowledge in marine and coastal environments.

In the course of that work, it occurred to me that local knowledge was valuable in monitoring species at risk but could be even more immediately impactful in the management of species being actively harvested. I was also aware of the legacies of conflict among fish harvesters, scientists, and resource managers that made sharing information and using such information challenging. I had many questions about who might have information that could inform fisheries management, what that information might entail, and how this information might be put into action. Of course, I was stumbling across simple questions long studied by fisheries scientists and management researchers, but they represented the first steps towards the research objectives eventually pursued in this thesis.

It was important to me to do this work in Atlantic Canada (Mi'kma'ki), where I had lived and worked for more than a decade already, given my keen interest in and awareness of local issues. A key case study in my work ended up being the recreational Atlantic mackerel fishery, an activity common in my own neighbourhood, and at many locations I spend time pursuing marine recreational activities of my own. My lived experience with health benefits from ocean activities partly informed my interest in how marine recreation might facilitate benefits for anglers. However, I recognized that in approaching a community (even my own community) as a researcher, I would always to some degree be engaging as an 'outsider' with a power differential between myself and those who might choose to contribute to or participate in my work. Notably, I was aware that I was a white, settler researcher operating in a space where there are unrealized Indigenous rights to natural resources, and a paucity of the Indigenous-led research that is needed to support sovereignty in resource governance. I had to reflect throughout the scientific process on how I might ask questions that could support, but not speak for, the various communities involved in fishing and fisheries management.

In the end, I have produced a body of work which does not simply ask questions about the nature of marine organisms or ecosystems, but investigates the processes by which we gather data, use information, and make decisions about how humans interact with them. Instead of asking "what?", I ask "how?" and "why?". As a result, my work is largely situated at the science-policy interface, where science interacts with society and government. In doing so, I hope to inform how fisheries science is done, how science is used, and how we conceive of what constitutes "science" in the first place.

1.5.2. Pragmatism

My research was largely responsive to recent changes in Canadian fisheries policy and significant management decisions, and thus rooted in pragmatism. A research paradigm, per Kuhn, refers to "shared beliefs within a community of researchers who share a consensus about which questions are most meaningful and which methods are most appropriate for answering those questions" (as interpreted by Morgan 2007). Pragmatism, as a paradigm, is based on the idea that researchers should use the methodological approach that works best for the research problem or question investigated (Kaushik and Walsh 2019). While conventional social research paradigms interrogate the nature of truth and reality (e.g., positivist vs. interpretivist approaches), pragmatism accepts that there can be single or multiple realities to study (Creswell and Clark 2011). Pragmatism is oriented toward more practical problem solving in the 'real world' and is associated with "abductive reasoning that moves back and forth between deduction and induction" – frequently summarized simply as doing "what works" (Kaushik and Walsh 2019). Given the interdisciplinary and applied nature of the questions studied here, and the desire to conduct research in a biology department that is responsive to dynamic social and policy contexts, pragmatism was a necessary research paradigm.

1.5.3. Mixed methods

Pragmatism is a paradigm frequently, though not necessarily, associated with mixed methods research (Morgan 2013). Throughout this body of research, I took a mixed methods approach to both study design and analytical strategy, where 'mixed methods' is defined as an approach in which both quantitative and qualitative data are collected and analysed within the same study (Creswell & Clark 2011, Shorten and Smith, 2017). This allows one to explore a given question from multiple points of view or ask different types of questions about a particular phenomenon. Furthermore, it allows for better understanding of similarities or contradictions between quantitative and qualitative insights and gives voice to human research participants more than quantitative methods alone (Shorten and Smith 2017). The domain of mixed methods research is relatively new, evidenced by the establishment of a field-specific academic venue, the Journal of Mixed Methods Research, only 16 years ago in January 2007 when their inaugural issue was released (Tashakkori and Creswell 2007). It is important to clarify that mixed methods research can be defined in different ways (see e.g., Morse 1991; Sandelowski and Barroso 2003) and perhaps exists on a spectrum from 1) the collection and consideration of distinct qualitative and quantitative data sets (i.e., mixed methods as a "method", or "quasi-mixed" methods) to 2) the complete integration of qualitative and quantitative approaches to research (i.e., mixed methods as a "methodology") (Tashakkori and Creswell 2007).

Regardless, the operative word is 'mixed' and data linkage or integration must occur at some (appropriate) stage of any mixed methods research process (Tashakkori and Creswell 2007) (**Figure 1.6**). One classification system for common mixed methods approaches identifies four typologies: 1) explanatory sequential (i.e., quantitative data collected and analysed first, then qualitative data are collected and analysed to help explain quantitative data), 2) exploratory sequential (i.e., qualitative data collected and analysed first, then quantitative data collected and used to test findings), 3) parallel (i.e., qualitative and quantitative data collected and analysed concurrently), and 4) nested (i.e., either qualitative or quantitative main design with the alternative paradigm embedded within the study to answer a complementary question).

In this case, my research was 'mixed' at multiple levels, given that some chapters involved primarily a qualitative approach (Chapter 5 – Community knowledge) while others were quantitative in nature (Chapter 3 – Data deficient recreational fisheries), and also in the sense that some chapters involved mixed methods within a given study (e.g., Chapter 2 – Look who's talking, parallel use of summary statistics + qualitative content analysis; Chapter 4 – The people's fish, nested use of quantitative survey with qualitative coding within certain sets of responses).

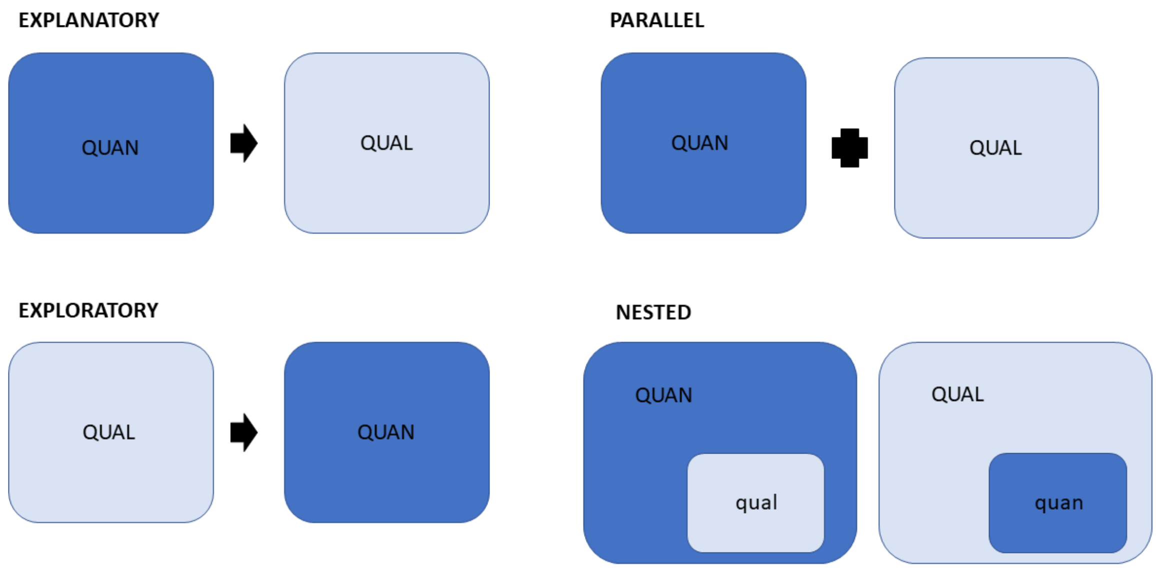

Figure 1.6: Typologies of common mixed methods research approaches (adapted from Halcomb and Hickman, 2015; Shorten and Smith, 2017)

1.6 Statement of co-authorship

The conceptualization of this thesis, the majority of data collection and analysis, and all writing was completed by me, in consultation with my advisors. However, I am grateful to several coauthors for their contributions to this work. Co-author Aaron MacNeil provided analytical support to produce Bayesian models in Chapters 3 and 4. Co-author Kaitlyn Curran assisted with dockside observation data collection in Chapter 3 and assisted with participant recruitment for Chapter 4. Angler and co-author Gary Duchesne collected data which were contributed to Chapter 3. Co-author Anthony (Tony) Charles contributed to the conceptualization and methodological approach in Chapter 5. I received with gratitude a variety of editorial comments from co-authors, journal reviewers, and my advisory committee in the development of this final document.

The following peer-reviewed articles have been published from this body of work to date (see **Appendix 2** for copyright releases):

Chapter 2: **Hamelin, K.M.**, Hutchings, J.A., and M. Bailey. 2023. Look who's talking: contributions to evidence-based decision-making for commercial fisheries in Atlantic Canada. Canadian Journal of Fisheries and Aquatic Sciences 00: 1-18.

Chapter 4: **Hamelin, K.M.**, M. Aaron MacNeil, K. Curran, and M. Bailey. 2022. "The people's fish": sociocultural dimensions of recreational fishing for Atlantic mackerel in Nova Scotia. Frontiers in Marine Science 9:971262.

Chapter 5**: Hamelin, K.M.**, A.T. Charles, and M. Bailey. Community knowledge as a cornerstone in fisheries management. *In press, Ecology and Society*

1.7 Summary

A common thread throughout my research is the unrealized (potential) value of community knowledge in fisheries science and management. I will explore how engaging with stakeholders and rightsholders need not 'dilute' the role of science in decision-making, but can enrich it, partly by forcing us to confront the objectives one means to achieve through fishing. Ultimately, my thesis seeks to explore strategies for 'going beyond' conventional strategies for fisheries management – beyond natural science assessment methodologies to include social sciences, local ecological knowledge, and Indigenous traditional knowledge; beyond the ecological pillar of sustainability to consider socio-cultural, economic, and governance dimensions; and beyond policy tools to synergize with grassroots stewardship efforts.

CHAPTER 2 – Look who's talking: contributions to evidence-based decision-making for commercial fisheries in Atlantic Canada

2.1 Introduction

Evidence-based fisheries management, through a participatory and transparent process, is critical to ensure the sustainability of fish stocks and the societal benefits conferred by their harvest (Cooke et al. 2017, Su et al. 2021). This is particularly relevant in regions such as Atlantic Canada (encompassing ancestral and largely unceded territory of the Mi'kmaq, Wolastoqey, Peskotomuhkati, Innu, Beothuk, and Inuit), where fishing is a cornerstone of the economy and culture of coastal communities (Andersen 1973; DFO 2022). In recent years, there have been increasing calls for more holistic ecosystem-based management (McLeod and Leslie 2009, Link et al. 2011, Fogarty 2014, Long et al. 2015) and increased attention to a 'full-spectrum sustainability' approach, comprising ecological, economic, social, and institutional dimensions of fisheries (Garcia 2008, Stephenson et al. 2017, Foley et al. 2020). However, the holistic study of ecosystems has been taking place for decades in academia (Slocombe, 1993), and the pursuit of a more holistic approach to sustainability originates in the field of international development (see e.g., United Nations 1993), not to mention the preceding tens of thousands of years of Indigenous stewardship grounded in holistic worldviews, which contemporary fisheries managers themselves acknowledge (Bundy et al. 2021). These principles are also not new in the field of fisheries either (see e.g., Charles 1994, 1995b; NRC 1999), and ecosystem-based approaches and full-spectrum sustainability objectives have been adopted as guiding frameworks for a variety of international bodies, including the Food and Agriculture Organization of the United Nations (De Young et al. 2008). However, work is still underway to operationalize and fully implement these principles in governance, both internationally and within Canada (e.g., Stephenson et al. 2019; Bundy et al. 2021).

In order to address these diverse objectives for fisheries (Stephenson et al. 2019, 2021), fisheries managers are increasingly expected to collect a broad range of information and knowledge contributions (Curran et al. 2012, Ommer et al. 2012, Paul and Stephenson 2020), weigh interests and values from a variety of rightsholders and stakeholders (Berkes 2009, Fanning et al. 2011, Stephenson et al. 2016, Cooke et al. 2020), and make decisions based on the best available scientific information (Stephenson et al. 2017, Su et al. 2021). Furthermore, the 'science' informing fisheries management must be understood not only as natural science, but also as social science or humanities research, as well as forms of experiential knowledge from Indigenous rightsholders and community stakeholders (Andersen 1978, Charles 1995b, Karl et al. 2007, St. Martin et al. 2007, Bonney et al. 2009, Su et al. 2021). At the same time, concerns have been raised that in this complex information/knowledge seascape the credibility of evidence informing management could be jeopardized without transparent science-policy procedures and appropriate peer-review protocols in place (Winter and Hutchings 2020).

In present-day Canada, the official governing body for marine fisheries is the federal Department of Fisheries and Oceans (DFO). The primary piece of legislation governing fishery resources in Canada is the *Fisheries Act*, notably one of the first pieces of legislation passed in the nation in 1868, the year after Confederation (Castañeda et al. 2020). Designed to ensure federal management and control of fisheries by the colonial government, it must be noted that for millennia before, Indigenous fishing practices in present-day Canada were governed by a variety of laws and customs centered on sustainable use (e.g., the concept of *Netukulimk* used by the Mi'kmaq; (McMillan and Prosper 2016) and embedded in diverse worldviews and cultural practices (Jones et al. 2010, Castañeda et al. 2020, Reid et al. 2021, Silver and Stoll 2022). The *Fisheries Act* has been amended over time, reflecting the priorities of various federal governments over the years (Hutchings and Post 2013, Bailey et al. 2016), with the most recent changes coming into effect in 2019 (Castañeda et al. 2020). To address the multiple dimensions and diverse objectives of current fisheries management practices, the 'modernized' *Fisheries Act* (2019, c.14, s.3; "Considerations for decision-making") now stipulates that in making decisions,

"*the Minister [of Fisheries and Oceans] may consider, among other things,*

- *The application of a precautionary approach and an ecosystem approach*
- *The sustainability of fisheries*
- *Scientific information*
- *Indigenous knowledge of the Indigenous peoples of Canada that has been provided to the Minister*
- *Community knowledge*
- *Cooperation with any government of a province, any Indigenous governing body and any body – including a co-management body – established under a land claims agreement*
- *Social, economic, and cultural factors in the management of fisheries*
- *The preservation or promotion of the independence of licence holders in commercial inshore fisheries*
- *The intersection of sex and gender with other identity factors"*

Notably, not all considerations in the modernized *Fisheries Act* are equal or even similar in terms of structure or function as they relate to a decision-making role. Each consideration may be informed by various types of information, principles, and practices (**Table 2.1**). For example, the *precautionary approach* and an *ecosystem approach*, listed here as one criterion, are distinct high-level guiding frameworks. In contrast, other considerations are primarily institutional priorities of the current federal government, such as *cooperation* with provincial/Indigenous/land claim bodies, the *intersection of sex and gender*, and the *preservation or promotion of the independence of licence holders*. Still other considerations comprise sources of information or informational context, some of which may be generated within DFO (e.g., *scientific information*), while others must be contributed by and grounded in the values and priorities of rights/stakeholders, including *Indigenous knowledge* and *community knowledge*, in addition to *social, economic, and cultural factors*. All considerations ultimately contribute to the multi-faceted goal of sustainability (listed as a 'consideration' in and of itself), with each consideration reflecting different aspects of the sustainability pillar framework (**Table 2.1**). Furthermore, this list does not reflect a directional procedure or hierarchy, and any given consideration(s) could be cited as the justification for a management decision. The Minister has complete discretion, such that they are not required to comprehensively assess and weight all considerations for every decision.

Table 2.1: Decision-making considerations cited by the Canadian *Fisheries Act* pertaining to the goal of full-spectrum sustainability

Decision-making consideration	Relevant pillars of sustainability	Relevant documentation
The application of a precautionary approach and an ecosystem approach	Ecological, Economic, Social, Governance	-Fishery Decision-Making Framework Incorporating the Precautionary Approach[5] -Sustainable Fisheries Framework[6] -A Harvest Strategy Compliant with the Precautionary Approach[7] -An Ecosystem Science Framework in Support of Integrated Management[8] -The Integration of Full-Spectrum Ecosystem-based Management into Canadian Fisheries Management[9]
The sustainability of fisheries	Ecological, Economic, Social, Governance	-Sustainable Fisheries Framework[2] -Sustainability Survey for Fisheries[10] -Sustainable Fisheries Resource Advisory Council of Canada[11]
Scientific information	Ecological, Economic, Social	-Canadian Science Advisory Secretariat[12] -Economic Analysis[13]
Indigenous knowledge of the Indigenous peoples of Canada that has been provided to the Minister	Ecological, Economic, Social, Governance	- Crown-Indigenous Relationship Overview[14] -DFO Reconciliation Strategy[15] -National Inuit Strategy on Research[16] -Policy on Participation in Science Peer-Review Meetings[17] -Public Engagement Principles[18] -An Act respecting the United Nations Declaration on the Rights of Indigenous Peoples[19]

[5] https://www.dfo-mpo.gc.ca/reports-rapports/regs/sff-cpd/precaution-back-fiche-eng.htm
[6] https://www.dfo-mpo.gc.ca/reports-rapports/regs/sff-cpd/precaution-eng.htm
[7] https://www.dfo-mpo.gc.ca/csas-sccs/Publications/SAR-AS/2006/2006_023-eng.htm
[8] https://www.dfo-mpo.gc.ca/science/publications/ecosystem/index-eng.htm
[9] https://waves-vagues.dfo-mpo.gc.ca/Library/40857384.pdf
[10] https://www.dfo-mpo.gc.ca/reports-rapports/regs/sff-cpd/survey-sondage/index-en.html
[11] https://www.dfo-mpo.gc.ca/fisheries-peches/initiatives/sfrac-ccdrh/index-eng.html
[12] https://www.dfo-mpo.gc.ca/csas-sccs/about-sur/index-eng.html
[13] https://www.dfo-mpo.gc.ca/ea-ae/economic-analysis-eng.htm
[14] https://www.dfo-mpo.gc.ca/transparency-transparence/mtb-ctm/2019/binder-cahier-1/1D-relationship-relations-eng.htm
[15] https://www.dfo-mpo.gc.ca/fisheries-peches/aboriginal-autochtones/reconciliation-eng.html
[16] https://www.itk.ca/wp-content/uploads/2018/04/ITK_NISR-Report_English_low_res.pdf
[17] https://www.dfo-mpo.gc.ca/csas-sccs/process-processus/peer-participation-pairs-eng.html
[18] https://open.canada.ca/en/content/principles-and-guidelines

Decision-making consideration	Relevant pillars of sustainability	Relevant documentation
Community knowledge	Ecological, Economic, Social	-Policy on Participation in Science Peer-Review Meetings[20] - Public Engagement Principles[21]
Cooperation with any government of a province, any Indigenous governing body and any body – including a co-management body – established under a land claims agreement	Governance	-Provincial and Territorial Acts and Regulations[22] -Crown-Indigenous Relationship Overview[23] -Land claim agreements, e.g., Labrador Inuit Land Claims Agreement Act (S.C. 2005, c. 27)[24]
Social, economic, and cultural factors in the management of fisheries	Economic, Social	-Economic Analysis[25] -Adjacency Principle (e.g., Independent Panel on Access Criteria for the Atlantic Coast Commercial Fishery[26]) -Sustainable Fisheries Resource Advisory Council of Canada[27]
The preservation or promotion of the independence of licence holders in commercial inshore fisheries	Economic, Social, Governance	-Inshore Regulations[28] -Atlantic Fishery Regulations, 1985[29] -Maritimes Provinces Fishery Regulations[30]
The intersection of sex and gender with other identity factors	Social	-Departmental Plan 2019-20: Gender-Based Analysis[31]

[19] https://www.parl.ca/LegisInfo/en/bill/43-2/c-15
[20] https://www.dfo-mpo.gc.ca/csas-sccs/process-processus/peer-participation-pairs-eng.html
[21] https://open.canada.ca/en/content/principles-and-guidelines
[22] https://www.dfo-mpo.gc.ca/aquaculture/management-gestion/regs-eng.htm#prov
[23] https://www.dfo-mpo.gc.ca/transparency-transparence/mtb-ctm/2019/binder-cahier-1/1D-relationship-relations-eng.htm
[24] https://laws-lois.justice.gc.ca/eng/acts/l-4.3/page-1.html
[25] https://www.dfo-mpo.gc.ca/ea-ae/economic-analysis-eng.htm
[26] https://waves-vagues.dfo-mpo.gc.ca/Library/263016.pdf
[27] https://www.dfo-mpo.gc.ca/fisheries-peches/initiatives/sfrac-ccdrh/index-eng.html
[28] https://www.dfo-mpo.gc.ca/fisheries-peches/commercial-commerciale/atl-arc/inshore-regulations-reglement-peche-cotiere-eng.html
[29] https://laws-lois.justice.gc.ca/eng/regulations/sor-86-21/page-1.html
[30] https://laws-lois.justice.gc.ca/eng/regulations/sor-93-55/index.html
[31] https://www.dfo-mpo.gc.ca/rpp/2019-20/SupplementaryTables/gba-eng.html

Although the modern *Fisheries Act* allows for the consideration of many priorities, information, and knowledge types, it remains unclear how these considerations are prioritized, where and when such information is available, who contributes to information-gathering processes, and what the management consequences of the various considerations might be. Several recent studies have investigated aspects of these information-gathering and decision-making processes, particularly in light of the amended *Fisheries Act*. For example, the inclusion of ecosystem elements in DFO science advisory reports was recently assessed by Pepin et al. (2019, 2022) and the application of the precautionary approach was examined by Winter and Hutchings (2020). Paul and Stephenson (2020) compared current data and management objectives within Canadian Integrated Fisheries Management Plans with the comprehensive evaluation framework for full-spectrum sustainability proposed by the multi-sector Canadian Fisheries Research Network (Stephenson et al. 2018, 2019). However, while Soomai (2017a, 2017b) has mapped consultative processes within DFO, an in-depth evaluation of how rights/stakeholders participate in information-gathering exercises and how their contributions influence decision-making has yet to be explored. Representatives of these groups have the potential to inform several decision-making criteria now specified in the *Fisheries Act*, particularly *scientific information*, *community knowledge*, *Indigenous knowledge*, and *social/economic/cultural factors*. Here, we use science-advising documents and briefing notes for decision-makers to explore the information and priorities informing commercial fisheries management decisions in Atlantic Canada, with a focus on how rightsholders and stakeholders contribute to and participate in the process.

2.2 Methods

There appear to be three primary ways that rights/stakeholders may contribute to processes informing decision-making related to commercial fisheries in Canada: 1) by directly contributing data or information to scientific processes, 2) by participating in the peer review of scientific information developed by the Canadian Science Advisory Secretariat (CSAS), and 3) by directly communicating with managers (e.g., during advisory committee meetings). These processes contribute to the creation of advice for decision-makers (**Figure 2.1**).

2.2.1 Canadian Science Advisory Secretariat

The Canadian Science Advisory Secretariat (CSAS) is the in-house organization that coordinates scientific peer review and scientific advice for DFO, including the production, communication (including publication), and use of information to be considered in fisheries management decision-making (https://www.dfo-mpo.gc.ca/csas-sccs/index-eng.htm; Soomai 2017a, 2017b). To achieve the objectives and operationalize the strategy developed in Integrated Fishery Management Plans, the Government of Canada implements an elaborate science advising process for fish stocks of commercial interest, culminating in a stock assessment and briefing notes for decision-makers (**Figure 2.1**; Soomai, 2017b). The outcome from a stock assessment meeting is the production of a Science Advisory Report representing the consensus of the peer review process taking place at the meeting (Soomai 2017b).

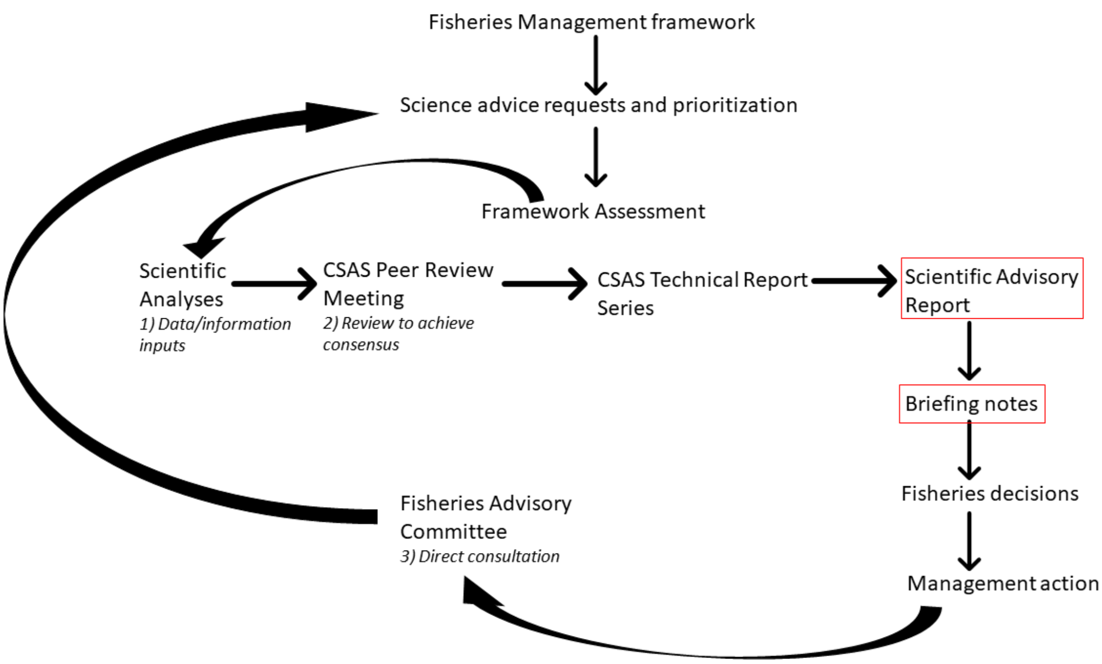

Figure 2.1: Processes of science advising and decision-making conducted by DFO Fisheries Management, adapted from Soomai (2017b). Three key engagement opportunities for rightsholders and stakeholders are highlighted, with red boxes indicating the key documents analyzed in the present study to evaluate their participation and contributions.

CSAS is largely focused on assessing population dynamics of target fish stocks within the ecological pillar of sustainability. Other data informing management regarding fishery operations (e.g., number of licences, value of landings and exports) are collected separately by the Economic Analysis and Statistics branch of DFO (https://www.dfo-mpo.gc.ca/stats/stats-eng.htm), representing a basic level of socioeconomic data from the fishery, and presented in aggregate. However, CSAS remains perhaps the most transparent and well-documented component of the fisheries management process. As such, while few of the *Fisheries Act* considerations listed above fall within the purview of current CSAS assessments, CSAS processes represent a useful case study to investigate use of information and knowledge contributions in fisheries management in Canada. In particular, CSAS includes an extensive peer review process during which rights/stakeholders are invited to comment on science advice in progress, and thus is an important venue to assess in my study. Methods used to explore a few key contribution points are summarized in **Figure 2.2**.

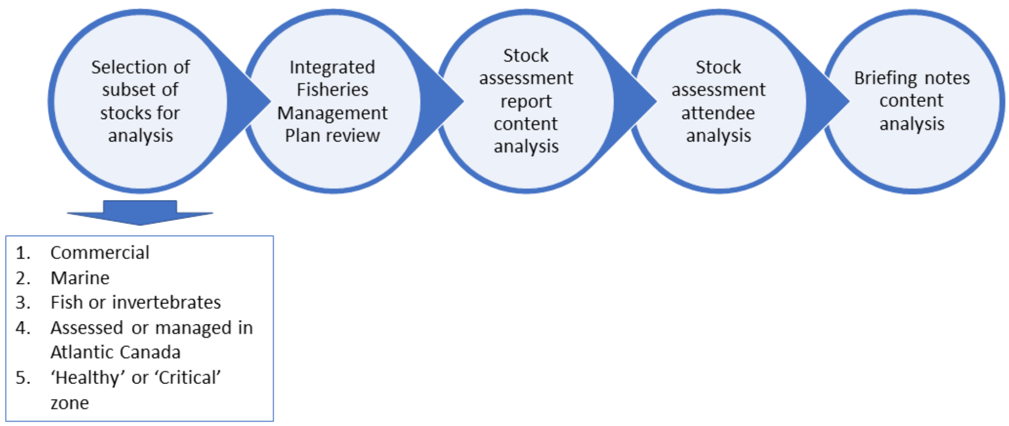

Figure 2.2: Flow chart of methods used to investigate participation of, and contributions from, rightsholders and stakeholders in fisheries management in Atlantic Canada

2.2.2 Stock selection

In order to assess the contributions of rights/stakeholders within science advising processes, I began by selecting a subset of fish stocks within Atlantic Canada from the most recent (2019) DFO Sustainability Survey data (https://www.dfo-mpo.gc.ca/reports-rapports/regs/sff-cpd/survey-sondage/index-en.html) to serve as case studies and compiled Science Advisory Reports for each stock for evaluation, specifically the most recent stock assessment available (as of October 2021). From the complete Sustainability Survey dataset (n=176 stocks), I applied 5 criteria to identify what resulted in our subset of 30 stocks: 1) commercial, 2) marine, 3) fish and invertebrates (i.e., not marine mammals), 4) assessed and harvested within Atlantic Canada (i.e., Maritime, Gulf, Quebec, and Newfoundland and Labrador DFO management regions; **Figure 2.3**), and assessed as either 5) 'Healthy' or 'Critical' under DFO's Sustainable Fisheries Framework (i.e., excluded 'Cautious' and 'Uncertain' stocks [n=49]; DFO 2009). Stocks currently under commercial moratorium, but impacted by other fisheries (including commercial bycatch or 'stewardship' fisheries), were excluded from this subset. Furthermore, stocks without a DFO Science Advisory Report (stock assessment) produced since 2005 were omitted, a criterion that also excluded stocks assessed primarily by the Transboundary Resource Assessment Committee (United States), North Atlantic Fisheries Organization, and International Commission for the Conservation of Atlantic Tuna. Although it is managed by the National Capital Region based in Ottawa, the Atlantic mackerel (*Scomber scombrus*, Northern contingent) stock was included here because it is assessed by the DFO Quebec regional office and is harvested exclusively in Atlantic Canada. Ultimately, the subset consisted of a tractable sample size for analysis, while also representing a diverse range of relatively data-rich stocks from a variety of species and fishery types having different management outcomes.

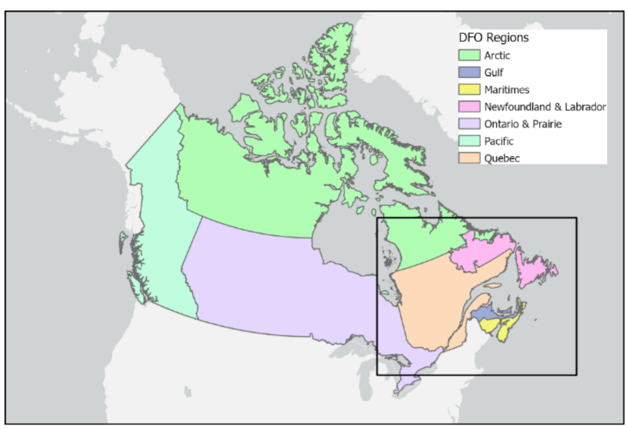

Figure 2.3: Map of regional units managed by Fisheries and Oceans Canada; those in the present case study are indicated by the black box. Sources: Esri, HERE, Garmin, FAO, NOAA, © OpenStreetMap contributors, and the GIS User Community. Government of Canada, Open Government: DFO-MPO_Regions2021 (https://open.canada.ca/data/en/dataset/3862c9fa-dbeb-4f00-ac03-c5da6551bf00).

2.2.3 Defining information and knowledge types

To evaluate knowledge inclusion in relation to the diverse objectives included in management plans and in light of recent *Fisheries Act* amendments, Integrated Fisheries Management Plans (IFMPs) for all selected stocks (where available) were accessed via the DFO website as of November 2021 and compiled for content analysis. Given that the *Fisheries Act* does not define *Indigenous knowledge* or *community knowledge*, and there are a wide range of knowledge types referenced within the environmental literature (Raymond et al. 2010), I reviewed definitions used in IFMPs to guide our investigation (**Table 2.2**). IFMPs used terminology including Aboriginal Traditional Knowledge (ATK – specific to Indigenous communities) and Traditional Ecological Knowledge (TEK – used for both Indigenous and non-Indigenous contexts) to reference accepted contributions from rights/stakeholders, typically within the "Section 2 – Stock assessment, science, and traditional knowledge" portion of management plans (**Table 2.2**). Using these definitions, I reviewed each IFMP available for our subset of stocks and identified how frequently ATK and TEK were referenced in the plan for each stock based on presence/absence and noted the capacity or context in which ATK and TEK would be considered.

I note that the above definitions do not reference contemporary experiential knowledge that is not passed down, which would surely fall within the realms of both *community knowledge* and *Indigenous knowledge*. Furthermore, rights/stakeholders participate in DFO-Industry partnerships to conduct research, which is primarily dedicated to generating new scientific data to complement or substitute for more conventional DFO scientific surveys, but likely also involves the local ecological knowledge and experiential insights of the harvesters (i.e., *community knowledge*). I note the use of "industry" in DFO documents, referencing the commercial fishing industry, which diverges from the terminology in the *Fisheries Act* around “community”. Certainly, *community knowledge* would comprise the knowledge of all types of (presumably non-Indigenous, given the distinction made for *Indigenous knowledge* in the *Fisheries Act*) fish harvesters, industrial or otherwise, in addition to perhaps other members of civil society. I explored these various nuances in further detail by evaluating documents within one example component of the CSAS science advising process: stock assessments, published within the Science Advisory Reports series (**Figure 2.1, 2.2**).

2.2.4 Identifying contributions from diverse knowledge types within stock assessment reports

To further assess information/knowledge inclusion in science advisory processes, the most recent (as of October 2021) CSAS stock assessments within the Science Advisory Reports publication series were compiled for each stock. Science advisory reports represent the final step in the CSAS process available to the public, before briefing notes are created and decisions about management action are made (Soomai 2017a). These documents are peer-reviewed, public advice for management obtained through consensual agreement among individuals present at assessment meetings, including a variety of rights/stakeholders. Note that while efforts to implement an ecosystem-based approach to fisheries in Canada are underway, most fishery assessments are still conducted as single-species scientific stock assessments.

Table 2.2: Definitions for traditional knowledge systems used by Fisheries and Oceans Canada in Integrated Fisheries Management Plans (IFMPs)

Terminology	**Definition from the IFMP**
Aboriginal Traditional Knowledge	"Knowledge that is held by, and unique to Aboriginal peoples. It is a living body of knowledge that is cumulative and dynamic and adapted over time to reflect changes in the social, economic, environmental, spiritual, and political spheres of the Aboriginal knowledge holders. It often includes knowledge about the land and its resources, spiritual beliefs, language, mythology, culture, laws, customs, and medicines."
Traditional Ecological Knowledge	"A cumulative body of knowledge and beliefs, handed down through generations by cultural transmission, about the relationship of living beings (including humans) with one another and with their environment."

A content analysis was conducted on the selected assessments for *Fisheries Act* considerations to which rightsholders and stakeholders might contribute, with a focus on flagging evidence stemming from *scientific information*, *Indigenous knowledge*, or *community knowledge*, which were *Fisheries Act* considerations determined most likely to hold relevance in the science-based CSAS process. Each assessment was reviewed thoroughly and the presence/absence of evidence of each of these 3 information/knowledge categories was noted. Summary statistics on presence/absence data were calculated in R Statistical Computing Software (R Core Team 2020). The presence of one of these information/knowledge types in a stock assessment document often represented input from a rights/stakeholder contribution from an upstream scientific process (**Figure 2.1**; the details of which are beyond the scope of this study), given that stock assessment peer review meetings yielding such publications are not typically intended to solicit new information.

In order to explore the nuances in definitions of *community knowledge* and *Indigenous knowledge* explored above, I specifically flagged rights/stakeholder contributions to **scientific information**, defined as information from a Western science tradition, hereafter referred to as 'dominant science' per Liboiron (2021), with sub-categories for **fishery-dependent data collected via collaboration** or **fishery-independent data collected via collaboration** in order to distinguish from data collected exclusively by DFO, and between data collected in the course of regular fishing activities versus data requiring dedicated effort and protocol development for sampling. This allowed for the identification of ways in which Indigenous or community contributions were made, but under the umbrella of scientific information. **Indigenous knowledge** was interpreted to include evidence of ATK or TEK, as defined in the IFMPs, or any other experiential knowledge or data contributed by Indigenous groups during the CSAS process. **Community knowledge** was defined here as TEK (per the IFMPs) or other experiential knowledge held by harvesters (the fishing 'industry') and other community members. As non-Indigenous academics, I recognize that *Indigenous knowledge* is not for us to define, and both *Indigenous knowledge* and *community knowledge* represent not just information inputs, but entire systems of knowing, learning, and doing (Fazey et al. 2014, Denny and Fanning 2016, Giles et al. 2016, Moon et al. 2021). For the purposes of this study, I sought to broadly identify any evidence of relevant information, methodologies, or other indicators of participation or leadership during content analysis.

2.2.5 Rightsholder and stakeholder engagement in peer review of stock assessments

While information/knowledge contributions might not always be cited or explicitly referenced in the text of the consensus-based advisory report, or perhaps these references exist in more detail in supporting science advice or proceedings documents, it is also worthwhile to investigate the types of participants brought to the table to peer review Science Advisory Reports (in this case, stock assessments). Where available, the list of rightsholders, stakeholders, or independent invitees attending the meeting yielding the science advisory report was compiled, typically from a list appended at the end of each stock assessment document for each stock in our selected subset (see Methods 1a). Attendees were classified according to rights/stakeholder type (e.g., DFO scientist, DFO manager, provincial authority, fishing or other industry representative, Indigenous representative, NGO representative, academic, representative from the United States; similar to Moreland et al. [2021]). Although academics are not invited to CSAS meetings as stakeholders per se, for convenience, I am including them in this category for analytical purposes. These diverse participants represented groups with the capacity to contribute scientific, Indigenous, and community knowledge to the peer review process, and it should be noted that any given participant may hold multiple types of knowledge (e.g., Yang, 2021), which would inform their ability to evaluate science advice. Given the goal of consensus within these meetings, I assume that if someone was present at the advisory meeting to produce each report, they would have had the opportunity to comment on and consent to the information presented. Summary statistics on count data for participants were calculated in R Statistical

Computing Software (R Core Team 2020). Statistics were reported as mean ± standard deviation, where relevant.

2.2.6 Briefing notes to decision-makers

It is important to note that rights/stakeholders may contribute to decision-making in a few other ways, beyond participating in scientific surveys or science peer review. Most notably, rights/stakeholders gather for regular Advisory Committee Meetings for a given fish stock or group of stocks, during which they may share experiences and weigh in on proposed management scenarios (**Figure 2.1**; (Soomai 2017a, 2017b). Individuals and groups (e.g., fishing associations, non-governmental organizations, etc) may also submit statements to the government for consideration. While minutes and outcomes from advisory meetings are not publicly available, it is possible to gain insight into the extent to which the wide range of possible information sources from rights/stakeholder contributions are considered as evidence by reviewing briefing notes to the Minister (or the Regional Director General [RDG], regional decision-making authorities within the department) regarding management decisions. These notes help to illuminate the 'black box' within which decisions are made by shedding light on how information is summarized and recommendations are made by DFO, particularly with respect to contributions from science advice and rights/stakeholder groups.

In order to gain insights into rights/stakeholder information informing management decisions, an Access to Information Act request was made (A-2021-00870 / MRV) to obtain all briefing notes for the Minister of Fisheries and Oceans, using Atlantic halibut (*Hippoglossus hippoglossus*) in Maritimes Region as a case study, representing one of the highest value per weight fish in the region, and a stock subject to intensive scientific scrutiny (determined during stock assessment content analysis in our study). All briefing notes pertaining to the Scotian Shelf/Grand Banks Atlantic halibut stock managed in Maritimes region were requested, from years 2014-2021 inclusive, representing years both before and after the *Fisheries Act* was modified, and beginning when Soomai (Soomai 2017a, 2017b) last investigated DFO fisheries management processes systematically. This request yielded eight memoranda to the RDG for domestic fisheries management decisions pertaining to Atlantic halibut (Maritimes region) for analysis. Memoranda to the RDG or Minister for 'information' rather than decision-making were excluded, as were several notices pertaining to Marine Stewardship Certification which did not have direct relevance to stock management, and several notices regarding international transboundary agreements which were beyond the scope of this study.

A content analysis was conducted for each of the eight relevant memos to identify key headings included in each document, an assessment of whether rights/stakeholders contributed information under a given heading, and a summary of supplementary documentation attached (where available). It should be noted that some documents in the package were redacted, as they were "public-denied, pursuant to section 68(a) of the Access to Information Act".

2.3 Results

2.3.1 Stocks selected

Of the 30 stocks analysed here, 20 stocks (67%) were classified as "Healthy", including stocks of American lobster (*Homarus americanus*, n=9 stocks), Arctic surfclam (*Mactromeris_polynyma*; n=2), Atlantic halibut (*Hippoglossus hippoglossus*; n=2), sea scallop (*Placopeten magellanicus*; n=3), silver hake (*Merluccius bilinearis*; n=1), and snow crab (*Chionoectes opillio*; n=2; **Table 2.3**). An additional 10 stocks (33%) were classified as "Critical", including stocks of Atlantic cod (*Gadus morhua*; n=3), Atlantic herring (*Clupea* *harengus*; n=3), Atlantic mackerel (*Scomber scombrus*; n=1), winter flounder (*Pseudopleuronectes americanus*; n=1), and yellowtail flounder (*Pleuronectes ferruginea*; n=1; **Table 2.3**). Northern shrimp (*Pandalus borealis*) comprised stocks in both "Healthy" (n=1) and "Critical" (n=1) classifications.

Of these stocks, the majority were managed by Maritime region (n=16, 53%), while five (17%) were managed by Gulf region, five (17%) by Quebec region, two (7%) by Newfoundland and Labrador, and two (7%) were managed jointly by Quebec and Newfoundland and Labrador (n=1) or Quebec and the National Capital Region (n=1) (**Figure 2.3**). These proportions approximately reflect the proportions of overall stocks managed by each region in the Sustainability Survey, although both Quebec and NL appear underrepresented here, which would result from a larger number of excluded stocks in our selection process (i.e., because they either manage more non-commercial stocks, marine mammals, stocks with Cautious or Unknown status, transboundary stocks, or stocks under moratorium).

2.3.2 Integrated Fisheries Management Plans

For the 30 stocks selected, there were 16 IFMPs available (53%), with multiple stocks and even species sometimes included within a single management plan (**Table 2.4**). Among these IFMPs, nine of the 16 (56%) explicitly mentioned the role of *Indigenous knowledge*, 3 of which stated that it was not available or that there would be no mechanism to include such knowledge. Additionally, five of 16 plans (31%) mentioned the role of *community knowledge*, although in two of these cases, inviting harvesters to participate in peer review was apparently the only mechanism for inclusion.

Table 2.3: Presence (1) / Absence (0) of various stakeholder engagement types evident in DFO stock assessment Science Advisory Reports for commercial species in Atlantic Canada, including scientific information (fishery-dependent or fishery-independent data collected in collaboration with rights/stakeholders), Indigenous knowledge, and community knowledge

Stock	Region	Status	Sci – DepCollab	Science - IndepCollab	Indig	Comm
Surf Clam, Grand Banks	Maritimes	Healthy	1	1	0	0
Silver Hake, 4VWX	Maritimes	Healthy	0	0	0	0
Lobster, LFA23-26A+B-SGSL	Gulf	Healthy	1	1	0	1
SeaScallop, OffshoreSFA27_Georges	Maritimes	Healthy	0	1	0	0
Atlantic Halibut, 3NOPs4VWX+5	Maritimes	Healthy	0	1	0	0
Sea Scallop, InshoreSFA29W	Maritimes	Healthy	0	1	1	0
Sea Scallop, InshoreSFA28_BoF	Maritime	Healthy	0	1	1	0
WinterFlounder, 4T	Gulf	Critical	1	1	0	0
SurfClam, Banquereau	Maritimes	Healthy	1	1	0	1
Lobster, Offshore LFA41	Maritimes	Healthy	0	1	0	0
Herring, 4VWX	Maritimes	Critical	0	1	0	1
Shrimp Scotian Shelf, SFA13-15	Maritimes	Healthy	0	1	0	0
Atlantic Cod, 4X5Y-Scotian Shelf/Bay of Fundy	Maritimes	Critical	0	0	0	0
Northern Gulf Cod, 3Pn-4RS	Quebec	Critical	1	1	0	0
Lobster, LFA17	Quebec	Healthy	1	0	0	0
Lobster, LFA19-21	Quebec	Healthy	1	0	1	0
Lobster, LFA22	Quebec	Healthy	1	0	0	0
Lobster, Inshore LFA33	Maritimes	Healthy	1	0	0	0
Lobster, LFA27-32	Maritimes	Healthy	1	0	0	0
Herring, 4T-4vNSpring	Gulf	Critical	1	1	0	1
Snow Crab, ScotianShelf_ENS-N&S	Maritimes	Healthy	1	0	0	1
Herring, 4R-Fall+SpringSpawner	Quebec-NL	Critical	0	0	0	1
NorthernShrimp, SFA6	NL	Critical	0	0	0	0
Lobster, Inshore LFA34	Maritimes	Healthy	1	0	0	0
Lobster, LFA35-38	Maritimes	Healthy	1	0	0	0
Snow Crab, Areas12&19&12E&12F	Gulf	Healthy	1	1	0	0
Yellowtail Flounder, SGSL_4T	Gulf	Critical	1	1	0	0
Atlantic Mackerel, NAFO3-4	Quebec-NCR	Critical	1	1	0	1
Atlantic Cod, 3Ps	NL	Critical	1	1	0	1
Atlantic Halibut, 4RST	Quebec	Healthy	1	1	0	0

2.3.3 Stock assessment content

Several types of research surveys were used to assess stocks, with varying techniques among different species of both Critical and Healthy status, and among the management regions (**Table 2.3**). Unsurprisingly, given the natural science focus of the CSAS mandate, and the biological and ecological goals of current stock assessment procedures, scientific information dominated the content of stock assessment reports. Fishery-dependent information compiled by industry/community members (in the form of mandatory or voluntary logbooks) was referenced in the assessment of 63% of stocks (n=19; **Table 2.4**). Fishery-independent surveys led by industry/community collaborations were referenced in 60% (n=18) of reports (**Table 2.3**).

Contributions from *Indigenous knowledge* were rarely mentioned in stock assessments, although in 2 cases (inshore sea scallop fisheries in Maritimes region; **Table 2.3**), catch estimates from food, social, and ceremonial (FSC) fisheries were included, and in 1 additional case, scientific data collected by the Listuguj Aboriginal community were referenced (American lobster, LFA 19-21 in Quebec region), although not presented. Whether or not these contributions count *as Indigenous knowledge* may be debatable, given that they may more closely represent scientific data collected by a rightsholder, but for the purposes of this paper, I did include them as such, given that they are associated with traditional FSC use as opposed to the commercial sector.

Contributions from other forms of *community knowledge* were referenced in 27% (n=8) of reports, comprising information from formal telephone surveys for harvesters (e.g., Atlantic herring, Gulf region), or informal references in the reports noting industry feedback (e.g., notes on observed changes in species distribution or timing of spawning which might impact surveys, or changes in fishing practices which might impact calculations of catch per unit effort).

Table 2.4: References to rightsholder/stakeholder knowledge described in Integrated Fisheries Management Plans for a selection of marine commercial stocks in Atlantic Canada

Year (Last updated)	Species/Stock	Jurisdiction (DFO Region)	Indigenous Knowledge	Community Knowledge
2009	Atlantic mackerel (*Scomber scombrus*), Northern contingent	National Capital Region	N/A	N/A
2009	Northern shrimp (*Pandalus borealis*), SFA 0-6	Newfoundland and Labrador	N/A	N/A
2014	Northern shrimp (*Pandalus borealis*), SFA 13-15	Maritimes	N/A	N/A
2014	Snow crab (*Chionoectes opillio*), CFA 12, 12E, 12F, 19	Gulf	ATK recognized as a source of information; where possible, DFO will consider and integrate	N/A
2015	Lobster (*Homarus americanus*), LFA 23-26	Gulf	ATK recognized as a source of information; where aboriginal organizations are able to share ATK, DFO will consider it within context of the management frameworks	N/A
2016	Snow crab (*Chionoectes opillio*), ENS & 4X	Maritimes	Fisher experience and observations from both aboriginal and non-aboriginal sources inform the stock assessment through at-sea-observed data and anecdotes shared through meetings and communications	TEK has been incorporated in assessment; early management measures (size limits, fishing seasons, avoidance of soft-shelled crabs - from lessons learned by traditional fishers; fisher knowledge continues to inform assessment process; focused, Industry-funded Joint Project Agreements
2017	Sea scallop (*Placopeten magellanicus*), Inshore	Maritimes	No historical knowledge of scallop fishing with vessels and drag gear by aboriginal people	No formal mechanism, but commercial and aboriginal fishermen participate in peer review

Year (Last updated)	Species/Stock	Jurisdiction (DFO Region)	Indigenous Knowledge	Community Knowledge
2018	Lobster (*Homarus americanus*), LFA 22	Quebec	N/A	Fisher knowledge studied in Master's thesis in 1995, incorporated into stock assessments in subsequent years
2018	Lobster (*Homarus americanus*), LFA 19-21	Quebec	ATK in this fishery is a potential source of information; when Aboriginal organizations are in a position to share, DFO will take into consideration	N/A
2018	Scallop (*Placopeten magellanicus*), Offshore	Maritimes	No ATK available for areas where offshore scallop fishery occurs	TEK would exist for Georges Bank for 65 years; shorter duration on other offshore banks; mainly consists of where found, species incidentally captured, general bottom type
2018	Groundfish (including Atlantic halibut, *Hippoglossus hippoglossus*; cod, *Gadus morhua*; silver hake, *Merluccius bilinearis*), 4VWX5	Maritimes	DFO aims to incorporate ATK into fisheries management planning	N/A
2020	Clam (*Mactromeris_ polynyma*), Offshore	Maritimes	No formal mechanism to include TEK	Fish harvesters participate in peer review
2020	Lobster (*Homarus americanus*), LFA 27-38	Maritimes	N/A	N/A
2020	Lobster (*Homarus americanus*), Offshore	Maritimes	N/A	N/A
2021	Atlantic herring (*Clupea harengus*), 4R3Pn	Newfoundland and Labrador	ATK and TEK in the form of observations and comments from Aboriginal groups are considered in management decisions when provided	N/A
2021	Atlantic herring (*Clupea harengus*)	Maritimes	N/A	N/A

While I did not anticipate social, economic, or cultural factors (another *Fisheries Act* consideration informed by rights/stakeholders) to be captured by CSAS assessment, it was interesting to note that one stock assessment (Arctic surfclam, Maritime region; **Table 2.3**) referenced an economic break-even analysis, which had been used historically to set the total allowable catch (TAC) for the fishery.

2.3.4 Stock assessment peer review

Of the 30 stock assessment reports, 20 had meeting attendee lists appended to the document. The consistent inclusion of meeting attendee lists within stock assessment documents began relatively recently, with all lists considered here coming from reports from 2019 to the present (in addition to one report from 2018 – Atlantic herring, Maritimes region). Meeting attendance averaged 31.6 ± 13.5 individuals. The largest meeting documented involved 60 rights/stakeholders (Atlantic mackerel); the smallest meeting involved 13 rights/stakeholders (Lobster, Maritimes, LFA 33). A variety of group sizes and group compositions were noted in each region and among stocks of different status (**Figure 2.4**). The individuals invited to peer review were frequently representatives of organizations (e.g., government agencies, fishing associations, NGOs, etc) as opposed to individuals representing themselves.

Federal employees dominated the majority of meetings, with DFO science personnel attending every stock assessment meeting and comprising the most numerous group at all meetings except for herring (4VWX, Maritimes), lobster (LFA 27-32, Maritimes), and snow crab (Scotian shelf, Maritimes) where the fishing industry was most numerous (**Figure 2.4**). The fishing industry was almost always the second most numerous group after federal science staff, except where they were the most abundant stakeholder, and in a few other exceptions: for Northern shrimp (SFA 13-15, Maritimes) and lobster (LFA 34 and LFA 35-

38, Maritimes) where Indigenous representatives were the second most numerous attendees; lobster (LFA 33, Maritimes) and yellowtail flounder (4T, Gulf), where DFO management personnel were second most numerous; and Atlantic halibut (Gulf), where academics were second most numerous (**Figure 2.4**). Representatives of Indigenous organizations were present at most meetings (except yellowtail flounder, 4T Gulf; herring, 4R NL), but usually had fewer representatives relative to other groups.

There was also relatively low representation from NGO, provincial, American, or academic groups (**Figure 2.4**). NGOs typically had only one representative in attendance and were more likely to attend meetings for stocks in the 'Critical' zone, except for various lobster stocks in the Maritimes region, where a not-for-profit organization called the Fishermen and Scientists Research Society (https://fsrsns.ca/) participates, given that they are contracted to help facilitate collaborative industry surveys (DFO 2004). Provincial representatives were present at most meetings, but always in low numbers. Low numbers of American government representatives attended meetings in which transboundary issues might be relevant, such as lobster (LFA 34-38, Maritime) in the Bay of Fundy region, which borders the lucrative Gulf of Maine lobster fishery, and Atlantic mackerel, for which transboundary stock harvest has been documented. Finally, academic researchers were present in low numbers and at only five (25%) of meetings, although a larger number attended the meeting for Atlantic halibut (Gulf region).

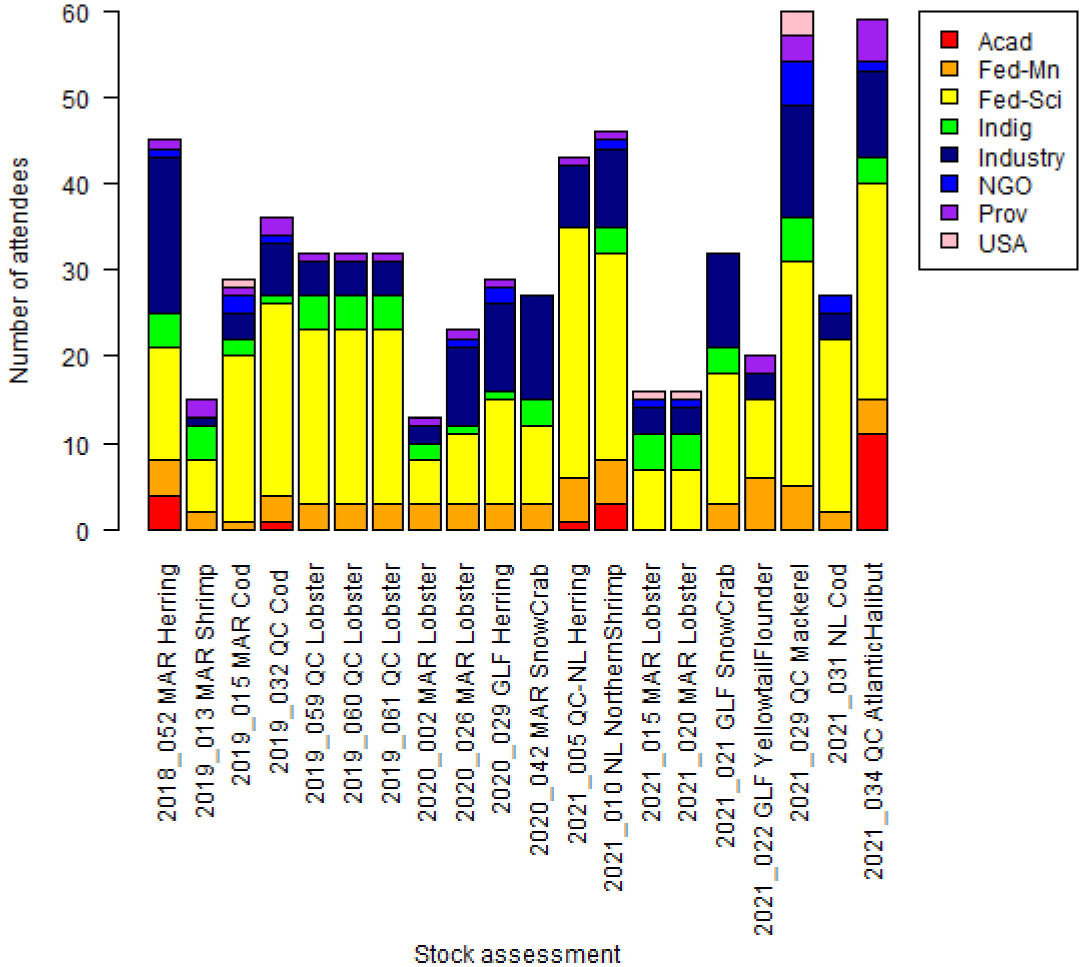

Figure 2.4: Number of stock assessment meeting attendees from various rightsholder and stakeholder groups identified within stock assessment documents for commercial fisheries in Atlantic Canada (Acad = academic scholars, Fed-Mn = federal management authorities, Fed-Sci = federal science staff, Indig = representatives of Indigenous communities or organizations, Industry = non-Indigenous fish harvesters or fishing associations, NGO = representatives of non-governmental organizations, Prov = provincial government authorities, USA = American [typically National Oceanic and Atmospheric Administration - NOAA] representatives).

2.3.5 Briefing notes

The primary consultative forum for Atlantic halibut is the Scotia-Fundy Groundfish Advisory Committee and thus virtually all comments from rights/stakeholders cited in briefing notes came from members of this committee. Given that the committee works on a variety of groundfish species, sometimes decisions about other groundfish stocks were discussed within a given briefing note, but for consistency, only content pertaining to Atlantic halibut was evaluated in detail here (**Table 2.5**). Sections within a briefing note were consistent for the 2014/2015, 2015/2016, 2016/2017, 2017/2018, and 2018/2019 fishing seasons: Summary, Background, Aboriginal Consultation/Considerations, Analysis/DFO Comment, and Recommendations/Next Steps (**Table 2.5**). However, notes from 2020/2021 and 2021/2022 had a streamlined format, perhaps in response to changes made in the *Fisheries Act* in 2019, which consisted of only Summary, Background (more concise than in previous years), Analysis and Considerations (similar to earlier Background details and Analysis/DFO Comment), and Advice, Recommendations, and Next Steps (similar to Recommendations/Next Steps). There is no direct equivalence to the "Aboriginal Consultation/Considerations" section in the new note format. In all cases, recommendations made by DFO staff were accepted by the decision-making signing authority.

Notes on perspectives of stakeholders were largely captured within the Background and Analysis/DFO Comment sections of the older note format (pre-2020), and primarily within the Analysis and Considerations section of the newer note format (2020-2022). It should be noted that all such content pertained to opinions from harvesters on TAC scenarios and management strategies, as summarized and contextualized by DFO staff, with limited original insights from their experiential knowledge regarding the state of the ecosystem, operational, or sociocultural context of the fishery.

Table 2.5: Summary on content pertaining to stakeholder and rightsholder concerns included in briefing notes for fisheries management decisions regarding Total Allowable Catch (TAC) for Atlantic halibut (Fisheries and Oceans Canada, Maritimes Region, 2014-2020)

Heading	**Typical Content**
Summary	Key points from briefing note
Background	Scientific and operational summary of fishery, including TAC recommendations and management opinions from Scotia-Fundy Groundfish Advisory Committee [SFGAC]
Aboriginal Consultation/Considerations	Summary of potential impacts of management decisions on Indigenous fishers and notes on participation of Indigenous fishers in SFGAC
Analysis/DFO Comment	Comments on likely outcomes from proposed TACs, relevance to national objectives and international commitments, rationale for stakeholder opinions on TAC scenarios (e.g., economics, desire for MSC certification, etc)
Recommendations/Next Steps	Recommendations made for TAC, modifications to quota allocation, and strategy for communication of decision to advisory committee and/or specific stakeholders of relevance

Notes on perspectives of fishery rightsholders were captured within the Aboriginal Consultation/Considerations section, when it was available. Interestingly, in reviewing the notes, the TAC was deemed by the Department to have limited effect on Aboriginal communal commercial licence holders in 2014/2015, 2015/2016, 2016/2017, whereas in 2017/2018 an increase to TAC was deemed to have a "moderately positive" effect, and in 2018/2019 and 2019/2020 it was deemed to have a "positive" impact. This evolution appeared to be linked to the fact that in the earlier years, the assessment considered the mobile gear (vessels <65') fishery, for which the Atlantic halibut quota is designated for bycatch only, whereas in the later years, the fixed gear fishery (vessels <45’) was considered, with the possibility to participate via competitive community quotas. Incidentally, beginning in 2017/2018, it was noted that Indigenous fishers requested more access to the halibut fishery. However, it was noted that participation in this fishery by Indigenous communities had been limited or variable, and in most years it was noted that very few (e.g., 1-3) Indigenous representatives attended SFGAC.

In addition to the content captured within a given briefing note, supplemental documentation was always appended. This documentation primarily included various internal summary documents, e.g., describing fishery objectives and management strategies and tactics; the most recent CSAS Science Advisory Report; relevant CSAS Science Responses (e.g., Stock Status updates, Harvest Control Rule updates); and advocacy letters from stakeholders (i.e., fishing associations).

2.4 Discussion

The “Considerations for Decision-Making” identified within the Canadian *Fisheries Act* theoretically include all necessary considerations relevant to achieving full-spectrum sustainability. They also (sometimes by necessity) require various rights/stakeholders to contribute to or participate in information-gathering exercises to make decisions based on some of these criteria. Information and knowledge about a given fishery, and the context in which that information is gathered or knowledge is formed, represents a cornerstone of the decision-making process. The path from management planning, to engaging with knowledge, information gathering, and decision-making varies among commercial stocks in Atlantic Canada. The majority of stocks in this region are subject to a relatively data-rich science advising process, with a number of avenues for rightsholder and stakeholder participation. Processes are moving in a direction towards more transparency (e.g., consistently sharing stock assessment meeting participant lists, noted here). However, there remain unexplored opportunities to both strengthen the quality of information inputs to management decisions (Winter and Hutchings 2020), and ensure participation and engagement of diverse knowledge types, to achieve more of the objectives identified as priorities for fisheries in the region (Stephenson et al. 2019) (**Table 2.6**).

Table 2.6: Information and knowledge contributions by rightsholders/stakeholders to evidence-based decision-making identified based on considerations stipulated in Canada's *Fisheries Act* (2019)

***Fisheries Act* consideration**	**Current contributions**	**Potential contributions**
Scientific information	-DFO in-house scientific research -Industry partnership surveys	-Academic research
Indigenous knowledge	-Attendance at CSAS meetings -Food-Social-Ceremonial catch (rare) -Assistance with scientific data collection (rare)	-Centering of Indigenous knowledge systems -Two-Eyed Seeing approaches to conducting science and industry partnerships -Greater consideration of Food-Social-Ceremonial fisheries
Community knowledge	-Attendance at CSAS meetings -Collaborative scientific surveys	-Traditional ecological knowledge from diverse 'industry' and community groups -'Citizen science'-style contributions

2.4.1 Stock assessment content: use of information from rights / stakeholders

Considering that TEK and other experiential knowledge forms from fish harvesters and other community members receive less attention in IFMPs than *scientific information* or *Indigenous knowledge*, according to our evaluation, these stakeholders play a large role in scientific data collection via log book documentation and industry partnerships for surveys, in the CSAS peer review process (large number and proportion of stock assessment meeting attendees), and in contributions to decision-maker briefing notes. Fish harvesters undoubtedly have rich experiential knowledge (*community knowledge* per the *Fisheries Act*) related to both marine ecology and fishery operations (Johannes et al. 2000, Haggan et al. 2007, Johannes and Neis 2007) and management agencies recognize the value of these contributions (Stephenson et al. 2016). Indeed, DFO has invested in developing industry-funded and industry-executed research partnerships as a means of supplementing their own dedicated scientific research programs for many years (DFO 2004). This appears to happen most successfully for high-value stocks, such as lobster, Atlantic halibut, and sea scallop (DFO 2018), perhaps because there are sufficient industry funds to support the work, or perhaps because there is increased motivation among harvesters to ensure high yields for years to come.

However, conducting scientific surveys on behalf of a management agency does not fully engage the breadth of knowledge accumulated by harvesters (Hind 2015), and both harvesters and, increasingly, scientific researchers agree that there is a wealth of knowledge and experience from these stakeholders that remains untapped (Hutchings and Ferguson 2000, Haggan and Neis 2007, Hind 2015, Stephenson et al. 2016). Indeed, "It is a mistake to focus on fishers simply as data collectors or knowledge sources, thereby ignoring their skills in hypothesis formulation, research design, and interpretation" (DFO 2004). Various comments made by harvesters regarding observed changes in animal distribution or fishing practices and their implications for sampling protocols and data interpretation were noted and considered in stock assessment documents reviewed here, showing some uptake of the local knowledge shared at some point in the science advising process. In the present Information Age in which there are new opportunities for sharing of 'bottom-up' information from stakeholders (Holm and Soma 2016), and engagement methods from the burgeoning field of ‘citizen’ or ‘community’ science could inform approaches to government-fisher research partnerships (Shirk et al. 2012, Fairclough et al. 2014, Charles et al. 2020, Paul and Stephenson 2020, Wilmoth et al. 2020, Caputi et al. 2021). Including community members in resource management in this manner can both foster an enhanced stewardship ethic and strengthen science-society relationships (Fairclough et al. 2014, Aceves-Bueno et al. 2017, Mason et al. 2020), assuming adequate trust is established between harvesters and scientists (Holm and Soma 2016).

It must be noted that fish harvesters and organizations representing Indigenous communities appear to have a disproportionately small role in science advising protocols, given the relative importance attached to the value of ATK and TEK in IFMPs, the fact that the few social objectives clearly specified in IFMPs relate to Indigenous concerns (Paul and Stephenson 2020), and the extensive rights and title held by Indigenous groups on these unceded territories (Wiber and Milley 2007). Similarly, Kadykalo et al. (2021) explored information use by natural resource managers in British Columbia, Canada and concluded that Indigenous obligations were “paid lip service”. However, guidelines, such as the principles of OCAP© (Ownership, Control, Access, Possession) developed by the First Nations Information Governance Centre, ensure that intellectual property from Indigenous communities remains with those communities, which may restrict the public documentation of such contributions to fisheries management. Additionally, it is clearly specified in IFMPs that it is the choice of these individuals and communities regarding what and how much information/knowledge they wish to contribute, and lack of trust or hesitancy to share may play a role (e.g., Kadykalo et al. 2021). Similarly, it is unclear whether limited participation by Indigenous representatives in consultative forums represented in brief notes has been by choice or by (perhaps unintentional) exclusion. In any case, there is recent interest expressed in briefing notes regarding increased Indigenous access to fisheries, including that documented for Atlantic halibut here.

Either way, there are both legal and practical reasons why science advising processes must evolve beyond a reductionist approach in which *Indigenous knowledge* is regarded as another ‘input’ to a natural science model (Reid et al. 2021). As non-Indigenous academic scientists, it is not for us to suggest how these processes should change, but notably, numerous thought leaders on Indigenous fisheries science and management in Canada have offered frameworks which could form a basis for enhanced partnership and leadership (e.g., Denny and Fanning 2016; McMillan and Prosper 2016; Reid et al. 2021b). Indeed, these frameworks could reframe management strategies to better bridge silos and reflect the holistic objectives involved in ecosystem-based or full-spectrum sustainability approaches. Developing ways that these approaches can help to transform the science advising and management decision-making process should be a high priority for a department whose mandate directs the Fisheries Minister to “work with Indigenous partners to better integrate traditional knowledge into planning and policy decisions” (Government of Canada 2021). This work appears to be underway, albeit in early stages.

2.4.2 Stock assessment peer review: bringing diverse groups to the table

Given that scientific assessments of fisheries are conducted in-house at DFO, and the dominant group present at such meetings is DFO science personnel, the agency responsible for conducting the science is also responsible for reviewing its quality and rigor, albeit in collaboration with invited rights/stakeholders. As noted by sociologists for some time (e.g., discussed within the context of DFO’s Northern cod stock assessments by Finlayson 1994), people who regularly work together on similar topics and meet frequently tend to be far more receptive of the views of colleagues within their group than they are of those not part of the group, potentially leading to a reluctance to entertain change or new knowledge/research from those outside the group. While stability and consistency in assessment approaches is valuable, the strong quantitative bias identified here towards 'internal' peer reviewers may limit external quality control and creative opportunities to integrate novel information sources to better address diverse fishery objectives not currently considered, given the extent to which individual instincts and priors are known to influence advice for decision makers (Schuch and Richter 2021).

This, therefore, lends itself to the need for including rights/stakeholders in the peer review process, evidenced by the wide range of additional meeting attendees documented here. However, given that the purview of CSAS is exclusively biological and ecological assessments, and that invitees are from a variety of backgrounds, frequently lacking formal training in dominant science methodologies, they are perhaps not well-prepared to contribute to a conventional scientific peer review. In contrast, they are best positioned to comment and critique from a place of traditional/experiential knowledge (harvesters) or from the values or priorities of the rights/stakeholders they represent. However, these meetings are not intended as opportunities for the contribution of new information from diverse knowledge types. Said another way, CSAS meetings do not serve as a time for new and diverse information and knowledge, but rather as a time for previously-conducted research, much of it done by DFO, to be peer-reviewed.

The presence and abundance of academic stakeholders, ostensibly a group having less vested interests than government scientists, were notably lacking at stock assessment meetings, and this represents a straight-forward opportunity to strengthen scientific peer review processes. The close "matching up" of science advice to feed into management objectives might be efficient from a governance perspective, but incorporating broader scientific expertise and perspective at the peer review stage could ensure that additional relevant information and issues are not overlooked (Soomai 2017a). It is possible that academics are invited to attend such meetings and do not always choose to take part, but there is evidence that (particularly early-career) researchers are keen to work on policy-relevant science, but may encounter barriers to do so (Andrews et al. 2020, Filyushkina et al. 2022). Atlantic halibut (Gulf) was a notable exception to this pattern, likely stemming from the rich research partnerships established between DFO Quebec and local academic institutions, with professors and graduate students conducting research on the species. Increasing invitations to academics, or representatives from NGOs and other agencies or networks responsible for conducting scientific research, may allow for both strengthened community engagement with educational institutions and more robust peer review of DFO science from those trained in dominant scientific methodologies.

2.4.3 Briefing notes: consolidating advice for decision makers

Contents of briefing notes provide additional insights into the way science advice is combined with additional types of information and influence to lead to a fisheries management decision such as setting a TAC, as explored here. The majority of stakeholder content in these notes is derived from fishing association or "industry" comments or contributions. These pertain directly to opinions about various TAC or management schemes, and thus do not fully capture the experiential knowledge of the harvesters which might effectively inform decisions, although I acknowledge these might be captured indirectly via contributions to requests for science advice not evaluated here.

It is important, here, to highlight once again that referencing fish harvesters as "industry" is inconsistent with the spirit of the *Fisheries Act* considerations, in which "community" is listed. This bias towards "industry" perspectives in the briefing notes reviewed here may be a result of the case study involving a high-value commercial species in the "Healthy" zone, and therefore of less conservation importance to other community groups in attendance at advisory committee meetings, such as NGOs. However, if the knowledge of "communities" i.e., entire coastal communities, are eligible to be considered, perhaps stakeholders from non-commercial fisheries, other ocean users, etc could be included in fisheries management processes, particularly given the public nature of fisheries resources (Berkes and Nayak 2018). These considerations are encapsulated in the move towards ecosystem-based approaches underway, and more specifically within the realm of marine spatial planning (Pomeroy and Douvere 2008).

2.4.4 Addressing challenges

Rights/stakeholders are only able to directly inform a few *Fisheries Act* considerations and most of the considerations do not have robust protocols in place to facilitate information-gathering to support evidence-based decision-making based on them at all. While mapping all possible information pathways for all considerations is beyond the scope of this particular study, to date, various frameworks for how to address the multiple dimensions of fisheries management have been proposed. For example, work has been done to explore to what extent ecological assessments can or should be conducted separately from or concurrently with social, economic, or institutional assessments and on what scale these assessments should take place (i.e., with respect to strategic versus operational cycles; Rindorf et al. 2017).

Questions remain about the extent to which CSAS, or an analogous process, could properly address the *Fisheries Act* "Decision-Making Considerations" beyond the ecological dimension that is the current focus. The 'science' involved in the current science advising system has thus far been confined largely to the natural sciences, with a focus on biology and population dynamics (Curran et al. 2012), but the sciences need not be so narrowly defined, particular in light of issues surrounding "post-normal science" (Funtowicz and Ravetz 1993). In addition to biological stock assessments, comprehensive 'assessments' could be conducted by social scientists with expertise in topics such as economics, sociology, anthropology, geography, political science, history, and psychology, and informed by applied discipline such as law, education, communication studies, and development studies (Bennett 2019). Indeed, DFO has recently begun to expand its social science capacity in Atlantic Canada, most notably within the lobster research team in the Maritimes region, given the socioeconomic significance and potential climate vulnerability of these stocks (Greenan et al. 2019). At the same time, one must be aware of the limitations of such methodologies as a panacea for the 'wicked problems' involved in fisheries (e.g., Parlee et al., 2021).

Furthermore, some of these "social, economic, and cultural" considerations (per the *Fisheries Act*) could also be informed directly by rights/stakeholders based on their lived experience and local knowledge. However, Slocombe (1993, p. 619, cited within Bundy et al. 2-21) articulates that "Gaining this knowledge requires using information and methods more familiar to community development, social impact assessment, and historical and ethnographic researchers and practitioners than to environmental planners and ecologists." Given the relatively limited number of in-house DFO personnel with expertise in these subject areas relative to the natural sciences, this is another area in which enhanced engagement with academic researchers would be helpful (Paul and Stephenson 2020). Indeed, a steering committee (of which one of the authors is a member) dedicated to exploring options for the use of social sciences in fisheries management has been established between DFO and the academic organization, Ocean Frontier Institute[32]. An example of this in another jurisdiction is the Strategic Initiative on the Human Dimension developed by the International Council on Exploration of the Seas (ICES)[33].

There remain concerns about how to conduct peer review for information/knowledge from any or all of these possible sources. Currently, peer review processes are focused on scientific peer review of biological and ecological research by DFO scientists in conjunction with rights/stakeholders who may or may not be trained in dominant science, but who also have relatively limited opportunities to contribute new insights from their valuable traditional or experiential knowledge. This has potential implications for both the credibility of the scientific product resulting from the peer review process, and the perceived credibility of ATK, TEK, and other experiential knowledge forms. For example, interestingly, Kadykalo et al. (2021) found that many managers believed local knowledge held by stakeholders was used for lobbying, and thus it tended to be weighted more heavily when it was aligned with management objectives and was considered confrontational if it conflicted. While an 'extended peer review community' is recommended in processes such as fisheries management, where uncertainty is high and there are 'high stakes' decisions (Funtowicz and Ravetz 1993), I am concerned that current processes of engaging rights/stakeholders in peer review are more performative in the name of inclusion and transparency, rather than truly effective in producing a high-quality, holistic evidence base. Indeed, Soomai (2017a) identified this type of "consultation-peer review" as a process which increases dialogue and legitimacy of the information produced, while simultaneously preventing rigorous review. It is certainly important to

[32] https://oceanfrontierinstitute.com/

[33] https://www.ices.dk/community/groups/Pages/SIHD.aspx#:~:text=SIHD%20is%20a%20network%20of,humanities%20into%20the%20organization's%20work

allow for ‘extended review’ opportunities in order to address public concerns about scientific uncertainty and facilitate understanding of risks involved in decision-making, particularly given that the fishing industry makes substantial financial investments in DFO scientific survey capacity (Soomai 2017a, 2017b). However, I propose that peer review streams within shared knowledge systems should also be prioritized (i.e., review by peers who can effectively assess the credibility, legitimacy, and saliency of the information presented (Cash et al. 2003, Tengö et al. 2017, Lemieux et al. 2018, Nguyen et al. 2019, Wheeler and Root-Bernstein 2020), for both scientific information generated and experiential or traditional knowledge engaged (e.g., via a form of cultural consensus modelling).

Furthermore, limitations on holistic data/information/knowledge availability limits scenario-development for evaluation by rights/stakeholders. Currently, based on what is summarized in briefing notes, in additional to author experience attending Advisory Committee meetings for some stocks, participants appear to largely be asked to weigh in on possible fishing levels, with consequential stock projections, without accompanying information on resulting socio-economic outcomes. Barriers remain to true knowledge sharing when rights/stakeholders are forced to advocate for their livelihoods amid uncertainty about socioeconomic impacts – with potential concerns that any given comment they share might lead to a decision with poor outcomes for themselves or their communities. Loring et al. (2021) explored extensively how stakeholders are forced to wield data they possess “in an attempt to justify their standing as citizens with legitimate needs and values and concerns.” Similarly, there is also the remaining question of power dynamics at peer review or decision-making tables, which is a topic of utmost importance, although beyond the scope of our study. Ultimately, decision-making power remains held by the Minister, who can make a decision at their own discretion, and while decision-makers appear to usually follow advice summarized by DFO staff, stemming from the outputs of advising processes, this structure maintains a top-down, authoritarian arrangement. Addressing this would require a move towards co-management (e.g., partnership with Haida Nation; Jones et al. 2010) to change the interpersonal dynamic and share power among rightsholders and stakeholders (Linke and Bruckmeier 2015).

2.5 Conclusion

Holistic and participatory approaches to achieving sustainable fisheries (Stephenson et al. 2019, 2021), within an evolving ecosystem-based management paradigm (Link et al. 2011), and grounded in the precautionary approach (Winter and Hutchings 2020), require new and different kinds of data inputs, and the interweaving of diverse knowledge systems. The present study represents a step towards mapping information and knowledge contributions from rightsholders and stakeholders to identify best practices and highlight potential opportunities moving forward. I found that academic researchers could be better engaged to assist with peer review of empirical data; there is a need to offer more engagement with traditional and experiential knowledge within venues where it can be effectively mobilized; and continued work towards true "Nation to Nation" relationships with Indigenous communities is required. Embedded within institutional priorities, this information/knowledge seascape and the sociocultural context in which it is created will form the base from which science advising and decision-making will move forward under the modernized Canadian *Fisheries Act*. In this progression, the role of rights/stakeholders is evolving, and must evolve, to ensure both a high-quality evidentiary basis for decision-making and inclusive and transparent management processes.

CHAPTER 3 – Exploring catch patterns in the data-deficient recreational mackerel fishery

3.1 Introduction

Fisheries management requires the consideration of all forms of removal from a fish population, including commercial, recreational, and subsistence fisheries, as well as natural mortality. Generally, the focus for data collection informing management tends to be on commercial fisheries where there are more likely to be policy mandates to monitor harvested species (Griffiths and Fay 2015). Recreational and subsistence fisheries, on the other hand, are more frequently under-reported (MacKenzie and Cox 2013, Radford et al. 2018, Smallwood and Ryan 2020) and therefore less likely to be both incorporated in stock assessment models and considered in fisheries management decision-making and assessment of trade-offs (Post et al. 2002, Cooke and Cowx 2004, Radford et al. 2018, Potts et al. 2020). While some recreational fisheries have data collection protocols in place, e.g., creel surveys, these tend to be limited in scope, participation/compliance tends to be incomplete, and they tend to focus on certain high-value sport fisheries (Carlander et al. 1953, Bernard et al. 1998, Brownscombe et al. 2019). Furthermore, there tends to be little-to-no dedicated data collection for less economically valued recreational fisheries, despite global understanding that recreational fisheries have social and food provisioning importance (Arlinghaus and Cooke 2008, Tufts et al. 2015, Arlinghaus et al. 2019, Potts et al. 2020). Such monitoring may be perceived as too challenging or costly, less of a priority (e.g., if the fishery has no clear and substantial economic value), or less urgent (e.g., if the stakeholders involved in the fishery do not have the opportunity to engage with management authorities to express their concerns) (e.g., Griffiths and Fay 2015).

Atlantic mackerel (*Scomber scombrus*; known in Mi'kmaq as Amalamaq) is one species with an active recreational fishery in eastern Canada, a region which encompasses traditional and unceded territory of the Mi'kmaq, Wolastoqey, Peskotomuhkati, and Beothuk. This mackerel stock comprises the northern contingent of the northwest Atlantic population (Gíslason et al. 2020, Gray Redding et al. 2020). Mackerel is a forage fish, i.e., an abundant, schooling fish that serves as the prey of larger animals, including seabirds, marine mammals, other fish, and humans (Studholme et al. 1999, Guénette et al. 2014, Pikitch et al. 2014, Nissar and Bakhtiyar 2022). Forage fish like mackerel occupy an essential ecosystem niche, sometimes described as a "wasp waist" position, whereby they exert both top-down control on zooplankton and bottom-up control on higher trophic level predators (Cury et al. 2000, Bakun 2006). Atlantic mackerel also hold important socioeconomic and cultural significance as a species harvested by Indigenous groups, caught commercially, used as bait in high-value fisheries (McLean 2022), and targeted by recreational anglers across the region (Brushett et al. 2021, Denny et al. 2020, Hamelin et al. 2022, DFO 2023a). The recreational fishery, in particular, is both data deficient and has become the subject of a great deal of scrutiny in recent years.

Owing to both overexploitation and possible ecosystem and climate changes, the northern contingent Atlantic mackerel stock has appeared to be at record low levels for nearly a decade (DFO 2023a), resulting in the closure of both the commercial and bait fisheries in Canada as of spring 2022[34]. As a result, aside from Indigenous harvest, recreational anglers remain the only fishers on the water targeting this species, yet despite centuries of cultural significance, there is no licencing (to keep track of the number of harvesters) or data collection (estimate of catch) from the sector. The stock assessment model has thus far been

[34] https://www.dfo-mpo.gc.ca/fisheries-peches/decisions/fm-2022-gp/atl-34-eng.html#:~:text=Fisheries%20and%20Oceans%20Canada%20(DFO,ceremonial%20fisheries%20will%20remain%20open

primarily fitted to data stemming from the total egg production (TEP) index from an annual egg survey in spawning areas in the Gulf of St. Lawrence, declared total landings (commercial), and catch-at-age compositions (Van Beveren et al. 2020). Catch bias stemming from missing recreational values was first recognized in the mackerel stock assessment model in 2016 (Van Beveren 2019).

Recreational catch of Atlantic mackerel in the region drew attention around that time because angling was purported to be a means by which some commercial harvesters obtained bait fish without a licence (Van Beveren 2017). There had been restrictions on minimum retention size (**Table 3.1**), including for recreational harvesters – a threshold generally set based on the estimated L50 for mackerel (i.e., the length at which 50% of females have reached reproductive size, and thus a proxy for fish that have spawned). However, since 2021, in addition to a minimum retention size of 268 mm, anglers must now also restrict themselves to a bag limit of 20 fish per person, maximum 5 lines and 6 hooks/line, and may only fish during the season from April 1 to December 31[35]. While these more restrictive regulations partially closed the bait loophole, there remains a broader interest in quantifying the population-level impacts of recreational angling. Recent studies recommend the collection of data on catch per unit effort and fish handling practices, as such fishery-dependent data could yield insights on the population in the absence of substantial commercial landings data (Hamelin et al. 2022). However, due to lack of institutional priority, systematic data collection in the recreational mackerel fishery has not taken place, made difficult by a lack of licensing through which to establish a database of anglers, and probably for practical reasons stemming from the large-scale, diffuse nature of the activity (Sutinen and Johnston 2003, Hyder et al. 2018).

[35] https://www.dfo-mpo.gc.ca/fisheries-peches/recreational-recreative/maritimes/pelag-eng.html

Table 3.1: History of recreational restrictions for Atlantic mackerel

Year	Size limit	Additional regulations
Pre-2016	250 mm	
2016-2018	263 mm / 10.3”	
2019-present	268 mm / 10.55”	
2021-present	268 mm / 10.55”	Winter closure, gear limits, bag limit (max 20 fish / person)

The present study set out to test ways to collect data on operational aspects of recreational mackerel fishing in light of the significant data deficiencies in the sector. Despite logistical challenges with collecting data, mackerel can be caught from a wide range of fishing spots, including wharfs and beaches in rural to urban communities, making it highly accessible and thus a good candidate for a form of dockside monitoring (Hamelin et al. 2022). Building off previous work done in Halifax Regional Municipality (HRM; Brushett et al. 2021), a systematic data collection protocol was developed to quantify fishing activity at selected preferred fishing locations to explore how many fish are caught and/or discarded. My goal was to begin to document patterns in catch of mackerel in the recreational fishery in this HRM case study, as a first step towards envisioning a region-wide assessment of the recreational mackerel sector

While dockside observations can offer an efficient catch sample across a wide area, the data encompassed a single season. A complementary approach involves collecting data more opportunistically via contributions of fishers and other coastal residents or visitors. For example, there have been a variety of initiatives recently to promote community-driven fisheries data collection (Venturelli et al. 2017, Roos and Longo 2021), including the Virginia Game Fish Tagging Program[36], Grunion Greeters[37], OceanEYEs[38], Florida Horseshoe Crab Watch[39],

[36]https://mrc.virginia.gov/vswft/vsft2.shtm#:~:text=Anglers%20participating%20in%20the%20tagging,to%20the%20program's%20top%20taggers
[37] http://grunion.pepperdine.edu/ggproject.htm

and FISHtory[40], among others in the United States (Oremland 2022), and e-Capelin (https://ecapelin.ca/) based in Newfoundland and Labrador. Such programs are not dependent on hiring observers and engage the angling community or nearby coastal community more directly in the process of monitoring and managing the fishery. Data collection may seem daunting or expensive to management authorities when fishing takes place in many places most of the time, and when there is no database through which to reach anglers. However, given that most people now carry data collection devices (i.e., cell phones), anglers and other coastal community members can easily share their observations. Indeed, recreational mackerel fishing is a topic of great interest on a variety of online platforms, and informal communities of practice (i.e., groups united by a common interest who work together to achieve individual and group goals; Lave and Wagner, 1991) have developed to facilitate information-sharing among anglers, mostly notably in fishing-oriented Facebook groups, website forums (e.g., www.novascotiafishing.com), and applications such as FishBrain (Hamelin et al. 2022). The result is an enormous wealth of 'citizen science', 'community science', or 'crowd-sourced' data (Eitzel et al. 2017).

While many studies attempt to extract and consolidate crowd-sourced records from a variety of users over a period or within a place of interest, there are some concerns related to this approach. First, there are a great many analytical challenges associated with temporally and spatially patchy data (e.g., Brick et al. 2022; Johnston et al. 2022). Second, there is the need to carefully consider research ethics in collecting and using data which were originally submitted to an app or social media site for non-research purposes (Monkman et al. 2018). Instead, to engage with fishing community-derived data, I established a relationship with one regular data contributor to a fishing website forum who

[38] https://www.zooniverse.org/projects/benjamin-dot-richards/oceaneyes
[39] https://myfwc.com/research/saltwater/crustaceans/horseshoe-crabs/citizen-watch/
[40] https://www.zooniverse.org/projects/safmcadmin/fishstory

shared the output of his data collection activities. From this, I was able to derive high-resolution insights into an avid fisher's practice over a 10-year period to give interannual context to accompany the single season of data collected by our research team from regular dockside visits.

Here, using dockside observations and angler-collected data, I a) describe trends in mackerel fishing activity during a 2021 dockside field season, and b) explore interannual trends in mackerel catch between 2012-2022 recorded by an angler fishing by vessel. In doing so, I was able to map out the many logistical challenges that will need to be overcome to do a rigorous evaluation of the recreational sector worthy of inclusion in a stock assessment model.

3.2 Methods

3.2.1 Dockside observations

Five well-known mackerel fishing sites in Halifax Regional Municipality (Kjipuktuk) were selected for standardized field monitoring (**Figure 3.1**): Fisherman's Cove, Eastern Passage; Bedford Wharf, Mill Cove, Bedford; the downtown Halifax waterfront boardwalk; 'The Dingle', Sir Sandford Fleming Park, Halifax; and Bay Lookout Provincial Park, Boutiliers Point. These locations represented a continuum from rural (Boutiliers Point) to suburban (Eastern Passage, Bedford, The Dingle) to urban (Halifax waterfront) environments and were selected based on observed/reported frequency of use and accessibility from downtown Halifax, the population centre of the region. Fishing took place off public wharf infrastructure at all sites except for Eastern Passage, where fishing occurred at the water's edge at a beach. In locations where it was logistically difficult to monitor the entire fishing location (e.g., Eastern Passage, Halifax waterfront boardwalk), a designated length of wharf or shoreline was selected for standardized monitoring. Although most angling literature focuses on rural or peri-urban environments (Pitchon and Norman 2012, Quimby et al. 2020, Marjadi et al. 2021), this fishery is just as lively in relatively dense urban settings (Hamelin et al. 2022) and thus I believe served as an appropriate case study to evaluate common angling behaviours and outcomes.

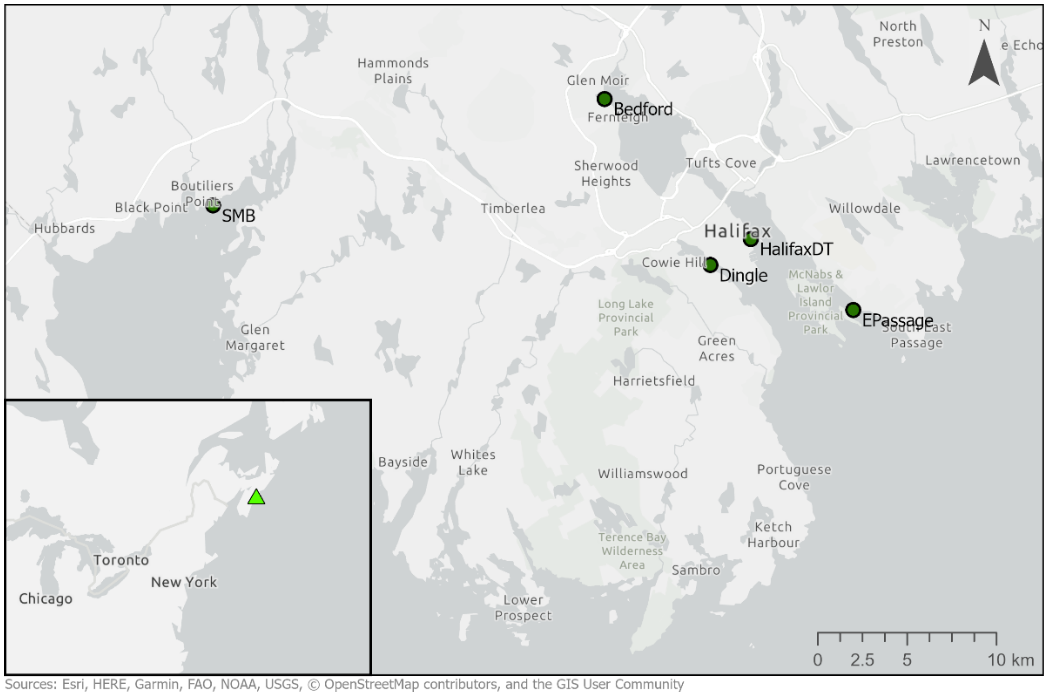

Figure 3.1: Map of Atlantic mackerel (Amalamaq, *Scomber scombrus*) recreational fishing sites visited as part of a dockside monitoring study in Halifax Regional Municipality / Kjipuktuk. EPassage indicates a beach fishing location at Fisherman's Cove, Eastern Passage; Bedford indicates Bedford Wharf, Mill Cove, Bedford; Dingle indicates 'The Dingle', Sir Sandford Fleming Park, Halifax; SMB represents Bay Lookout Provincial Park, Boutiliers Point.

Each site was visited once per week on a consistent day of the week (i.e., Halifax downtown on Mondays; The Dingle on Tuesdays; Bedford on Wednesdays; Eastern Passage on Thursdays; Boutilers Point on Fridays), from June 14 – September 24, 2021, which corresponds approximately to the preferred fishing season (albeit slightly truncated owing to waning daylight hours), as identified by mackerel fishers in the region (Brushett et al. 2021, Hamelin et al. 2022). This also aligns with the limited information I have about mackerel spatial distribution in the region which indicates that, in response to energetic constraints, the species moves north from mid-Atlantic waters into Canadian waters in the spring to spawn before returning to warmer waters in late fall (DFO 2023a, dos Santos Schmidt et al. 2023). During each site visit, a non-participant observational study was conducted during a 1-hr research period (18:00 – 19:00, local time, observed to be a popular fishing time), whereby the number of active anglers, the number of mackerel caught by each angler, and the number of mackerel discarded by each angler were noted throughout the hour.

3.2.2 Harvester-collected data

An avid angler, Gary Duchesne, has kept a detailed record of his mackerel angling practice over a ten-year period, from 2012-2022, making note of fish catch, as well as operational and environmental correlates, on near-daily fishing trips by personal outboard motor boat throughout Halifax Harbour, approximately corresponding to sites between Eastern Passage and The Dingle noted here. These data were shared with the research team in the form of a spreadsheet. Given that Gary was not always fishing alone, it was necessary to calculate landings per angler as noted, and thus data are reported here per person, where the person was either Gary or in some cases a guest on board.

3.2.3 Analysis

R Statistical Computing Software (R Core Team 2023; https://www.r-project.org/) was used to visualize dockside monitoring data, with a LOESS (locally-estimated scatterplot smoother) approach to allow for the examination of key trends over the course of the 2021 fishing season. Angler-collected data was also visualized in R in order to examine key operational aspects of recreational fishing interannually over a ten-year period, with consideration for time periods defined by different sets of management regulations.

3.3 Results

3.3.1 Summary statistics – Dockside observations

Investigating number of fishers over time throughout the season, I found a rapid increase in number of anglers fishing between the start of the season in mid-June and the peak in angling activity mid-August, with a more gradual decline in number of anglers later into the fall season (**Figure 3.2a**). There was a slight increase in total mackerel caught in an observation period from the start of the season to early July with a possible peak around late August / early September, but large numbers of 0 catch outcomes resulted in difficulty determining meaningful trends over time (**Figure 3.2b**). Using maximum catch by a given angler was an analytical approach that was explored to attempt to control for angler skill, a factor which undoubtedly results in varying (e.g., large numbers of 0 catch) yields (**Figure 3.2c**). Maximum catch allows for the visualization of the most someone was able to catch during an observation period and thus can offer insight into what it was possible to catch. Maximum catch reveals a small peak around early August, perhaps indicating when catch is most likely, as opposed to when anglers prefer to be outside fishing.

Interestingly, a pronounced bimodal trend was visible when investigating the proportion of mackerel retained by anglers per observation period, showing two periods in 1) late July / early August and 2) early September when anglers kept virtually all of their catch (**Figure 3.2d**). Thus there appear to be two key peaks or pulses during the season when larger fish were present (assuming discards are primarily undersized fish, resulting from the minimum retention size regulation). Alternatively, this period could be associated with higher levels of voluntary catch and release regardless of size, but data on angler preference for retention or release were not collected. By all metrics, large numbers of anglers neither caught nor retained a single fish during the observation period. Retention numbers were generally well below the 20 fish per person bag limit.

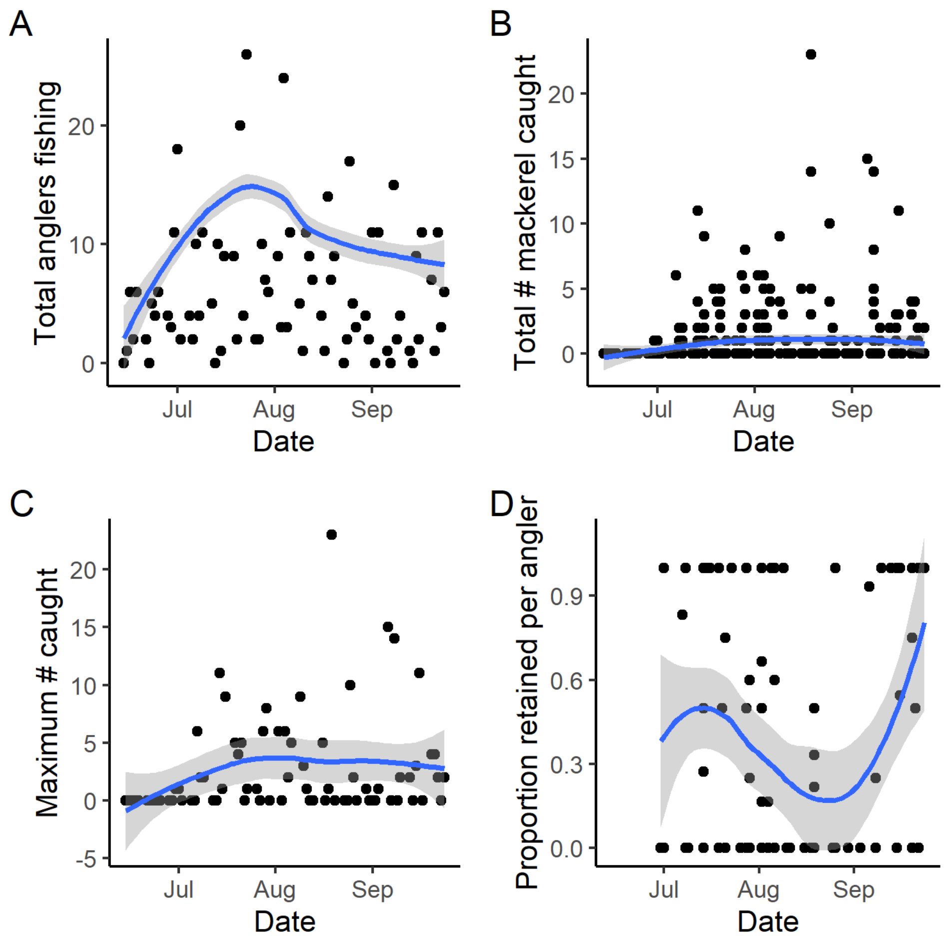

Figure 3.2: A) Number of recreational mackerel anglers fishing per sampling site per 1-h observation period over time, B) Number of mackerel caught by anglers in a 1-h observation period over time, C) Maximum number of Atlantic mackerel caught by an angler per 1-hr observation period over time, D) Proportion of Atlantic mackerel caught and retained by anglers as opposed to discarded over time

3.3.2 Patterns on longer time scales – angler data

Given limited notes on discards early in the time series, relative patterns in landings are reported here as opposed to total catch. There is a slight indication that Gary landed higher numbers of mackerel in past years, and fewer mackerel in recent years, but generally there is high variability in catch even for such an experienced angler able to pursue schools of fish by vessel (**Figure 3.3a**). Notably, 2015 and 2017 appeared to be anomalous years with higher than usual retention of mackerel. Retention in 2021 and 2022 was limited by the 20 fish per person regulation. Note that these data represent mackerel retained per angler, for consistency in effort with our dockside monitoring data, as it was sometimes indicated that Gary had guests on board fishing with him. For Gary, 2021 was a much lower than typical year, owing to the bag limit in place, and thus our estimate of regional mackerel landings based on 2021 should be considered a minimum estimate relative to past years.

Gary's data depicts a remarkably consistent periodicity in the fishing season year-to-year ranging from June to October, notably extending about a month later than our field observation season. The highest numbers of mackerel were landed in mid-to-late summer (~ early August) and fall (**Figure 3.3b**), which is approximately in line with the bimodal pulses in landings observed via our dockside monitoring in 2021. Notably, there appear to be high levels of catch in the fall, suggesting that trends observed by the field observation team in September are truncated by our survey effort as opposed to angler behaviour or fish presence.

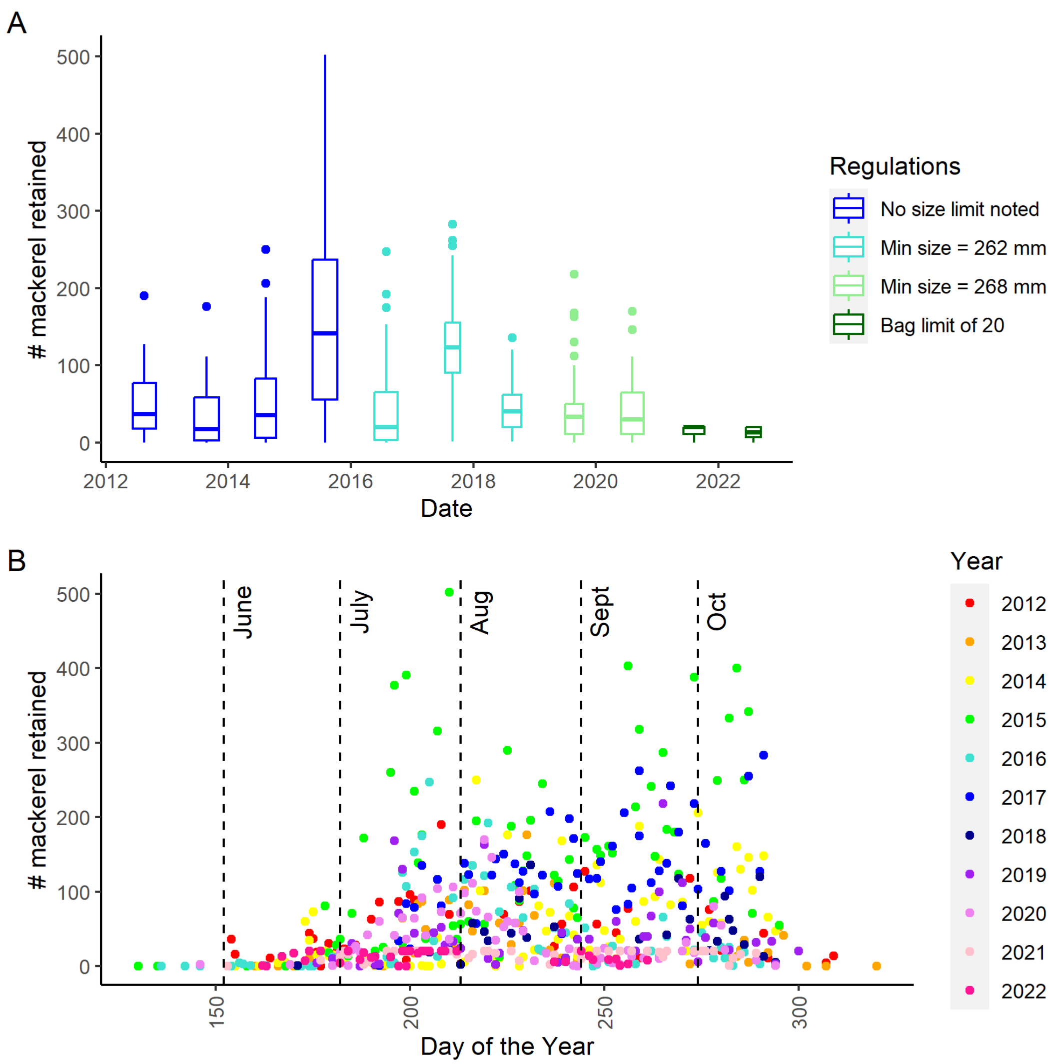

Figure 3.3: A) Boxplot of mackerel landed per angler per fishing day in a given year, where the box represents the interquartile range, the horizontal line indicates the median, B) Number of mackerel landed per angler per fishing day over the course of a season from 2012-2022

3.4. Discussion

3.4.1 Patterns in mackerel catch and landings

Broadly speaking, it is believed that mackerel arrive in Atlantic Canadian waters to spawn in the Gulf of St. Lawrence in June / July, and then depart to forage throughout Atlantic Canada, eventually making their way offshore (Cape Island) and to southern New England to winter (at which point there is mixing with the southern contingent which spawns in mid-Atlantic waters off the United States) (D'Amours and Castanguay 1992, DFO 2023a). I have documented a recreational fishing season in HRM which operates between late June and October, generally aligned with this migratory pattern. Furthermore, multiple peaks or pulses in patterns of mackerel catch over the course of a given season were noted, suggesting that migrating schools of reproductive-age fish are entering and departing the Halifax Harbour / St. Margaret's Bay region in waves throughout the fishing season. In recent years it appears these pulses align approximately with a period in late July/early August, and another in September, with some interannual variability in when the pulses occur.

It is unclear how the arrival of schools in this part of Nova Scotia compare with mackerel fishing access points in other eastern Canadian provinces, but mapping these local surges in both space and time can provide insights into drivers of fine-scale mackerel distribution, an ongoing data gap in Canadian mackerel science, which is of particular concern in light of ongoing climatic changes (Overholtz et al. 2011, Bruge et al. 2016, Mbaye et al. 2020, Chust et al. 2023). While there are limited data on environmental drivers of mackerel movements in the northwest Atlantic northern contingent described here, a wider literature is available documenting the influence of food availability and stock size / structure on distribution in the northeast Atlantic and for the northwest Atlantic southern contingent (Jansen and Gislason 2011, Overholtz et al. 2011, Jansen et al. 2012, Utne et al. 2012, Radlinkski et al. 2013, Van Der Kooij et al. 2016, Nikolioudakis et al. 2019).

With respect to year-to-year trends, there are two key years which stood out in Gary's data as anomalous in terms of high levels of retained fish: 2015 and 2017. It is notable that 2015 was the last year of a major recruitment event for the northern contingent of northwest Atlantic mackerel (DFO 2023a). Given that mackerel take a minimum of ~2 years to reach maturity, the 2017 surge likely reflects the arrival of adult fish from this event returning to Atlantic Canada as spawning adults (and large enough to be retained by anglers) for the first time. It is also notable that 2015 appears to be the last year before the minimum retention size of 262 mm was instated for recreational anglers, perhaps yielding a larger amount of retention before restrictions tightened.

3.4.2 Working towards estimating mackerel removals in the recreational sector

It should be noted that this is an early attempt at exploring recreational mackerel catch in one particular region (Halifax Regional Municipality), given that no data collection is conducted in the recreational fishery by management authorities, and it is impossible to conduct a conventional creel survey given the lack of licensing and therefore a lack of registry of anglers. Although low numbers of catch were typically observed per person by my team (much lower than the 20 fish / person bag limit suggests, and often zero), there is a very large number of possible anglers across the region. This large stakeholder group should thus be explicitly considered in future management processes. However, there are significant barriers that stand between small-scale exploratory studies such as the one conducted here, and a true evaluation of recreational removals appropriate for inclusion in a stock assessment model. Admittedly, roving surveys such as those conducted here may be prone to underestimating total harvest, while overestimating catch per unit effort. While I was thorough in data collection efforts, there remain numerous logistical challenges and data deficiencies for assessment efforts in this fishery and in scientific research for this species more broadly.

Dockside observations, such as those conducted here, have the potential to play at least a partial role in monitoring for this species. With limited staffing, large amounts of data were obtained, and with the selection of key fishing "indicator" sites, a diversity of fishing habits and outcomes were captured within a particular municipal region. However, this protocol was not without its challenges. There is the potential for human error –i.e., familiarity with local fish species, sharp eyes, and a keen attention to detail were all required. Anglers must also be fishing in a location where it is easy to see fish caught, discarded, and retained. Furthermore, a sense of trust and comfort must be maintained such that anglers will behave normally and not hide their catch, which has been reported elsewhere (Brushett et al. 2021). While I do not have serious concerns about these issues in our study, given our non-confrontational, observational approach, I recognize that a more formalized program (e.g., interview-style surveys or surveys staffed by federal agents) might prompt wariness from anglers or avoidance of certain fishing sites. In any case, I believe these data represent a reasonable minimum estimate of catch and landings, and such point estimates are often worthwhile in data-limited scenarios (Sande et al. 2022).

While there are significant logistical challenges to overcome in dockside monitoring, ideally a study such as ours could expand to sample not only various sites on particular days, but various sites across multiple days at multiple times of the day, to fully capture both spatial and temporal variation in catch patterns. A set 1-hour observation period was selected based on rates at which anglers were observed coming and going within such a time period, however Brushett et al. (2021) found that a majority of anglers stated they fished for 2-3 hours and thus an expanded period of observation would have been preferable. Another limitation was related to standardizing effort: while I used the unit of “per angler” here, defined by one rod per person, different anglers may have had different numbers of hooks per rod, affecting likelihood of snaring a fish and therefore estimates of fishing effort. Nevertheless, survey effort conducted here gives us a starting point to understand how recreational anglers catch and discard mackerel in one region with an active fishing community across urban to rural sites.

However, in working towards a more comprehensive assessment of recreational mackerel removals for the entire northern contingent of mackerel, it is unclear whether the sites observed here in HRM are representative of all of Nova Scotia, much less all of eastern Canada, given that this complex and extensive coastline encompasses multiple bioregions and includes a wide range of sociocultural communities targeting a species that is migratory and thus has varying distributions over time. In a regional-scale assessment of mackerel fishing, selection of appropriate sampling sites and index anglers would need to be representative of the full scope of the geographic and human demographic diversity in eastern Canada. Furthermore, more refined estimates of the number of anglers in the region are also needed, given that rough estimates available are now >8 years old and such surveys are typically administered to licensed anglers, yielding limited relevant insights for unlicensed marine species such as mackerel (DFO 2015). Furthermore, while dockside observers and anglers alike can most easily quantify catch patterns in terms of numbers of fish, estimates of removal require units of biomass for use in stock assessment models, a conversion which requires the use of age distribution and weight-at-age data. Currently, these datasets have only been derived based on samples from the commercial fishery, which may or may not be directly applicable to the recreational sector. Ultimately, setting out a clear list of data gaps needing to be filled is an important step towards assessing potential impact of recreational fishing on the mackerel stock is light of recent declines.

While having any estimate of recreational removals can help inform stock assessment and other management efforts in a data-limited setting (Van Beveren et al. 2020), one must use caution in making conclusions about impacts of such fishing on the mackerel population more generally. Partly this is a result of the assumptions that must be made when working with a data-deficient system, which introduce uncertainty, as detailed below. However, partly this is also because mackerel are a forage fish characterised by schooling behaviour, and thus fishery-dependent data, such as the catch-per-unit-effort collected here, may not mirror population trends as closely as other species, a phenomenon known as hyperstability. This effect may be particularly heightened for data collected by Gary, who fishes from a vessel and therefore is more mobile to pursue schools, as opposed to waiting for fish to be in the vicinity of a given wharf. There is a large body of literature that suggests large schools can be formed and maintained by forage fish, despite declines in population, which would lead to higher than expected catchability relative to stock status (e.g., Jakobsson 1985, Winters and Wheeler 1985, Arreguín-Sánchez 1996, Poulsen and Holm 2007, Bertrand et al. 2008, Barange et al. 2009). Innovation in fishery-independent surveys, perhaps through other forms of collaborative science than the ones explored here, remain necessary.

It is notable that, compared to mackerel surveys conducted in the region by the Ecology Action Centre (Brushett et al. 2021), the proportion of retention I observed tended to be lower than their estimation of 61% of fish landed. This is likely owing to the tightening of mackerel regulations since their surveys were conducted, but also potentially due to the decline in the proportion of larger mackerel in the population over time (DFO 2023a). Proportion of catch discarded is perhaps the component of greatest management relevance in this fishery because release rates can impact total fishing mortality beyond known catch (Cooke and Schramm 2007, Ferter et al. 2013). Furthermore, choice of management tools has been known to directly impact retention rates. For example, gear specifications (e.g., mandated barbless or circle hooks; Cooke and Suski, 2004) or other effort controls can decrease discard rates. Other tools, such as decreasing bag limits or increasing size limits (which have both occurred in the Canadian recreational mackerel fishery recently), can increase discards (Ferter et al. 2013). Furthermore, this is an issue of concern among at least some members of the angling community, and thus there is high potential for successful collaboration with stakeholders to explore this issue (Hamelin et al. 2022).

Addressing key information gaps could guide research efforts on the implications of discards in the recreational mackerel fishery. First, the extent to which high discard rates result in a dramatic underestimation of fishing mortality depends on post-release survival of discards, particularly those which are undersized and therefore mandatory discards according to current regulations. While some research has been conducted on mackerel handling and discards in the commercial sector in Europe (Tenningen et al. 2021), no data are available to date on outcomes from recreational fishing. Best practices for catch and release fishing have been synthesized more generally (e.g., Cooke and Suski 2005; Brownscombe et al. 2017), but Atlantic mackerel differs from recreational species more commonly studied such as salmonids or freshwater species (e.g., Lennox et al. 2015; Van Leeuwen et al. 2020; Clarke et al. 2021). Namely, Atlantic mackerel is a marine, pelagic forage fish, and its family Scombridae is known to have unique metabolic physiology (Wegner 2011), which might result in unique vulnerabilities or adaptive capacity. Currently, mackerel are suspected to be particularly vulnerable to handling stress (Hamelin et al. 2022). Second, it is unclear the extent to which high recent discard rates are a function of changes in size distribution or an artifact of management changes. Crisafulli et al. (2023) recommend an intervention analysis with time series data to evaluate the impact of any management interventions. Such insights might assist mackerel anglers and managers with adopting best practices to optimize catch to be retained (e.g., to meet food needs; Hamelin et al. 2022), while minimizing unnecessary mortality.

3.4.3 Engaging local users and their data

In recreational fisheries where licensing exists, managers and scientists often have access to a registry of anglers who are obligated to participate in creel surveys as a mandatory condition of their fishing license, and thus can be 'sampled' using methods known to be optimally compatible with quantitative methods used by fisheries modellers. For example, in the Pacific Region in Canada, sport fishing license holders participate in iRec (Internet Recreational Effort and Catch reporting program; https://www.pac.dfo-mpo.gc.ca/fm-gp/rec/report-declarez-eng.html). However, such methods are not possible in a fishery such as the recreational mackerel fishery discussed here, given the lack of licensing and thus lack of straightforward access to the community of anglers. In cases such as these, it is necessary to turn to data collected opportunistically. For example, here I have shown that mackerel anglers have the potential to collect and contribute their own high-quality data, in the absence of a formal creel survey structure. This angler-derived data is a form of fisheries monitoring that might be considered more acceptable, transparent, and legitimate to the angler community, and nonetheless has the potential to have scientific credibility.

The role of digital sharing of fisheries data is already well-studied with respect to monitoring recreational fisheries (Venturelli et al. 2017, Holder et al. 2020, Lennox et al. 2022, Sbragaglia et al. 2022). Crowdsourcing of fisheries data online leads to the accumulation of a huge quantity of difficult-to-obtain data, representing a form of 'swarm intelligence' (i.e., collective wisdom of self-organized individuals) (Venturelli et al. 2017). At the same time, as demonstrated here, such data allow for the essential task of identifying 'knowledge keepers' like

Gary, since local ecological knowledge is not necessarily distributed equally within a community (Davis and Wagner 2003). Identifying candidate leaders or representatives within dispersed informal 'communities' (such as the group of mackerel anglers in Atlantic Canada) might otherwise be difficult. A few avid anglers may act as sentinels, sharing insights that would be most useful for studying population dynamics and distribution. Put another way, perhaps one does not need data from everyone, but rather a few key anglers – e.g., Gary. As an avid angler who fishes from a vessel, Gary was also able to offer unique insights into catch rates into fishing from a different platform than the anglers who were observed by our dockside monitoring team. It is nonetheless important to also recognize that all anglers of varying skill-levels and avidity can inform hypothesis development, data sampling protocols, and data interpretation, as well as insight into sociocultural context in assessing the fishery (e.g., Hamelin et al. 2022). Our intention here was not necessarily to test a form of creel survey, but rather to explore the wealth of insights offered by those self-motivated to conduct their own independent fisheries science.

In any case, our experience suggests that a potential key to ensure both high-quality data, and the trust and respect needed to build productive relationships between anglers and scientists, is to support fisher- or angler-led venues, where data collection systems are created, designed, and useful for fishers or anglers first. This means that, at the outset, they might not necessarily appear well-designed for data collection from the perspective of conventional scientists (within the realm of "dominant science", per Liboiron 2021). Instead, they are foremost a platform that is trusted and desirable for use by anglers. Thus the key step becomes less designing a research protocol, but building relationships to work together to use the data for mutually beneficial purposes. In engaging with stakeholders or rightsholders in such a manner, it may not be a question of 'bringing to the table' but rather 'going to the table' (assuming one has established the trust to be welcomed there).

At the same time, one must be careful to not reduce angler information-sharing to a data collection exercise. Fish harvesters are constantly identifying and addressing issues that emerge in the fishery more rapidly than management activities are conducted (Sbragaglia et al. 2023). Indeed, an analysis of social media content shared by anglers in a Facebook group based in South Africa identified the evolution of "pro-environmental" behaviour over time, including changes to catch-and-release and fish handling practices (Allison et al. 2023). This was not achieved via targeted intervention by scientists or managers, but rather was a natural progression that emerged through discussion and sharing within the group. Allowing some of these grassroots communities of practice to lead, rather than be subsumed within, current management practices might result in innovative approaches to both data collection and resource stewardship (Cowx et al. 2010, Holder et al. 2020). One can look to Ducks Unlimited as an example in another sector whereby resource users (i.e., hunters) have led the way in resource conservation (Reid et al. 2018).

3.5 Conclusion

In light of the relatively small removals of recreational catch estimated here relative to current bag limits, the argument may be made that assessing recreational fisheries is less important, less relevant to stock assessments, and not worth the survey effort. Boucquey (2017) explored potential conflict between prioritization of commercial versus recreational fishing, stemming from different meanings attributed to the concepts of value, waste, and public resources. Managing fisheries with recreational harvesters in mind requires considering objectives such as individual or community wellbeing, as opposed to current metrics focused on biological or economic yield (Ihde et al. 2011). Valuing recreational fishing requires consideration of the sector throughout the fishery assessment and allocation process, with resources dedicated accordingly.

In this sense, recreational fisheries, such as this one for Atlantic mackerel, are perhaps more like the small-scale fisheries sector and demand unique consideration to "close the harvest strategy gap" (Fowler et al. 2023). Notably, Atlantic mackerel is also an important species to Indigenous communities in Atlantic Canada (Denny et al. 2020). While outside the scope of this study, the consideration of how both recreational and (possible future) commercial or bait fishing access intersect with Indigenous rights to fish for mackerel will be a key question. Put another way, this time of closure and rebuilding allows time for reflection on equitable access to fisheries in line with various fishery objectives. While insights from different forms of knowledge, including those of fish harvesters, are acknowledged to able to provide insights that can inform population biology and ecology (Boldt et al. 2022), they have only garnered attention recently in the case of Atlantic mackerel in light of threats to and eventual closures of commercial and bait fisheries, suggesting they are perceived as 'last resort' data. Now it is essential to include any remaining fish harvesters left interacting with Atlantic mackerel in the assessment and decision-making process. I propose that fisher-led initiatives could be key to maintaining the crucial link between fish, people, and place that yields the knowledge and values which may be essential for the recovery of Atlantic mackerel.

CHAPTER 4 - "The people's fish": Sociocultural dimensions of recreational fishing for Atlantic mackerel in Nova Scotia

4.1 Introduction

The overarching goal of fisheries management is often stated simply as 'sustainability'. For some time, it has been acknowledged that fisheries represent complex socio-ecological systems (Charles 1994, 1995b, McLeod and Leslie 2009, Link et al. 2011, Fogarty 2014, Long et al. 2015), and thus sustainability can be understood to involve multiple dimensions including ecological, economic, social (including cultural), and institutional (or governance) pillars (De Young 1999; Stephenson et al. 2017; Foley et al. 2020). Indeed, these multiple components are often included in frameworks in support of ecosystem-based management (EBM), an approach many jurisdictions are in the process of formally adopting (Garcia and Charles 2007, Marasco et al. 2007, De Young et al. 2008, Long et al. 2015, DePiper et al. 2017). However, many fisheries assessments, including those in Canada, still focus largely on the biological or ecological and, to a lesser extent, economic components of the coastal and marine systems within which fisheries operate (Charles 1994, 1995a, Ommer et al. 2012, Urquhart et al. 2013, Stephenson et al. 2019, Paul and Stephenson 2020).

Reliance solely on population or bioeconomic assessments may result in fisheries management decisions that ignore important cultural and social objectives (Fowler et al. 2022). For example, core social objectives identified by the collaborative, multi-stakeholder Canadian Fisheries Research Network (Stephenson et al. 2019) included sustainable communities, health and well-being, and ethical fisheries. Socio-cultural benefits from fisheries may also be defined using an ecosystem services framework, with 'cultural services' comprising culture and amenity, recreation, aesthetics, and education and research (UNEP 2006, McLeod and Leslie 2009). So-called 'human dimensions' research is the key to capturing these aspects of fisheries, allowing for an understanding of human cognitions, behaviours, and relationships related to fishing and fisheries governance, and consequently the mapping of links and feedbacks between both the human and natural components of the system (De Young et al. 2008, Hunt et al. 2013).

Although human dimensions research has been taking place since the 1960s, and is on the rise in contemporary fisheries research (De Young et al. 2008, Bennett 2019), recreational fisheries are generally understudied compared to commercial sector fisheries (Brownscombe et al. 2019, Cooke et al. 2019, Holder et al. 2020). The Food and Agriculture Organization defines recreational fishers as those that do not rely on fishing to supply a necessary part of their diet or income (FAO 2012), and thus they fish for other benefits (e.g., cultural ecosystem services). There are several parallels between marine recreational fisheries and small-scale fisheries in the sense that they are often poorly defined, diverse in scope, and often not well represented in research and assessment procedures (Pita et al. 2020a). In any case, without assessment of the full breadth of human-fish interactions within these socio-ecological systems, it is unlikely it will be possible to achieve the goal of both sustainable ecological and human communities.

The Atlantic mackerel or Amalamaq (*Scomber scombrus*) fishery in Atlantic Canada operates in a complex socioeconomic seascape, encompassing the ancestral and unceded territory of the Mi'kmaq, Wolastoqey, Peskotomuhkati, and Beothuk who fished mackerel for millenia (Denny et al. 2020). Atlantic mackerel is a once-common forage fish that provides a critical intermediate link in the North Atlantic food web between small fish and invertebrates at lower trophic levels and top predators at higher trophic levels, including larger fish, birds, marine mammals, and humans (Department of Fisheries and Oceans 2007, Van Beveren et al. 2017a). While Atlantic mackerel are found throughout the North Atlantic, the Northern contingent of the western Atlantic population is found largely within Canadian waters (Gíslason et al., 2020; Moura et al., 2020; Van Beveren et al., 2020). Unfortunately, after significant population declines in recent years attributed to overexploitation, and possible ecosystem changes or climate change impacts, the Canadian Department of Fisheries and Oceans (DFO) has assessed mackerel in the 'critical' zone under the Sustainable Fisheries Framework, meaning that the stock is below the defined Limit Reference Point and requires conservation action to rebuild the population (DFO, 2021).

However, Canadian mackerel stock recovery has been complicated by the fact that there are a variety of fisheries that target this stock with differing objectives (**Figure 4.1**) (DFO, 2007; Van Beveren et al., 2017a). The species continues to hold significance to Indigenous groups such as the Mi'kmaq (Denny et al. 2020), who retain Aboriginal rights and title to fishery resources (Wiber and Milley 2007). Furthermore, there has been a commercial fishery harvesting mackerel for sale and export, supporting livelihoods across the region. There has also been a commercial bait fishery which harvests mackerel for use as bait in other commercial fisheries, including the multi-billion-dollar lobster or Jakej (*Homarus americanus*) industry (DFO 2022), and as bait for bluefin tuna sport fishing. Finally, there is a long history of a culturally significant recreational fishery throughout the region (Brushett et al. 2021), with mackerel representing the second most frequently caught recreational species in the provinces of Nova Scotia and Prince Edward Island (DFO 2015). Most recreational anglers fish for mackerel in coastal waters using a standard rod-and-reel fishing pole, typically with multiple hooks per line.

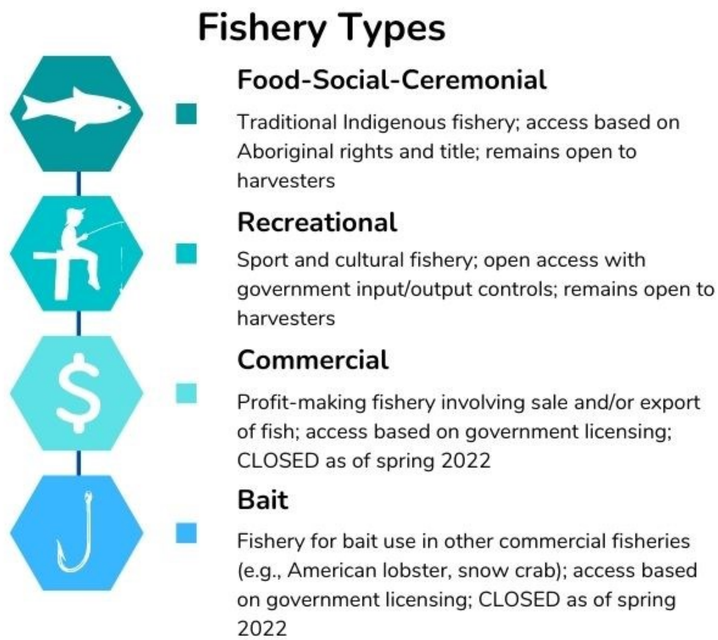

Figure 4.1: Summary of fishery types targeting Atlantic mackerel or Amalamaq (*Scomber scombrus*) in Atlantic Canada

To address the precarious state of Atlantic mackerel, a combination of conservation measures has been put in place in recent years, most significantly the closure of the commercial and bait fisheries in spring 2022 (Government of Canada 2022). Currently, FSC fisheries are allowed to continue uninterrupted, while recreational fishing is permitted with ongoing restrictions on the season, gear, minimum size, and number of fish able to be retained by recreational fishers[41]. There is neither a licensing requirement nor formal data collection (e.g., creel survey) for recreational mackerel fishing in the region, and thus it is challenging to know how many anglers are fishing and how many fish they catch.

[41] https://www.dfo-mpo.gc.ca/fisheries-peches/decisions/fm-2021-gp/atl-31-eng.html

Data collection in recreational fisheries is notoriously challenging (Griffiths et al. 2017, Hyder et al. 2020) and, for many recreational fisheries in North America, recreational fishing is viewed as a public good (i.e., open access) with less influence from managers on where and how often anglers fish (Cox et al. 2002, Daedlow et al. 2011, Hunt et al. 2021). Nevertheless, the recreational fishery now likely represents both the largest group of stakeholders interacting with Atlantic mackerel and the most valuable source of fishery-dependent data.

Human dimensions research on the recreational component of the mackerel fishery in eastern Canada has been much-needed, given that within fisheries management, recreational anglers are less frequently consulted than commercial fishers – likely due to difficulty in accessing individuals not represented by stakeholder associations, rather than a lack of willingness to participate (Hyder et al. 2020). Furthermore, while the number of recreational mackerel anglers in the region is presently unknown given the lack of licensing and data collection in the fishery, this community of under-engaged stakeholders might in fact be the most numerous, given the ubiquity of the activity in the region (Brushett et al. 2021), and the fact that globally, recreational anglers are considered significantly more numerous than commercial harvesters (Arlinghaus et al. 2019). Furthermore, there have been substantial economic, social, and cultural benefits from recreational fishing documented around the world (Cisneros-Montemayor and Sumaila 2010, McManus et al. 2011, Arlinghaus et al. 2015, 2019, Griffiths et al. 2017, Hyder et al. 2020, Pita et al. 2020b), and it remains unclear which of these might be most relevant to mackerel anglers in our region.

The present study – conducted one year before the current commercial closure - focused on exploring the sociocultural and operational aspects of the recreational mackerel fishery. Using a questionnaire, I asked 1) who fishes for Atlantic mackerel for recreational purposes, 2) how they fish (i.e., an assessment of common practices and behaviours), and crucially, 3) why they fish for Atlantic mackerel, in order to determine sociocultural benefits (e.g., cultural ecosystem services) and who in the fishing community is likely to benefit in different ways. Just as a commercial industry might be jeopardized, these recreational benefits equally stand to be lost if the Canadian mackerel stock continues to decline, although it can be difficult to assign value to recreational fishing when considering management options because of a lack of methods to integrate cultural value into the current assessment process. Furthermore, while the focus of recent media attention in eastern Canada has, understandably, been on what is lost when a commercial fishery is closed (e.g., FFAW, 2022), here I investigated the benefits that are retained when traditional and recreational fisheries maintain access to their target species.

4.2 Methods

4.2.1 Data collection

The study population comprised adults (18+) of all backgrounds who 1) self-identified as recreational mackerel anglers and who 2) fish in Nova Scotia, Canada **(Figure 4.2)**. Nova Scotia, a province known by the slogan "Canada's Ocean Playground" (Develop Nova Scotia, 2021), hosts a large number of recreational anglers, and has coastal access points in both rural areas and Halifax Regional Municipality (HRM; K'jipuktuk), the capital of the province and the largest urban area in Atlantic Canada. The province has a population of approximately 923 598[42], of which approximately 83% are 18 or older[43], with a median age of 45.5 years[44]. The population of the capital of HRM represents

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[42] https://www12.statcan.gc.ca/census-recensement/2016/dp-pd/hlt-fst/pd-pl/Comprehensive.cfm
[43] https://novascotia.ca/finance/stats.div/papers/demograf/demo4.htm
[44] https://www12.statcan.gc.ca/census-recensement/2016/dp-pd/prof/details/page.cfm?Lang=E&Geo1=PR&Code1=12&Geo2=PR&Code2=01&SearchText=Canada&SearchType=Begins&SearchPR=01&B1=All&type=0

approximately 48% of the provincial population[45]. The total number of recreational mackerel anglers within the province is unknown. A DFO report from 2015 estimates that there are 49 714 recreational anglers across all target species (freshwater and marine) in the province (DFO 2015). However, these data are at least 7 years out-of-date, and the survey yielding the 2015 report was distributed primarily to anglers in licensing databases, which might not cover groups who target mackerel.

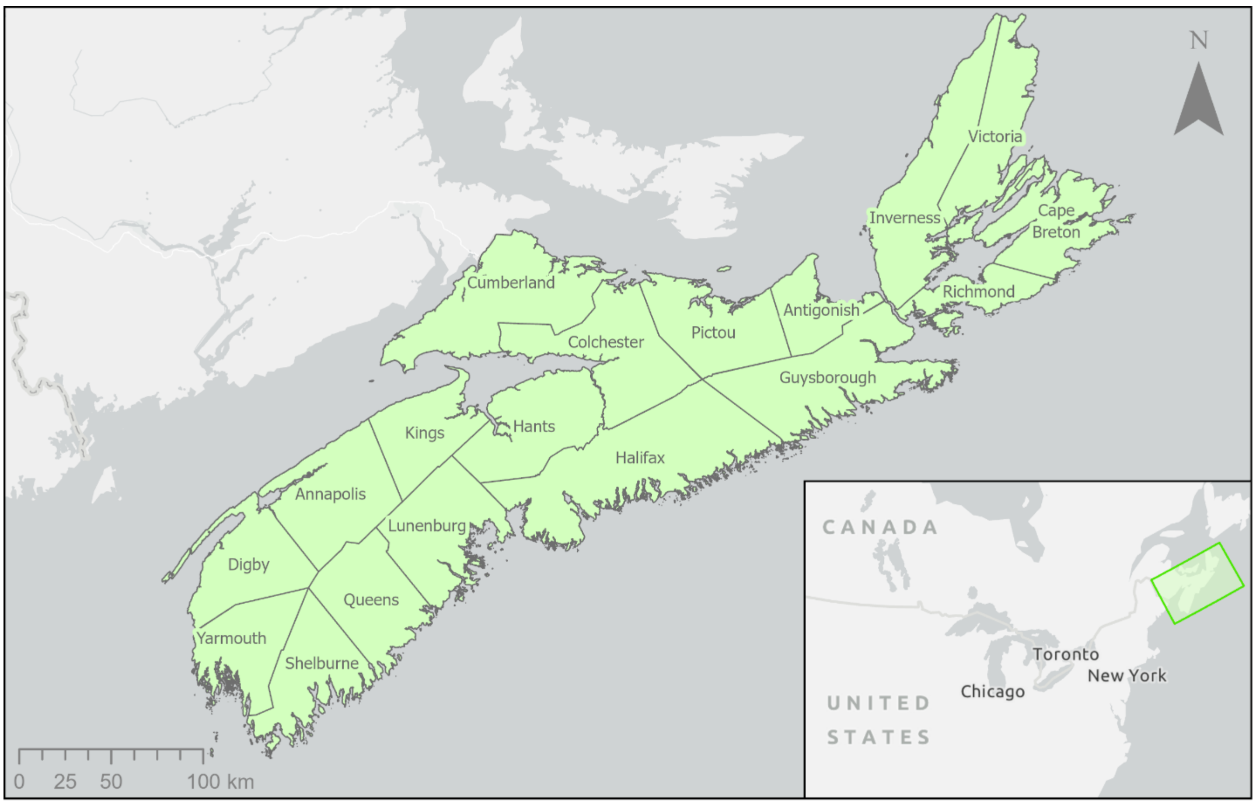

Figure 4.2: Map of Nova Scotia, the province in eastern Canada (located within the traditional and unceded territory of the Mi'kmaq and Wolastoqey) which compromised the geographic scope of recruitment for a research study on recreational mackerel fishing in the region. Solid lines delineate county borders within the province (Nova Scotia Geographic Data Directory, https://nsgi.novascotia.ca/gdd/).

[45] https://www12.statcan.gc.ca/census-recensement/2016/dp-pd/hlt-fst/pd-pl/Comprehensive.cfm

A voluntary questionnaire of 39 questions (**Appendix 1**) was administered online using password-protected Opinio software, which provided an anonymous web link to open the survey. A 'cookies' feature was used to ensure only one submission was received per participant. Ethical approval was obtained from the Dalhousie University Research Ethics Board (2021-5622) and the survey included an introduction page outlining the objectives, risks, and benefits of the research and requesting the consent of participants before proceeding to the questionnaire. Our research questionnaire was offered in English, as this is the primary language understood by all members of the research team, and is the most commonly spoken language in the study region. While there was no compensation offered for participation, the chance to win 1 of 5 $100 Mastercard gift cards via random draw was offered as an incentive. Contact information for prize winners and for respondents interested in receiving a copy of research results was disaggregated from survey data to maintain anonymity.

Participants were recruited by distributing information cards with a survey link during dockside visits to known recreational fishing locations in HRM and opportunistically at fishing sites elsewhere in the province. Additional information cards were distributed to libraries, community centres, and outdoor sports shops throughout HRM. Although the survey was conducted in English, to convey project objectives and recruit individuals from diverse populations, some of the project summary information on the recruitment card was translated into French, Arabic, Mandarin Chinese, Spanish, Korean, and Hindi, representing additional significant language groups in Nova Scotia[46]. While I attempted to work with colleagues and collaborators to translate materials into Mi'kmaq, I was unable to do so for this study. While this was unfortunate, given our project goals around equity and inclusion, I acknowledge that most Indigenous individuals in

[46] https://www12.statcan.gc.ca/census-recensement/2011/dp-pd/vc-rv/index.cfm?Lang=ENG&VIEW=D&CFORMAT=jpg&GEOCODE=12&TOPIC_ID=4

Nova Scotia speak English (Nova Scotia 2021), and thus it is unlikely this represented a language barrier.

The survey was shared online through social media accounts associated with this research project to increase geographic reach around the province. In addition, the link was posted on relevant local fishing social media groups (e.g., 'Mackerel and Squid Fishing Nova Scotia' on Facebook), and sent to relevant organizations for distribution (e.g., Fishermen and Scientists Research Society, Nova Scotia Federation of Hunters and Anglers) to invite anglers from elsewhere in Nova Scotia to respond. The survey was also distributed via university channels, including the email list servs for the Dalhousie Department of Biology and the Marine Affairs Program, and was featured on the 'Today at Dal' news page.

Although these opt-in recruitment methods meant participants were largely self-selecting, the combination of recruitment via social media and recruitment in-person allowed for both access to a broad range of participants around the province, in addition to more personalized invitations to those who might be less familiar with social technologies. Survey invitations and information cards encouraged participants to request a paper copy of the survey if preferred, but no such requests were made and all submissions were received through the online Opinio platform.

Survey responses were collected between Monday June 14 and Friday October 8, 2021, which approximately corresponds to the primary recreational mackerel fishing season in Nova Scotia, based on previous survey work (Brushett et al. 2021). The questionnaire (see **Appendix 1**) was divided into two sections: 1) Fishing Activity and 2) Demographics. Within the Fishing Activity section, a combination of multiple-choice (MC) and open-ended (OE) questions were used to identify: experience with fishing (MC), target species of interest (MC/OE), locations of fishing activity (MC), additional types of mackerel fishing conducted (MC), years of experience (MC), fishing season (MC), frequency of fishing activity (MC), observed changes to size or abundance of fish (MC), observed changes to fishing regulations (MC), sharing of fishing data (MC), reasons for fishing (OE), consumption of mackerel (MC), importance of mackerel as food (MC), value of mackerel in diet (MC), financial valuation of mackerel as a food source (OE), importance of fishing activity (MC), social context of fishing (MC), personal effects if fishing were no longer possible (OE), and additional comments or concerns (OE).

Within the Demographics section, multiple-choice questions were be used to identify the region in which the participant resides, identity as an immigrant or refugee, ethnic identity, level of English proficiency, languages other than English used, gender identity, LGBTQIA2S+ identity, age, disability status, education level, income, and employment status and sector. At the end of each section (i.e., after 'Fishing Activity' mid-way through; after 'Demographics' at the end of the survey), there were opportunities for respondents to share any additional thoughts or ideas not captured by the structured questions. Providing open-ended questions was important to ensure respondents had opportunities for self-expression and to facilitate the solicitation of concerns or perspectives from the community unanticipated by the research team.

4.2.2 Analysis

A mixed-methods approach was used to analyze questionnaire responses. For demographic data, summary statistics (frequency counts and proportions [%]) were generated using Opinio software. It should be noted that sample size varied among questions because responses were not mandatory, and respondents varied in the number of questions answered. Furthermore, some multiple-choice questions allowed the respondents to 'check all that apply', and thus in those cases the counts reported always represent the number of selections, not the number of respondents. These data were compared with similar data from Statistics Canada[47] or Nova Scotia Economics and Statistics[48] to characterize the angler community of respondents relative to the general population of the province.

For open-ended questions (e.g., reasons for fishing), an inductive qualitative thematic coding method was used. First, responses were read to identify keywords, which became a list of potential codes. Similar potential codes were then grouped into themes. Responses were read a second time and tagged with these themes to determine their prevalence. A response may have been associated with multiple themes if warranted. Coding was performed by the first author.

To quantify relationships between the reasons for fishing identified and various other demographic or behavioural characteristics, I developed a suite of Bayesian statistical models in PyMC (v4; www.pymc.io). Multiple reasons for fishing were often identified within a given response, leading to multinomial responses. As our objective was to summarize responses among groups, rather than pursue predictive modelling or causal inference, models were built for each covariate, using a Dirichlet multinomial data likelihood. Selected key covariates included 1) when a participant learned to fish (young / adult), 2) where a participant learned to fish (in Nova Scotia / elsewhere), 3) newcomer status (immigrant or refugee / born in Canada), 4) target species (target mackerel / other or no preference for target), 6) disability (disability identified / no disability identified), 6) fishing platform (wharf / beach or shoreline / boat), and 8) social context (alone / friends / family / kids). Models were evaluated for convergence

[47] https://www.statcan.gc.ca/en/start
[48] https://novascotia.ca/finance/statistics/

using traceplots and R-hat statistics (McElreath 2020), and full model code and outputs are available online (see https://gist.github.com/mamacneil/69680dd42be3c4174ae6f9759d7b6919).

4.3 Results

4.3.1 Demographics of Survey Respondents

There were 285 total responses received, with 215 (75.4%) fully completed surveys. About half of respondents (n=115, 51.6%) live in HRM, which is similar to, but may slightly overrepresent, the proportion of Nova Scotians who reside in HRM (48%)[49]. The next most numerous counties included nearby Lunenburg County on the south shore of Nova Scotia (n=22, 9.9%) and Cape Breton Regional Municipality (n=15, 6.7%), the largest community on Cape Breton Island, although rural Queens, Shelburne, Yarmouth, Annapolis, Kings, Hants, Colchester, Cumberland, Pictou, Antigonish, Guysborough, Richmond, Inverness, and Victoria counties were all represented **(Figure 4.2).** These results are largely consistent with the counties in which anglers said they fished, suggesting that while there is some intra-provincial travel to fishing spots (notably anglers from HRM leaving the urban setting to fish in more rural counties), most people tend to fish relatively close to where they live. A relatively large number of respondents (n=25, 11.4%) identified as newcomers to Canada (i.e., immigrants or refugees; nearly double the 6.1% of the provincial population comprising immigrants[50]). Furthermore, 14 respondents (5.9%) identified as Indigenous (on par with 5.7% of the provincial population that identifies as Indigenous[51]), suggesting that some people with Indigenous rights to fish (i.e.,

[49] https://www12.statcan.gc.ca/census-recensement/2016/dp-pd/hlt-fst/pd-pl/Comprehensive.cfm
[50] https://www12.statcan.gc.ca/census-recensement/2016/as-sa/fogs-spg/Facts-pr-eng.cfm?LANG=Eng&GK=PR&GC=12&TOPIC=7
[51] https://www12.statcan.gc.ca/census-recensement/2016/as-sa/fogs-spg/Facts-PR-Eng.cfm?TOPIC=9&LANG=Eng&GK=PR&GC=12

via FSC fishing) self-identify as recreational anglers. While the vast majority (n=186, 83.8%) of respondents were native English speakers, there were numerous French-speaking anglers (n=27), perhaps representing the province's long-standing Acadian population, in addition to smaller groups of speakers representing dozens of other languages.

With respect to gender identity, those who responded suggest that the fishing community is a largely male-dominated group, with 182 (82%) identifying as male. Additionally, 48 (24%) identified as having a disability, which was a slightly lower proportion than the provincial prevalence of 30%[52]. Physical (i.e., mobility, flexibility, pain) challenges were the most common disabilities identified by respondents. Only 3 of these individuals were off work due to their disability, while the others were either working or retired. Education levels were largely consistent with the general population of Nova Scotia[53], with 44 (19.7%) respondents identifying a high school diploma as the highest level achieved (versus 25.3% of the provincial population, the largest education category) and 44 (19.3%) respondents identifying a community college diploma (21.8% of the general population). Completion of an apprenticeship was slightly more prevalent among respondents (n=33, 14.8%) than the general population (9.9%), whereas the prevalence of having attained a university Bachelor's degree (n=36, 16.1%) was slightly below provincial metrics (20.8%), despite the fact that local university publication channels were one of the various methods used to promote the survey. The most common annual household income within the group was the $25 000-50 000 (CAD) band (n=49, 22.2%), which was below the median household income in NS (median income in 2020: $66 300, excluding zeros, for "economic families and persons not in economic families, per Statistics

[52] https://novascotia.ca/accessibility/prevalence/
[53] https://novascotia.ca/finance/statistics/news.asp?id=13362#:~:text=sex%20cohorts%20and-,HIGHEST%20LEVEL%20OF%20EDUCATION,Scotians%20reported%20a%20college%20diploma.

Canada[54]). The majority of respondents (n=121, 54.5 %) were employed full-time, with a substantial secondary group of retired individuals (n=44, 19.8%). There were 18 respondents (8.2%) who identified as working (or having worked) in the commercial fishery sector.

4.3.2 Benefits from Fishing

In asking why respondents fish recreationally for Atlantic mackerel, eight key themes emerged (ordered from highest to lowest probability of an angler choosing the reason): 1) food, 2) sport, 3) bait, 4) social connection, 5) time outdoors, 6) accessibility, 7) relaxation/mental health, and 8) tradition **(Table 4.1**). I found that fishing for food, sport, and bait were the most likely reasons to fish for mackerel (**Table 4.1**). Most respondents cited the taste and nutritional value (e.g., omega-3 fatty acids) of the fish as key reasons they eat mackerel as **food**. The respondents also explained that this fishing activity may contribute to their own food security (e.g., "Mackerel is a vital resource for our family, I try to stock up some to help get us through the winter"), provide food for pets (e.g., domestic cats), or be shared with friends, family, and especially elders in their community who enjoy eating mackerel. However, most identified that there was limited impact on their grocery budget or that the expenditures on gas and equipment negated any financial benefit of the value of the food. Individuals who fished for **sport** found the activity "fun", "challenging", "engaging", or found the 'thrill of the chase' satisfying (e.g., "I love the feeling of catching 3-4 on the line it's a great fight…"). Among anglers who aim to acquire **bait** to use in other fishing activities, most cited recreational striped bass (*Morone saxatilis*) fishing as the use of the bait, although others mentioned targeting sharks, groundfish

[54]https://www150.statcan.gc.ca/t1/tbl1/en/tv.action?pid=1110019101&pickMembers%5B0%5D=1.5&cubeTimeFrame.startYear=2016&cubeTimeFrame.endYear=2020&referencePeriods=20160101%2C20200101

(e.g., Atlantic cod), and one respondent even used it in bear hunting, with the bear meat caught serving as subsistence food for them.

Social connection was the next most likely reason for fishing, with respondents citing the great camaraderie that takes place while mackerel fishing, "bonding with friends and family", and the opportunity to meet people from different backgrounds, ages, and cultures. The motivation to get **outdoors** was another key benefit, i.e., "the enjoyment of being in nature" or "something to do while enjoying the sea". **Accessibility** of the fish and fishing activity was another reason respondents choose mackerel fishing, citing that they "are relatively easy to catch compared to other fish", require little gear, and are "youth friendly" (i.e., appropriate for teaching children to fish). **Relaxation** or mental health was identified as an additional reason for fishing (e.g., "It is a wonderful peaceful way of relaxing, love the solitude with nature."). **Tradition** was a theme that emerged from comments identifying mackerel fishing as a regular seasonal activity they anticipate, an activity they learned from their family growing up (e.g., "…it is an outdoor activity that I have enjoyed since I was a child. I was raised in a fishing family."), or as an activity to pass on to youth in their community. Crucially, most respondents identified multiple reasons for, and benefits derived from, recreational mackerel fishing.

Table 4.1: Prevalence of motivations for anglers fish for Atlantic mackerel or Amalamaq (*Scomber scombrus*) in Nova Scotia / Mi'kma'ki for recreational purposes. Values are posterior means and standard deviations (SD), with lower (HPD 3%) and upper (HPD %97) 94% uncertainty intervals, given by the highest posterior density (HPD) from an intercept-only Bayesian model.

	Mean	**SD**	**HPD 3%**	**HPD 97%**
Food	0.443	0.024	0.399	0.490
Sport	0.216	0.021	0.178	0.257
Bait	0.173	0.019	0.138	0.209
Social	0.065	0.013	0.041	0.089
Outdoors	0.036	0.009	0.020	0.055
Accessibility	0.033	0.009	0.018	0.051
Relaxation	0.023	0.008	0.010	0.038
Tradition	0.010	0.005	0.002	0.020

4.3.3 Covariates of Fishing Benefits

Modeling reasons for fishing as a function of when a respondent learned to fish revealed that those who grew up fishing from a young age were much more likely to fish for food (2.8x, Bayesian highest posterior density [HPD] odds ratio) or bait (2.2x) than an angler who learned to fish as an adult (**Figure 4.3**). On the other hand, anglers who learned to fish as adults were more motivated by relaxation (2.8x), tradition (1.7x), and accessibility (3.5x). Anglers who learned to fish in Nova Scotia were more likely to fish for food and bait than those who learned to fish elsewhere. In contrast, folks who learned to fish elsewhere were much more likely to be motivated by tradition (2.1x) and accessibility of the fishery (3.1x). Modelling results suggest newcomers (i.e., immigrants or refugees) to Canada were more likely to fish mackerel for accessibility (2.2x), sport (1.9x), and food (1.5x) than Canadian-born anglers. In contrast, Canadian-born anglers were more likely to fish for social connection, relaxation, or bait.

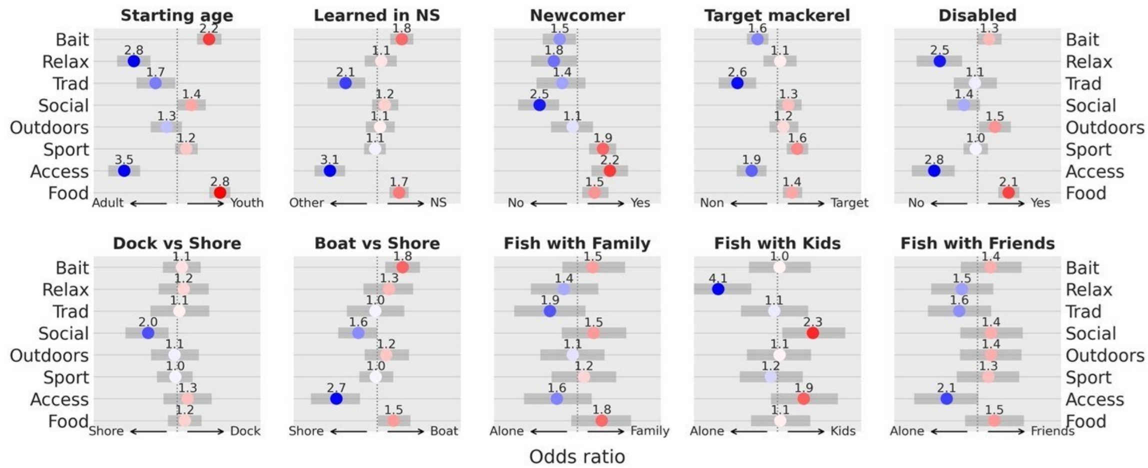

Figure 4.3: Odds ratio plots for reasons anglers fish for Atlantic mackerel or Amalamaq (*Scomber scombrus*) in Nova Scotia / Mi'kma'ki for recreational purposes as a function of selected key covariates. Points are highest posterior density (HPD) odds ratios for conditions listed at the bottom of each panel, with grey bars representing 50% HPD intervals. Grey bars not spanning unity (vertical 1:1) are considered to have clear evidence of differences between groups. Colours shaded for magnitude of the odds ratio for conditions on the left (blue) and right (red).

Model results suggest that anglers targeting mackerel specifically were more likely to fish for sport (1.6x), food (1.4x), and social (1.3x) reasons than those with less target specificity. Those with less preference for catching mackerel specifically were more likely to be motivated by tradition (2.6x), accessibility (1.9x) or bait (1.6x). In addition to Atlantic mackerel, anglers most frequently caught pollock (n=99 responses), striped bass (n=69 responses), cod (n=57 responses), squid (n=55 responses), and flounder (n=44 responses; **Table 4.2**). It should be noted that it appears some of these species are caught incidentally or concurrently while Atlantic mackerel fishing (e.g., pollock, squid), while others are likely caught during separate recreational fishing trips (e.g., striped bass;

suggested by the differences in species distribution and gear types required), but it was not always possible to conclusively distinguish between the two scenarios.

Table 4.2: Additional species of fish caught by recreational Atlantic mackerel fishers in Nova Scotia / Mi'kma'ki

Common Name	Species Name	Number of Mentions
Pollock	*Pollachius virens*	99
Striped bass	*Morone saxatilis*	69
Cod	Gadus morhua	57
Squid (Shortfin)	*Illex illecebrosus*	55
Flounder (Various, e.g., Yellowtail, Winter)	*Various (e.g., Pseudopleuronectes americanus, Limanda ferruginea*	44
Cunner / Perch	*Tautogolabrus adspersus*	41
Sculpin	*Myoxocephalus spp.*	40
Herring	*Clupea harengus*	24
Trout (Various, e.g., Speckled/brook, brown, lake, rainbow)	Various, *e.g., Salvelinus fontinalis, Salmo trutta, Salvelinus namaycush, Oncorhynchus mykiss*	13
Haddock	*Melanogrammus aeglefinus*	13
Eel	*Anguilla rostrata*	10
Smelt	*Osmerus mordax*	9
Other	Various	140

Anglers who identified as having a disability were much more likely to fish for food (2.1x) than others, whereas, perhaps surprisingly, those who did not identify as having a disability cited relaxation (2.5x) and fishery accessibility (2.8x) more often. Considering fishing platforms, those fishing from a wharf/dock and beach/shore had relatively high interest in fishery accessibility compared to those fishing from a boat. Anglers fishing from a beach/shore were more likely to cite social connection as a reason for fishing (e.g., 2x more than wharf/dock). Modelling reasons for fishing as a function of social context suggests that those fishing alone are more motivated by tradition and accessibility than those fishing with friends or family. Anglers fishing with children are much more likely to be interested in the value of social connection

(2.3x) and accessibility of the fishery (1.9x), but they are much less likely to fish for relaxation.

There was no evidence of a relationship between reasons for fishing and avidity (frequency of fishing trips). Anglers of various income levels fished for similar reasons, with increased income associated with a slightly higher likelihood to be motivated by food and slightly smaller likelihood for fishing as a tradition. While men and women both fished for similar reasons, model results suggest that women were much less likely to fish for mackerel to use as bait than their male counterparts.

4.4.4 Management and Conservation

About half of respondents identified that they catch fewer Atlantic mackerel now than in the past (n=122, 48.8%) and most reported that they are smaller than they used to be (n=148, 59%). Notes shared by survey respondents suggest that this might vary among sites (not specified), at different times of the year, and that there were sometimes trade-offs between number and size (i.e., they might see more fish, but fewer of legal size to retain). It is likely that individuals who selected “Not sure” for these questions did not have a long enough time series to compare, as the majority in this category had been fishing <1 year or 1-3 years. Virtually all respondents have observed fishing regulations for Atlantic mackerel getting stricter over time.

While the purpose of the questionnaire was not to identify support for or alternatives to current management practices, many opinions on conservation and management were shared in the open-ended comments, suggesting an interest in engaging with management procedures (**Figure 4.4**). The group was split in supporting current regulations (n=22 comments), opposing current regulations (n=21 comments), and advocating for changes to regulations (n=20 comments). A total of 35 comments highlighted concerns over the impact of commercial fisheries or explicitly blamed the commercial fishery for declines in the mackerel stock. Assessing relative impacts of these fisheries is beyond the scope of the present research.

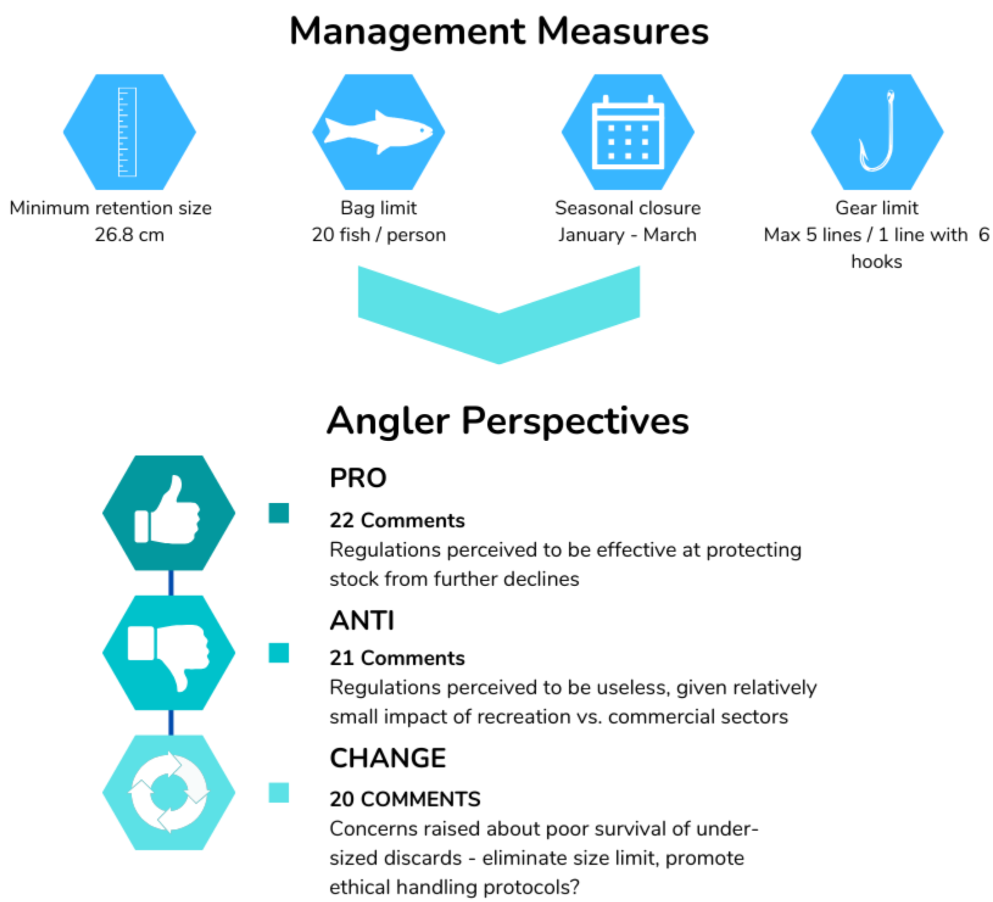

Figure 4.4: Summary of current restrictions and angler perspectives on current management measures for recreational Atlantic mackerel or Amalamaq (*Scomber scombrus*) fishing in Nova Scotia / Mi'kma'ki

Those in favour of the regulations expressed desire for a sustainable fishery, sometimes citing concerns about other depleted fish populations in Atlantic Canada, including herring and various groundfish, such as Atlantic cod. They believe stricter rules in response to fewer and smaller fish made sense, acknowledging that all anglers "have a role to play" in ensuring future stock health. Many cited concerns about the large amount of catch (sometimes caught for the commercial bait fishery under the guise of recreational fishing, particularly before there was a bag limit instated), illegal retention of undersized fish, and unethical handling/discard methods that they had observed from other recreational anglers. One respondent drew a comparison with hunting and described surprise at the lack of education, enforcement, and licencing in recreational fishing compared to the rigorous protocols in place to ensure sustainable harvest of land animals in the region. Another individual mentioned interest in a saltwater licence that would apply to recreational species including mackerel. However, importantly, it was made clear that in any case, these regulations must be developed and implemented in cooperation with the fishing community and informed by the local knowledge of anglers to ensure that they are based upon credible, legitimate, and salient information. As one respondent put it, "We're out here fishing and understand the species and therefore it would be beneficial to listen to us."

On the other hand, respondents who opposed current regulations largely felt that the restrictions were disproportionate to the small perceived impact that recreational anglers have on the resource, particularly in comparison to the more intensive commercial fishery. A sentiment shared by numerous respondents was that "recreational fishers are being penalized for commercial overfishing". The impact of purse seiners was specifically cited as an example of a commercial fishery capable of making detrimental impacts on the stock. There were concerns that management efforts might jeopardize important food-gathering activities of locals. Some expressed dismay that a fish so well-suited to human consumption (e.g., because of taste/nutrition) was commonly used as a bait fish. In any case, most anglers felt that it is important that this fishery resource remains a public good ("the people's fish"), rather than a species only accessible for commercial purposes.

Advocates for regulation changes unanimously highlighted concern over post-release survival of undersized discarded fish, given that "current regulations mean that often undersized fish are thrown back even after they are seriously injured by the hooks". It is believed by many respondents that mackerel has a high vulnerability to handling stress relative to other species. Given that there is a minimum size limit, a 20-fish / person bag limit, and overall fewer big fish to be caught, the result may be forced high-grading and a much higher rate of mortality of mackerel than the bag limit would suggest. Some anglers propose doing away with the size limit and allowing the first 20 fish caught (of any size) to be retained to reduce waste. Alternatively, gear modification (e.g., hook type) and ethical handling practices were suggested to improve survival of discards.

Additional insights from open-ended comments included concerns about climate change (e.g., impacts on timing to migration), access to preferred fishing spots (e.g., overcrowding at popular wharfs, addition of 'no fishing' signs in certain locales, accessibility for anglers with disabilities), food safety (e.g., possible signs of contamination in fish from heavily industrialized Halifax Harbour), and continuity of Indigenous traditions (i.e., connection between declines in wildlife populations and loss of Mi'kmaq culture). With respect to Indigenous traditions, one participant elaborated that they are one of the few left in their reservation community who still practices traditional Mi'kmaw culture, including mackerel fishing. They cite environmental challenges such as global warming and social challenges such as prevalence of social media as key barriers to the continuity of traditional Mi'kmaw ways of life.

Other participants felt that mackerel fishing is an activity that binds Nova Scotians together, with one participant describing it as a shared cultural activity uniting and benefiting African Nova Scotians, Mi'kmaq, Acadians, and newcomers to the province. Another respondent even suggested it could be an untapped opportunity for ecotourism. In particular, fishing was highlighted as a means of engaging youth in ocean stewardship (e.g., through activities such as the Little Fishers Club, Bedford, NS; see https://www.facebook.com/groups/382070278528023). Additionally, a number of anglers expressed interest in research on another local, understudied recreational species, often targeted concurrently by mackerel anglers: shortfin squid (*Illex illecebrosus*).

4.4 Discussion

4.4.1 Benefits from Fishing

If fisheries are valuable for benefits beyond economic gain, it is important to engage with the full range of rightsholders and stakeholders utilising the resource to understand who they are, and how and why they fish, and to make management decisions in consideration of continued access to the full range of benefits derived from fishing. Here I identified numerous important motivations for, and benefits derived from, recreational mackerel fishing in Nova Scotia, including the recreation value and aesthetic aspects of getting outside in nature (i.e., cultural ecosystem services) highlighted from other studies (UNEP 2006, Hunt et al. 2013), in addition to the provisioning of nutritious, culturally appropriate food. These benefits contribute to numerous social objectives for fisheries, such as those outlined by the Canadian Fisheries Research Network, namely the objectives of health and well-being (e.g., via the physical and mental health benefits of relaxation, time outdoors, and nutritious food) and sustainable communities (e.g., via local, accessible food, social connection, and tradition).

Fishing for mackerel for consumption was the most-cited reason to fish in our study. Thus, Atlantic mackerel represents a relatively rare example of a fish stock harvested in eastern Canada and largely consumed locally (as opposed to exported to high-value markets; Fisheries and Oceans Canada, 2022) and prepared at home (as opposed to consumed in a restaurant). An analogous fishery in the region could be the recreational fishery (sometimes known locally as the "food fishery") for Atlantic cod, most notably within the neighbouring waters of the province of Newfoundland and Labrador, another stock (famously) under commercial moratorium. While Arlinghaus and Cooke (2008) discuss recreational fisheries as "non-commercial fishing activities that are not the individual's primary resource to meet nutritional needs", this definition may underplay the various ways food plays a role in coastal communities. For example, while mackerel might not be necessary for food security in the region (defined as "physical and economic access to sufficient safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life" (FAO, 2003), it might play a significant role in food sovereignty, a concept which encapsulates "the right of local peoples to control their own food systems, including markets, ecological resources, food cultures, and production modes" (Wittman 2011). There might be alternative protein sources available for many, but Atlantic mackerel fishing is a form of small-scale fishery that provides culturally appropriate and nutritious seafood for a wide range of communities across the region, with a relatively high degree of accessibility, insofar as limited equipment or expertise is required to catch mackerel during high-density 'runs' in the summer and autumn months.

However, the desire to harvest food synergizes with other social and cultural motivations and benefits. The activity of fishing for mackerel also contributes significantly to cultural heritage in the region, for Indigenous communities who have harvested mackerel in the region for millennia (Denny et al. 2020), for those in non-Indigenous communities in Nova Scotia with centuries of experience mackerel fishing (Fisheries and Oceans Canada 1982), and for newcomers arriving in Nova Scotia from around the country and around the world, bringing their traditions of catching and consuming fish with them, as evidenced by this study. Recreational mackerel fishing is an intergenerational activity, in terms of sharing food with community elders, bonding with family members, and teaching children about the marine environment and food harvest.

4.4.2 Access to Fishing

Our findings highlight that accessibility is also a significant motivation to take part in this fishery for those who learned to fish as adults (and perhaps have less fishing skills and experience), newcomers to Canada (who may have less knowledge about local species, fishing locations, and practices), and those fishing with children (who seek a 'starter' fish to teach children angling techniques). Individuals fishing with children appear to be focused on the youth experience, prioritizing the social connection, as opposed to their own relaxation. Anglers with disabilities were less likely to say they fished mackerel because it was easily accessible, perhaps because they face additional barriers, or perhaps because this group already consists of experienced anglers who need not seek out an 'easy catch'. Our findings suggest that availability of dock and wharf infrastructure, as well as appropriate stretches of shoreline (ideally with a deeper 'drop-off'), are associated with fishery accessibility. Ensuring that relevant infrastructure is available and well-maintained (e.g., in public parks, government wharfs, etc), is an essential component to ensure the continued provisioning of fishery benefits. Beach and shoreline locations appear particularly important for social connection, perhaps because there is more space to congregate, and they offer alternative activities for other friends and family members.

While the diversity of the angler community creates rich opportunities for multicultural and intergenerational relationship-building at the wharf and on the water, this means that there are also several complex priorities to balance in managing fishery access moving forward. This includes access for rural coastal communities, access for urban anglers in the face of coastal gentrification and industrial development[55], and access for newcomers to Canada. Recreational fishing effort in and near urban centres (such as HRM) is particularly understudied (McPhee 2017, Kadfak and Oskarsson 2020, Griffin et al. 2021). However, social processes such as demographic change and urbanization, including those occurring recently in the rapidly growing HRM[56], are known to affect recreational fishing participation (Bissell et al. 1998), so it is essential to consider these mechanisms in visioning a future for this fishery.

Interestingly, I found that those with less preference for mackerel as a target species were more interested in tradition, accessibility, and bait than those with target specificity. This highlights that for many, the activity of fishing itself is as important as what is caught. Awareness of these non-catch benefits of recreational fishing is important, particularly for a stock in decline. When satisfaction with fishing experience is decoupled from catch, high levels of effort may be maintained despite declines in fish abundance (Hyder et al. 2020, Kleivan et al. 2020, Nieman and Solomon 2021). On the other hand, anglers can continue to enjoy some of the benefits of fishing as a sport even if retention of fish is limited.

[55] https://www150.statcan.gc.ca/n1/daily-quotidien/220209/g-b001-eng.htm
[56] https://www150.statcan.gc.ca/n1/daily-quotidien/220209/g-b001-eng.htm?utm_source=citynews%20halifax&utm_campaign=citynews%20halifax%3A%20outbound&utm_medium=referral

4.4.3 Methodological Reflections

It is important to acknowledge that due to the opt-in nature of the questionnaire used in this study, “historical legacies and contemporary realities” introduce bias with respect to who would choose to respond, which would in turn influence results documented here (Biggs et al. 2021). For example, given that language barriers were sometimes encountered during community outreach, and given the relatively high proportion of immigrants and refugees identified in the survey, it is likely that respondents from this group represent a subset of a larger, more diverse community of newcomer anglers. While multilingual outreach materials were developed, it was not possible to administer and analyze the questionnaire itself in multiple languages, and additional sociocultural factors may have influenced willingness to share personal information. Also, while FSC fishing was not the focus of this study, our work demonstrates that at least some FSC mackerel fishers harvest alongside other anglers. A recent study of the Mi’kmaw mackerel fishery has been explored through a Mi’kmaw Ecological Knowledge workshop conducted by Unama’ki Institute of Natural Resources (Denny et al. 2020), and is worthy of separate consideration by management officials in light of differential rights to fishery access held by Indigenous groups in the region.

Furthermore, there is a history of mistrust among fish harvesters, scientists, and fisheries managers in eastern Canada which can be traced back decades to the Atlantic cod stock collapse and moratorium in the 1990s (Hutchings et al. 1997, Neis et al. 1999, Murray et al. 2006, Haggan et al. 2007, Hutchings 2022). Willingness for some anglers to participate in fisheries research may have been impacted by personal experience with, or media exposure to, these issues. In addition, there was likely a bias toward engagement with urban anglers given that the research team was based in HRM and was able to conduct more regular dockside visits in the (sub)urban area. Having the questionnaire available online increased reach province-wide, but potential respondents without reliable internet access, or those who have less comfort or interest in use of technology, may have been underrepresented because of our reliance on a virtual survey platform. Despite these limitations, there is qualitative evidence of information saturation in most response categories, and thus the insights presented here are still of great value. Although cultural traditions might be similar in other parts of eastern Canada where Atlantic mackerel is caught for recreational purposes, it is unclear whether it is appropriate to extrapolate our findings to other provinces beyond Nova Scotia.

4.4.4 Management and Conservation Implications

The value of recreational angler experiential knowledge, such as the information documented here, is greater than ever before as of the upcoming 2022 fishing season in light of the recent commercial fishery closure. Many of the respondents to our survey noticed declines in fish abundance and size over time, and thus this community might represent a pool of potential local resource stewards who could help enact win-win solutions for people and the environment (Granek et al. 2008), perhaps analogous to partnerships between Ducks Unlimited and hunters (Reid et al. 2018). As demonstrated here, anglers find management measures more acceptable when they reflect their knowledge base and address the most urgent perceived threats to the fishery (Granek et al. 2008, Zukowski et al. 2011, Hyder et al. 2020). Granek et al. (2008) identified enforcement, advocacy, conservation, and research as key venues through which recreational anglers could directly engage with management.

Indeed, in this study, some important insights were captured incidentally with implications for fisheries management efforts. First, it appears that recent increases in recreational restrictions on Atlantic mackerel have largely been imposed to reduce large-scale fishing (e.g., for commercial bait) under the guise of ‘recreational’ fishing (Van Beveren et al. 2017a). Respondents’ perceptions that recreational catch may be less of a management concern than harvest for commercial reasons seem correct, although accurate measures of catch from recreational mackerel fishing remain unknown (see Chapter 3; Van Beveren et al. 2017b, Brushett et al. 2021). This was reflected in the 2022 government decision to close commercial and bait fisheries, while maintaining FSC and recreational access (Government of Canada 2022). Furthermore, current restrictions on the fishing season implemented during the winter months do not appear to limit true recreational fishing activity in practice, given that recreational fishing largely takes place in summer and autumn. While a saltwater licence, brought up by one respondent, has been discussed as an option within the DFO advisory process in the past, it has yet to be implemented, perhaps due to lack of support from stakeholders in the past or lack of prioritization by internal decision-makers. Given the numerous comments contributed here opposing increasing restrictions, it is unclear whether recreational mackerel anglers would be supportive of licensing. Additional comments about the influence of climate change on mackerel abundance or distribution are also important, as these issues are of interest to fisheries scientists and fisheries managers as well (Overholtz et al. 2011, Bruge et al. 2016, McManus et al. 2018, Mbaye et al. 2020). In fact, there are numerous calls to action (Boyce et al. 2021) and work is underway (Pepin et al. 2019, 2022) to better integrate climate and other oceanographic considerations into fisheries assessments in Canada.

Many community concerns shared in open-ended comments centred on post-release mortality of undersized fish. While it may be controversial to advocate for the removal of a minimum size limit for a fish stock in decline, given long-standing inclusion of size limits for conservation purposes in a wide range of fisheries, this regulation ignores the particular sensitivity of mackerel to handling stress observed by many of the respondents (see also Tenningen et al., 2021). Instead, relying primarily on the bag limit to restrict catch might actually lead to reduced mackerel mortality in the recreational fishery. Although in freshwater fisheries, long dominated by recreational users, catching fish of a certain size is optimized as opposed to maximizing yield (Ihde et al. 2011), it is well known that there are a variety of species, particularly in the marine environment, for which catch-and-release measures are ineffective (e.g., Atlantic cod [Ferter et al., 2013] or rockfish [Granek et al., 2008] due to barometric effects). Alternatively, or additionally, community-led education efforts around gear recommendations and ethical guidelines for handling fish could minimize handling stress and improve survival of undersized discarded fish. It is essential that restrictions are effective and appreciated by the community, given that effective data collection and management rely on an engaged fishing community that understands and wants to support management (Cooke et al. 2019, Hyder et al. 2020).

A key challenge for rebuilding the Atlantic mackerel stock is the use of mackerel for bait in large commercial fisheries. It appears that bait usage in recreational fishing also has a (likely much smaller) impact on the mackerel stock as well. A shift from conventional use of bait fish to the development of alternative bait products has been proposed as a conservation solution in the commercial sector (Hewitt 2018, Patanasatienkul et al. 2020, Zhou 2021). Recreational anglers may also benefit from alternative bait options in the pursuit of species such as striped bass, which could shift recreational fishing pressure on mackerel to prioritize access for those fishing for food/nutritional or cultural purposes. Given that I found evidence of more interest in bait among individuals with less target species specificity, it appears that mackerel bycatch or species able to be caught concurrently with mackerel might be acceptable bait equivalents for recreational anglers. It is essential that, in any case, recreational fishers are engaged directly to help inform or test the efficacy and acceptability of bait alternatives.

4.5 Conclusion

For stocks like Atlantic mackerel within Canadian waters, there remain important knowledge gaps in understanding of biological processes, relatively short and few survey inputs, and under-reporting of catch from both domestic and bordering international fisheries (e.g., overlap with the Southern contingent of Atlantic mackerel in neighbouring American waters) (Van Beveren et al. 2017b). These must be addressed if successful rebuilding of the stock for continued FSC/recreational access, and a reopening of commercial/bait access, is to be realized. At the same time, it is important that in developing conservation strategies, particularly in light of scientific uncertainty, these efforts do not unintentionally cause social harms which might undermine local stewardship capacity and support for stock recovery (Bennett et al. 2021b). For example, here I document a range of benefits relating to both food provisioning and cultural ecosystem services currently enjoyed by the large community of recreational mackerel anglers in Nova Scotia, which might be threatened by continued decline of the stock, or regulations which may limit retention for food or access to the fish.

In order to make management decisions informed by this complexity, more holistic fisheries assessments are necessary, which will likely require greater input from a larger and more diverse group of rightsholders and stakeholders (e.g., for recreational fishing: Cooke and Cowx, 2006; Granek et al., 2008; Mapstone et al., 2008). There are already calls to include human dimensions in creel surveys for recreational fisheries broadly (Nieman et al. 2021). For example, here I demonstrate that recreational mackerel anglers from a variety of rural, suburban, and urban communities must be engaged, and that resources to facilitate the inclusion of both Indigenous fishers and newcomer anglers must be available. By speaking directly to members of the fishing community, as I have done in this study, fisheries scientists and managers can avoid traps such as reinventing the wheel when knowledge is already held by the fishing community; making incorrect assumptions about human behaviour; dismissing human components of the system as too complex; or distilling human influence to an inappropriately simplistic assessment of 'impact' (Hunt et al. 2013). Assessing the wide range of different ways people rely on and interact with fish is an essential first step toward healthier human-nature relationships, thriving ocean ecosystems, and sustainable and equitable provisioning of benefits for fish harvesters of all stripes.

CHAPTER 5 – Community knowledge as a cornerstone in fisheries management

5.1 Introduction

Over much of the past century, fisheries management was characterized by a centralized structure in which 1) a uniform, "top-down" approach was implemented, 2) based on efforts to control complex and diverse systems of aquatic species, harvesting fleets, supply chain actors, and human communities, and 3) designed with limited decision-making power for those directly involved in fishing (Charles 1994, 2012). After decades of centralization in fisheries management, calls to include stakeholders and rightsholders over the past 30 years (e.g., Charles 1994) have led to a variety of changes in fisheries management regimes around the world. While these changes can broadly be summarized as a move towards 'co-management' as an umbrella term, defined as "the sharing of power and responsibility between government and resource users" (Berkes et al. 1991), it has been argued that co-management varies along two axes: 1) the degree to which decision-making is shared between the government and harvesters, and 2) if and how co-management is implemented across the various functional components of the management process (Puley and Charles 2022). These different forms range from enhanced consultation, to knowledge co-production at the science-policy interface, to true decentralization and power-sharing via co-management, giving harvesters, processors, and communities a clear stake in the sustainability of the resource (Pinkerton 1989, Berkes et al. 1991)

Within the ongoing evolution of fisheries management practices towards various forms of co-management, knowledge inclusion from diverse stakeholders and rightsholders is a key means through which multiple sustainability goals (including those relating to ecological, economic, social, and institutional dimensions) and more effective governance may be achieved (De Young et al. 2008, Garcia 2008, Stephenson et al. 2017, Foley et al. 2020). In industrialized countries, where fisheries management remains largely centralized, there are nonetheless small steps towards more holistic fisheries assessments and extensive participation. For example, in Canada, an Advisory Committee for a given fish stock (or set of stocks) is formed to engage stakeholders and rightsholders beyond the formal science advising process (Soomai 2017a, 2017b, Hamelin et al. 2023). In addition, the relevance of rightsholder and stakeholder contributions has been highlighted in the amended Canadian *Fisheries Act* (2019, c.14, s.3; "Considerations for decision-making"), the primary piece of legislation governing fisheries in Canada, which now explicitly cites 'community knowledge' as one of the possible decision-making criteria informing fisheries management, distinct from and in addition to 'Indigenous knowledge', 'scientific information', and 'social, economic, and cultural factors', among other considerations.

However, the *Act* does not define the term 'community knowledge', and there appears to be no formalized working definition within the federal management agency, Fisheries and Oceans Canada (DFO), leading to the key question: who comprises the 'community(ies)' holding relevant knowledge? There are a wide range of definitions of 'community' within the social sciences, which are highly contextual, but generally encapsulate "a set of interrelationships among social institutions in a locality" (Bell and Newby 1975). Presumably these communities would include and perhaps centre fish harvesters, but a 'community' with the knowledge to inform fisheries management need not be defined so narrowly. In their investigation of the anthropological scope of fishing communities, Clay and Olson (2008) identified five key themes in conceptualizing fishing communities: visible connection to the industry (via vessels, gear, infrastructure), connections between land-based and at-sea networks, kinship playing a role in the labour process, multiple household and family-level ties to fishing, and the persistence of a cultural connection to fishing. However, they note that there are "awkward incongruities between the anthropological emphasis on situational meaning and legal demands for exactness" in applying this definition in a policy context (Clay and Olson 2008). Others (e.g., Ross 2015) reference 'communities of the mind' per Pahl (2005), i.e., communities characterized by the thoughts and feelings of those who belong to them. This draws from contemporary community research which defines a community less as a discrete 'object' and more as something that is enacted or carried out (Liepins 2000, Pahl 2005, Crow 2008, Ross 2015), perhaps also in line with notions of 'communities of practice'. Liepins (2000) cautions that this complexity in describing a 'community' has not been adequately considered in social studies and policy discourse.

In defining the 'community', there are implications for which rightsholders and stakeholders are perceived to hold 'community knowledge'. A stakeholder can be defined broadly as someone who gets benefits from the fishery, is concerned about fishery issues, and / or has a role to play in managing or making decisions regarding the fishery. Here, I recognize rightsholders as a distinct group with inherent and/or legal rights to resource access; e.g., in Canada, rightsholders are Indigenous Peoples. In many contexts, including within DFO, stakeholders and some rightsholders are referenced under the umbrella term 'industry', which seems to refer broadly to members of the commercial fishing sector, but notably may exclude other key types of fish harvesters (e.g., "Aboriginal fisheries" and "recreational fisheries" are other categories under DFO jurisdiction). Given the various ways to define a community, it is thus unclear when or if harvesters should be engaged as representatives of a commercial sector, a sociocultural group, a regional or municipal populace, or some combination of these categories. Analogous legislation in the United States, the Magnuson-Stevens Fishery Conservation and Management Act, defines a fishing community as "…a community which is substantially dependent on or substantially engaged in the harvest or processing of fishery resources to meet social or economic needs, and includes fishing vessel owners, operators, and crew and United States fish processors that are based in such community" (H.R. 5126, 116th Congress). Efforts have been made to compile a database of fishing communities in the United States based on a variety of such characteristics (Sepez et al. 2006). However, it has been argued by others that all Canadians have a stake in the state of fisheries within our national jurisdiction, as stipulated in the Oceans Act (S.C. 1996, c.31), which identifies Canadian territory within the Arctic, Pacific, and Atlantic Oceans as "the common heritage of all Canadians". This suggests that the 'community' informing fisheries management decisions might be very broad indeed.

In addition to the 'who' in understanding 'community knowledge', the 'what' matters as well: what kind of relevant knowledge can a community hold and contribute? Like Hakkarainen et al. (2020), here I draw from a constructive social science epistemology and define knowledge as "justified belief that is used to claim a truth and determined by acceptance of that truth in a particular context" (Van Kerkhoff and Lebel 2006, Jacobson 2007). Notably, how the 'community' is defined will affect the type(s) of knowledge they are believed to hold, the contributions they can make to decision-making 'evidence', and their ability to participate in consultative, collaborative, or community-led management processes.

If our definition of the communities in question centres fish harvesters, their knowledge might be highlighted as key. Fishers' knowledge has been of interest to researchers for decades, beginning with work pioneered by amateur historians, embraced by ethnographers, expanded by social scientists, and eventually applied by ecologists and oceanographers (Hind 2015, Stephenson et al. 2016). Indeed, a great deal of data used to support fisheries management in Canada currently comes from the harvesting sector itself (Hamelin et al. 2023). However, it is important to note that, regardless of how broadly the community is defined, valuable 'knowledge' can take many forms, and is not simply a data source, given that knowledge might be expressed via transmission, practice, beliefs, values, and adaptation (Giles et al. 2016). The extent to which community 'knowledge' is considered or mobilized in fisheries management will likely be a function of the power-sharing in the governance regime in question. Furthermore, given that Indigenous knowledge is recognized separately in the *Fisheries Act*, it is clear that 'community knowledge' can come from non-Indigenous communities, however Indigenous communities nonetheless possess 'community knowledge' as well and thus the 'communities' referenced in the *Act* might include groups of individuals across sociopolitical contexts.

Given that not all criteria referenced in the *Fisheries Act* need to be evaluated or considered every (or any) time a management decision is made in Canada, questions remain about when, how, and to what end these 'communities' should be engaged in current fisheries management protocols. When does it matter most, presumably with the ultimate goal of achieving objectives for Canadian fisheries management, such as those identified by Stephenson et al. (2019)? Questions raised above about the Canadian context might be best informed by practices and guidelines from elsewhere in the world, and in turn, insights gleaned here in Canada might inform efforts toward co-management in all its forms in other jurisdictions. To that end, this study involved a scoping literature review to investigate what 'community knowledge' might entail, as it pertains to fisheries management, and who the relevant 'communities' might be. This study identifies under what conditions community knowledge can influence fisheries management and the outcome of these impacts (e.g., Where and when has it been used? What was done? What was the outcome?). Recommendations are compiled for practices which could guide efforts, including those in Canada, to engage with communities toward the goal of full-spectrum sustainability for our fisheries and in keeping with legislation around the multiple inputs required for evidence-based decision-making.

5.2 Methods

5.2.1 Literature search

The Scopus academic database was used to find relevant articles for a scoping review. This database was determined to offer a wide variety of sources and an ability to narrow the search with a great degree of specificity. To develop appropriate search terms for a scoping analysis, an iterative process was used to identify documents about community knowledge in fisheries management, involving a broad search to identify possible key words, narrowing down the key words to those most relevant, and a final targeted search to obtain papers for review (**Figure 5.1**). The search procedure was conducted on January 31, 2023 and the final search yielded 824 results, sorted by Scopus into a list ranked by greatest inclusion of the search terms. The first 100 ranked articles within the scope of the study with full-text article versions available were compiled for analysis, representing the 100 most relevant papers based on the search terms used (see **Electronic Supplement**). I recognize that focusing on academic literature excluded management reports, NGO reports, and other technical papers which may have offered unique perspectives on community knowledge in fisheries. Furthermore, as anglophone researchers, I recognize that the English-language literature reviewed here represents only a portion of disseminated findings in this field, given its global scope. However, the papers I reviewed included a wide range of on-topic studies which could be analyzed in a systematized way, yielding relevant insights for our purposes.

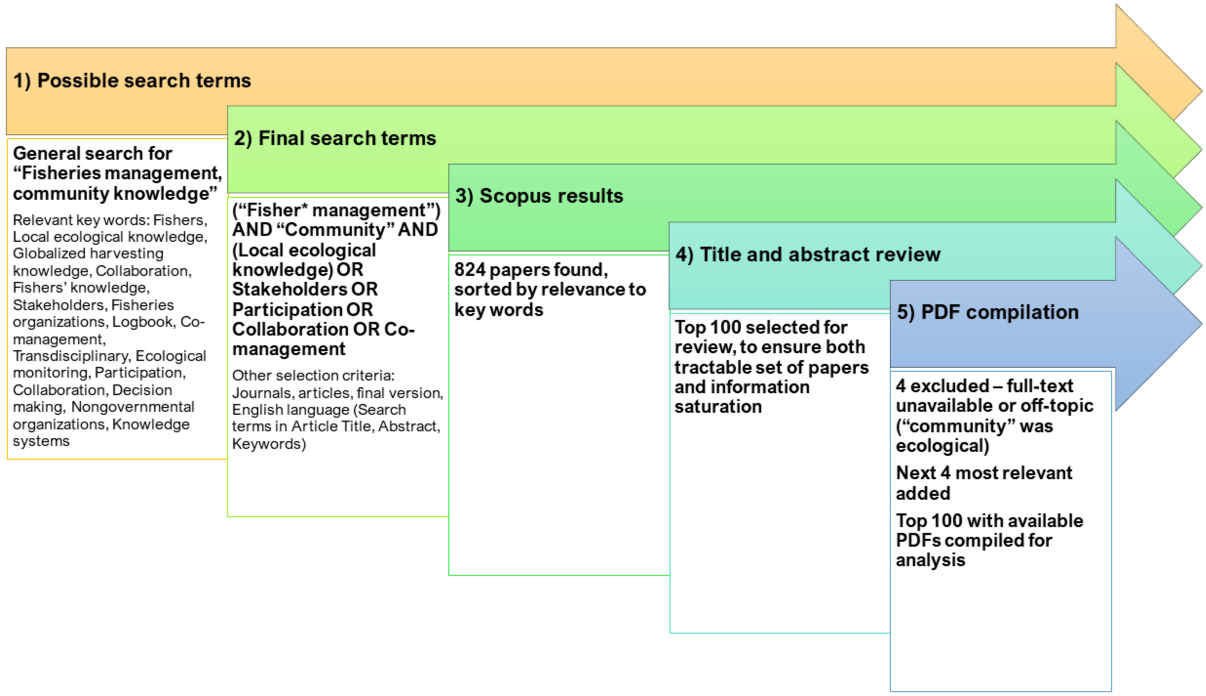

Figure 5.1: Flow chart summary of scoping review protocol for community knowledge in fisheries management

5.2.2 Literature review

The final 100 papers selected for analysis were compiled and uploaded to NVivo Qualitative Analysis Software (https://lumivero.com/products/nvivo/). Within NVivo, each paper was read in its entirety to deductively code for and compile (where relevant and available) the following information: 1) management context, 2) list of community members, 3) reference to community knowledge, 4) engagement methods, 5) enablers, 6) barriers, 7) outcomes, and 8) recommendations (**Table 5.1**).

Table 5.1: Information collected during scoping review for community knowledge in fisheries management

Code	Description
Management context	Relevant management scheme, protocol, or 'problem'
Community members	Participants or stakeholders identified by the researchers (meant to represent candidate members of the 'community', although they may differ in their involvement in the fisheries research vs. the actual management scheme being studied, e.g., women may have been deemed knowledgeable about the fishery by the researchers, and would be coded as fishing community 'members', even if current management protocols did not [yet] engage women),
Community knowledge	Description of data / information / or knowledge contributed or held by community
Engagement methods	Research or consultative methods used to engage with community knowledge holders
Enablers	Enabling conditions facilitating success for communities engaging in management or for groups working with communities
Challenges	Challenges preventing success for communities engaging in management or for groups working with communities
Outcomes	Outcomes from research or management intervention
Recommendations	Concrete suggestions for engagement with community knowledge in fisheries management

5.2.3 Data analysis

R Statistical Computing Software (R Core Development Team, 2022) was used to visualize the compiled literature with respect to publications over time, publications by journal, and publications by geographic region to describe the breadth of the literature evaluated here. Qualitative content analysis was conducted on the remainder of the data collection categories to synthesize key findings with an inductive approach. In some cases, for exploratory purposes, the word cloud function in NVivo was used to help visualize key concepts within each theme, where words were sized proportionately to frequency (settings: 1000 most frequent words, minimum word length = 3 letters, grouped with synonyms). Key findings from the 'outcomes' theme, specifically, were further sorted according to the four pillars of sustainability frequently referenced in fisheries management

(Charles 1994, Foley et al. 2020), to link specific study outcomes to larger-scale sustainability objectives for fisheries management more broadly. Inspired by Giles et al. (2016), the enablers and barriers discussed here were sorted into three categories, which have previous been used to summarize challenges in knowledge exchange practices: 1) conceptual, 2) logistical, and 3) communication factors. Recommendations identified within the articles reviewed were compiled according to three components that reflect how community knowledge could be operationalized in fisheries management in a quasi-chronological order: 1) setting up the system, 2) working together, and 3) achieving results.

5.3 Results

5.3.1 Summary of literature

The articles analyzed here were published between 1991 and 2023, with an increasing trend in the number of articles published over time (**Figure 5.2**), reflecting both recent interest in this subject matter and likely increased publication rates for academic articles in general. These articles represented 39 academic journals, and the largest number were published in Marine Policy (n=33 / 100) or Ocean and Coastal Management (n=12 / 100), with <5 from any other journal. Top fisheries journals (e.g., Fish and Fisheries) have notably fewer papers than one might expect, while the most prevalent journals, although not fisheries-specific, may represent venues likely to publish research on work from the social sciences relevant to community work, policy, and management in fisheries.

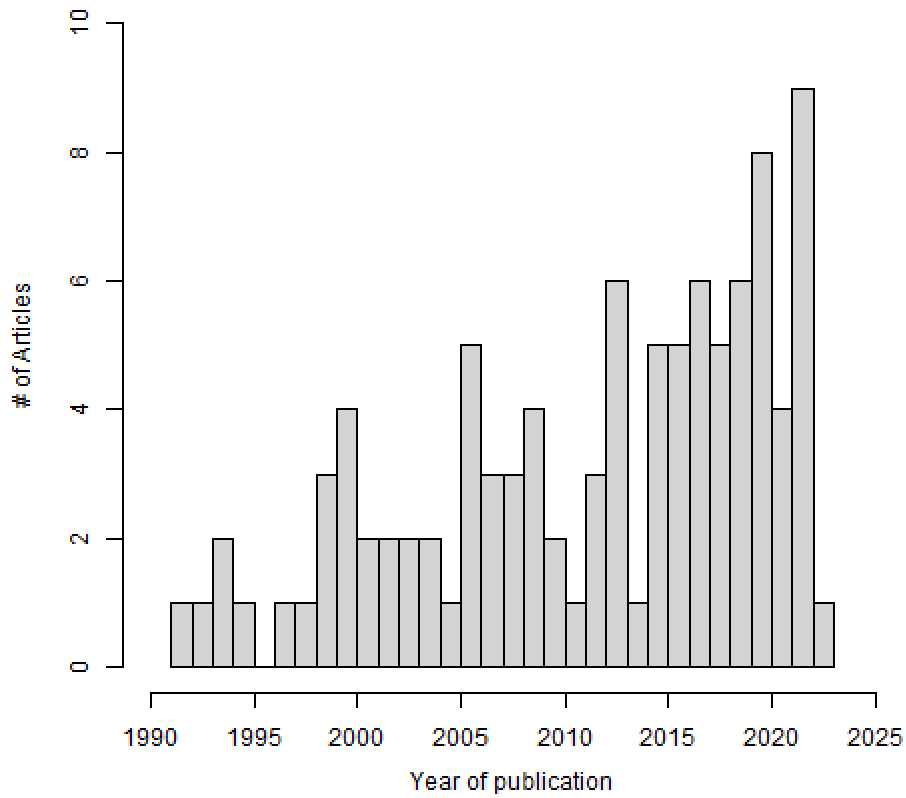

Figure 5.2: Number of academic journal articles published in a given time period from a scoping literature review on community knowledge in fisheries management

In terms of geographic region, the largest number of studies was based in or focused on Asia (n=31 / 100), with North America (n=17 / 100), Europe (n=13 / 100), Oceania (n=11 / 100) also featuring large numbers of studies, and <10 articles highlighting other regions of the world (**Figure 5.3**). While most articles focused on a particular country, with USA (n=10 / 100), Bangladesh (n=7 / 100), Brazil (n=6 / 100), Philippines (n=5 / 100), and Canada (n=4 / 100) the most prevalent, the largest single category of articles comprised synthesis or case study articles which covered multiple countries from a given region or from around the globe (n=20 / 100). In terms of subject matter and approach, the articles fell largely into two categories: 1) research studies that explored possible inputs or contributions from communities to the process of fisheries management, and 2) studies that evaluated outcomes and implications from actual community inputs to (or community-led) fisheries management.

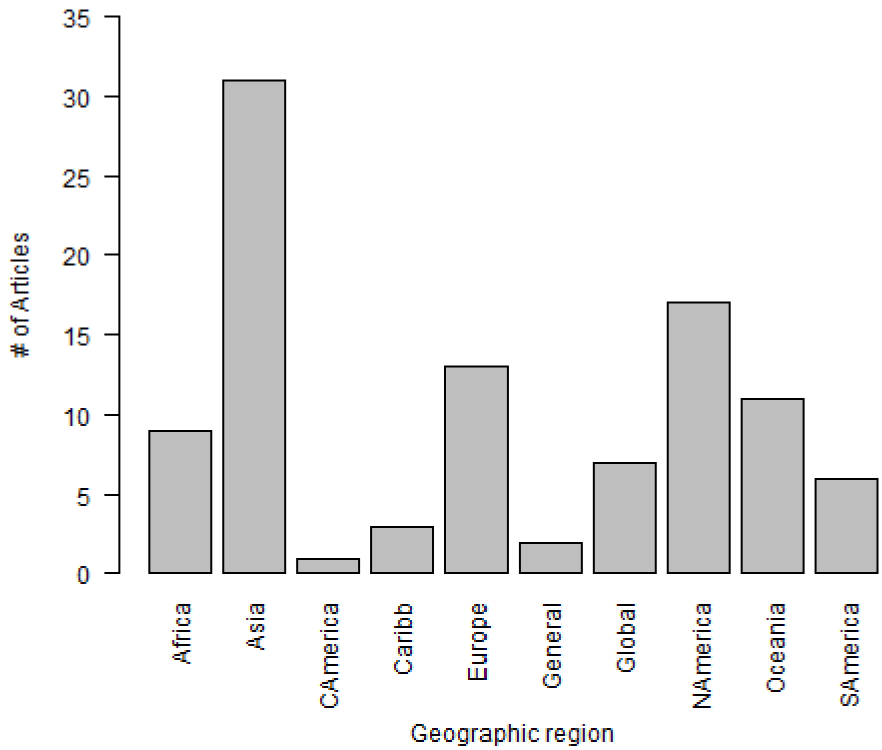

Figure 5.3: Number of academic studies based in or focusing on a given geographic region in a scoping literature review on community knowledge in fisheries management (Note: CAmerica = Central America, Caribb = Caribbean, NAmerica = North America, SAmerica = South America)

5.3.2 Management context

To begin crafting a working understanding of community knowledge from the literature, I needed to explore the types of management regimes represented in our search results. The articles covered a wide scope of management contexts, ranging from small- to large-scale fisheries in developing to developed economies. While I refer to these binaries (e.g., “developed” vs. “developing”; Global North vs. Global South) here for ease of exposition, I fully acknowledge that they do not do justice to the nuance and spectrum of development status, assets, and capabilities that exist. Some articles focused on assessing implementation of, or compliance to, new fisheries laws or management plans (e.g., Mulekom 1999, Satria and Matsuda 2004, Owusu et al. 2023), including multinational agreements such as ‘Brexit’ (Appleby and Harrison 2015). A large number focused on recommending, documenting, or evaluating community co-management as a fisheries management approach, either in contrast to centralized management approaches, or alongside or embedded within Indigenous or traditional practices and institutions (e.g., Pomeroy 1991, Noble 2000, Pomeroy et al. 2001, Rab 2009, Pinho et al. 2012, Journal et al. 2015, Yang and Pomeroy 2017, Montgomery and Vaughan 2018, Zucchetti Schons et al. 2020). A wide range of terms were used to describe these projects or initiatives, including community-based management (CBM) (e.g., Alpizar 2006), community marine spatial planning (CMSP) (e.g., Morzaria-Luna et al. 2020), community-based resource management (CBRM) (e.g., Pomeroy 1996), community-based coastal resource management (CBCRM) (e.g., Maliao and Turingan 2009), community-based fisheries management (CBFM) (e.g., Mustafa 2009, Nasuchon and Charles 2010, Kabir et al. 2013, Leopold et al. 2013), co-management-based organizations (CBO) (Kabir et al. 2013), or participatory fisheries management arrangements (PFMA) (Leite and Pita 2016). A large number of such studies were based in southeast Asia, where concentrated efforts to shift to community-based co-management have taken place in countries like the Philippines.

Many studies were more local and place-based, with research occurring in a small-scale or subsistance fisheries context (e.g., Hviding and Baines 1994;

Kuperan et al. 1994; Ruddle 1998; Harris et al. 2002; Geheb and Crean 2003; Ahmed et al. 2013; Aswani et al. 2013; Leite and Gasalla 2013; Guanais et al. 2015; Herrera-Racionero et al. 2015; Nakhshina 2016; Gauvreau et al. 2017; Mendoza et al. 2022), while others were national case studies from more industrialized locations (e.g., implications of ITQs or science-policy protocols in the 'global North' (Charles 1997, Eythorsson 2000, Hawkins 2002, Hoof 2010, Yagi et al. 2012, Chambers and Kokorsch 2017, Tirrell 2017, Soomai 2017b), or international in scope (e.g., discussing membership status in regional fisheries management organizations [RFMOs]; Edeson 2006, Lodge and Lodge 2006, Dong and Guo 2022). The concept of fish harvesters and other stakeholders organizing into labour unions, community organizations, and other forms of advocacy or decision-making institutions was referenced regularly (e.g., Ruddle 1998, Mulekom 1999, Sutinen and Johnston 2003, Lieng 2018). Additional topics of interest included health and safety in the fisheries industry (e.g., Kaplan and Kite-Powell 2000, Oerther et al. 2022); the integration of recreational fishing into management, typically in developed countries (e.g., Gray et al. 2012, Hamelin et al. 2022); the rise of ecosystem-based approaches (e.g., Bergho et al. 2008, Heron et al. 2008, Fletcher et al. 2016, Mattingley et al. 2016, Apa et al. 2020, Boubekri et al. 2022, Sari et al. 2022); implications of marine protected area establishment (e.g., Lowry et al. 2009, Batista et al. 2011, Weigel et al. 2014, McNeill et al. 2019, Salvadeo et al. 2021); and relationships between fisheries and human wellbeing, culture, and socioeconomic factors (e.g., Sekhar 2007, Santha 2008, Feeney 2013, Curry and Curry 2007, Ounanian 2019, Szymkowiak and Kasperski 2021), including gender (Calhoun et al. 2016, Ikechukwu Uduji and Okolo-Obasi 2020, Mangubhai and Lawless 2021). The primary ways of doing research on communities involved in fisheries management were via interviews or surveys/questionnaires (typically of a semi-structured format), or via (comparative) case study analysis. In other cases, participatory action research or observation strategies were used.

5.3.3 Exploring 'community'

Recognizing the myriad management regimes involved in fisheries management globally, a wide range of individuals and groups were referenced in the studies, comprising candidate 'communities' or 'community members' to be involved in management. Generally, these community members could be divided into 2 primary categories depending on whether they had relevance to management 1) via their role in the fishing 'industry' and 2) via their role as residents in a place-based community where fishing takes place (**Figure 5.4**). These two categories do not necessarily represent a discrete dichotomy, and there was particular overlap in how fish harvesters are positioned as either or both members of an industry and members of a place-based community. In considering prevalence of particular individuals and groups within the literature, 'fishers'/'fishermen' and 'government' / 'management' are evident as two dominant groups – depicting an overarching image of fisheries management as a bilateral exchange between resource harvesters and resource managers (see e.g., Jentoft 2000). 'Representatives', 'organizations', 'industry' and 'associations' are also key players, representing the importance of the collective, and the fact that certain 'leaders' representing these collectives are usually engaged in collaborative research or management initiatives. Less frequently, additional 'industry' members and supply chain actors or 'workers' (e.g., 'processing') were also consulted.

While less numerous, a meaningful category of articles focused more holistically on feedback or insights from the place-based community in which the fishing activity took place, usually referred to as 'households', 'residents', or the 'village' in the context of rural, developing nations, with 'Elders' and 'Chiefs' noted in certain contexts with customary / Indigenous governance systems. In this subset of papers, the ‘community’ encompassed a variety of, or all, individuals directly or indirectly connected to the fishery, defined by their social connections, including family, friends, and peers of harvesters. Notably, these studies tended to include a greater consideration of the role of ‘women’ and ‘family’.

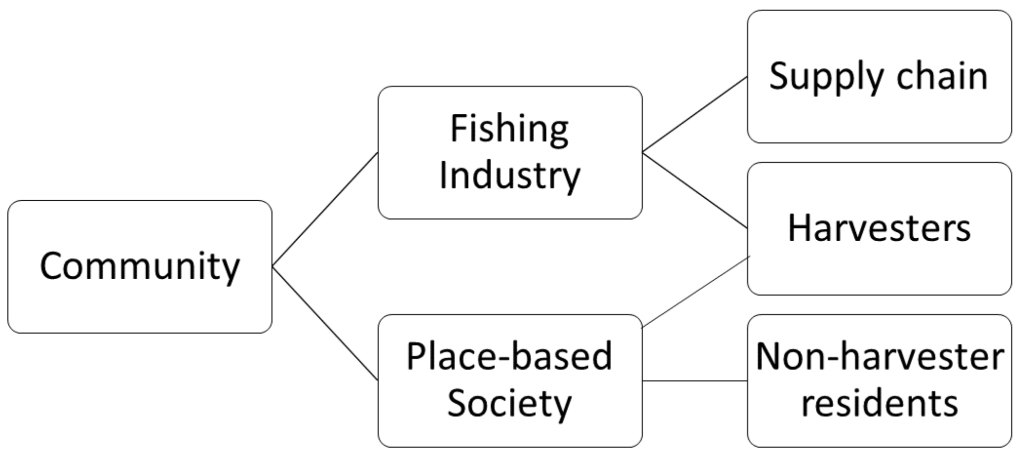

Figure 5.4: Groups identified as ‘community members’ engaged in fisheries management based on a scoping literature review

‘Researchers’ and ‘scientists’ involved in collaborative work were also noted. While these groups would have valuable feedback to share on community partnerships, they most often belonged neither to the fishing industry, nor the place-based or sociopolitical ‘community’ directly affected by fisheries management decisions, including (although not necessarily) instances of Western researchers working in other parts of the world. Likewise, staff and representatives of 'NGOs' were also referenced. Again, while certainly playing a meaningful role as stakeholders in fisheries management, whether these individuals belong to the 'community' affected by fisheries management is debatable, as they often originated from different geopolitical or sociocultural settings, arriving in a fishing community to launch a program or build capacity.

5.3.4 Examining 'knowledge'

Contributions solicited from or provided by community members were frequently referred to as 'local knowledge'. Within this body of knowledge, there were community contributions from across the data – information – knowledge - wisdom spectrum (per Ackoff 1989, Rowley 2007), ranging from simple measurements and data inputs ('catch', 'species', 'size') to highly contextual and embodied knowledge (e.g., 'learning', 'trust', 'opinions', 'values'). 'Knowledge' as a data input tended to be more compatible with dominant science (per Liboiron, 2021) methodologies that frequently dominate fishery assessment protocols across geopolitical contexts. A proportion of the studies focused on harvesters and other community members as sources of information, and their 'knowledge' as data inputs, however as management protocols moved from the consultation to the co-management end of the spectrum, there was a shift from considering knowledge as 'data' to knowledge as a practice. 'Knowledge as a practice' often involved stakeholders or rightsholders sharing their perspectives and preferences with respect to management strategies and governance regimes.

5.3.5 The role of community across dimensions of sustainability

Outcomes of the studies reviewed here were sometimes outcomes from research projects and sometimes evaluations of management actions in practice. In considering the goal of full-spectrum sustainability for fisheries, I have identified ecological, economic, social, and institutional outcomes (**Figure 5.5**).

Here, I considered ecological sustainability to relate to the resilience of the fishery target species and surrounding ecosystem. Economic sustainability was associated with both financial viability and equity with respect to costs and benefits of participation. Social sustainability involved cultural vitality, social cohesion, and individual and community wellbeing. Institutional sustainability was interpreted to mean functional and fair governance practices. With respect to ecological sustainability, a variety of studies documented increased trust in or legitimacy of biological or ecological research by communities (e.g., Gray et al. 2012, Morzaria-Luna et al. 2020), including in support of conservation initiatives (e.g., Marine Protected Areas [MPAs]) (Kuperan and Mustapha Raja Abdullah 1994, Weigel et al. 2014, Chitara-Nhandimo et al. 2022). This stemmed from, and perhaps resulted in, increased use of local or traditional ecological knowledge (e.g., Leite and Gasalla 2013, Gauvreau et al. 2017, Bulengela et al. 2020), or instating local monitoring programs (e.g., Pomeroy 1996). There were mixed results on whether more participatory scientific research protocols led to better conservation outcomes from an ecological point of view, at least on the time frames documented, although conservation outcomes were frequently listed as objectives for studies or management interventions. Ultimately, within this body of research, there were a variety of attempts to integrate data sources, test approaches, and apply frameworks towards ecologically sustainable fisheries or toward a more holistic goal of integrated sustainability, i.e., more resilient social-ecological systems more broadly.

To that end, many study results focused on social outcomes for the communities in question. Frequently, concerns held by rightsholders or stakeholders were identified and sometimes even addressed through the research process. As a result, the myriad relationships between and implications of fisheries (and their associated management mechanisms) for individual and community well-being were illuminated. Generally, having community input or even leadership in fisheries management led to increased compliance with regulations (e.g., Weigel et al. 2014, Yang and Pomeroy 2017, Owusu et al. 2023), and thus fewer conflicts and associated social costs (e.g., Hoof 2010, Yang and Pomeroy 2017). However, while many community-related initiatives found enhanced cohesion among diverse stakeholders and rightsholders as a result of increased collaboration or participation (e.g., Sekhar 2007, Rab 2009, Aswani et al. 2013, Barclay et al. 2017), there were many other instances in which the divergent motivations and values within and between groups, and conflict among heterogenous individuals, communities, and sectors brought together, were documented (e.g., Alpizar 2006, Herrera-Racionero et al. 2015). Overall, however, a greater awareness of local customs, motivations, and perceptions was often the result of the research (e.g., Aswani 2006, Sekhar 2007, Yagi et al. 2012, Pinho et al. 2012, River et al. 2015, Barclay et al. 2017, Gauvreau et al. 2017, Hamelin et al. 2022, Grace-McCaskey 2018, Curry and Curry 2007, Liao et al. 2019, Szymkowiak and Kasperski 2021).

In the papers I reviewed, this awareness led to outcomes with implications for institutional dimensions of sustainability. Conflicts of jurisdiction between centralized versus localized management authorities were documented (e.g., Ruddle 1998, Satria and Matsuda 2004, Mpomwenda et al. 2022). Documenting changes to laws and policies, including decentralization processes – i.e., moving towards a form of community co-management – was a common topic, with mixed results, including some of the positive outcomes described thus far, but also sometimes limitations stemming from lack of capacity or lack of integration with other legal structures, community development initiatives, or local customs (e.g., Mulekom 1999, Nasuchon and Charles 2010, Leite and Pita 2016, Morzaria-Luna et al. 2020). In some of these cases, the outcome of the research was simply documenting some of these capacity needs to support decentralization to communities, or to address inconsistencies or implement new ideas for linking policies and practices to enhance operationalization of management plans (e.g., Geheb and Crean 2003, Feeney 2013, Carlson et al. 2019, Elvarsson et al. 2020). Frequently, a positive outcome toward institutional sustainability was social organizing within communities to support participation, advocacy, and leadership (e.g., Hviding and Baines 1994, Pomeroy 1996, Brown and Pomeroy 1999, Sutinen and Johnston 2003, Pinho et al. 2012, Ounanian 2019, Zucchetti Schons et al. 2020).

Finally, economic outcomes were less frequently discussed, but nonetheless were an undercurrent in many of the outcomes discussed above. There were overall mixed findings with respect to equity in access and benefits from fisheries in the literature, with some studies concluding that management led or informed by communities increased incomes or economic equity/benefit-sharing (e.g., Amarasinghe and Silva 1999, Dominguez-Torreiro et al. 2004, Maliao and Turingan 2009, Yang and Pomeroy 2017), while others documented perpetuation of inequitable access (e.g., Tirrell 2019), or the research illuminated injustices previously ignored or underappreciated (e.g., Eythorsson 2000, Calhoun et al. 2016, Hossain and Rabby 2019, Ikechukwu Uduji and Okolo-obasi 2020, Marin-Monroy et al. 2020, Mangubhai and Lawless 2021, Oerther et al. 2022). The cost of conservation (e.g., MPAs) was also documented in a variety of cases (e.g., Kaplan and Kite-Powell 2000, Batista et al. 2011, Mcneill et al. 2019, Boubekri et al. 2022). Generally, research within the field of fisheries management tends to be short-term, with relatively few longitudinal studies through the process of decentralization, or from knowledge production through to its uptake, implementation, and evaluation. Furthermore, here I identified more outcomes oriented towards social and institutional sustainability, which perhaps reflects the greatest concerns of community-based fisheries management researchers or their participants. However, I acknowledge that distinctions among the 'pillars' may be somewhat subjective and there are likely relationships between and among various sustainability outcomes.

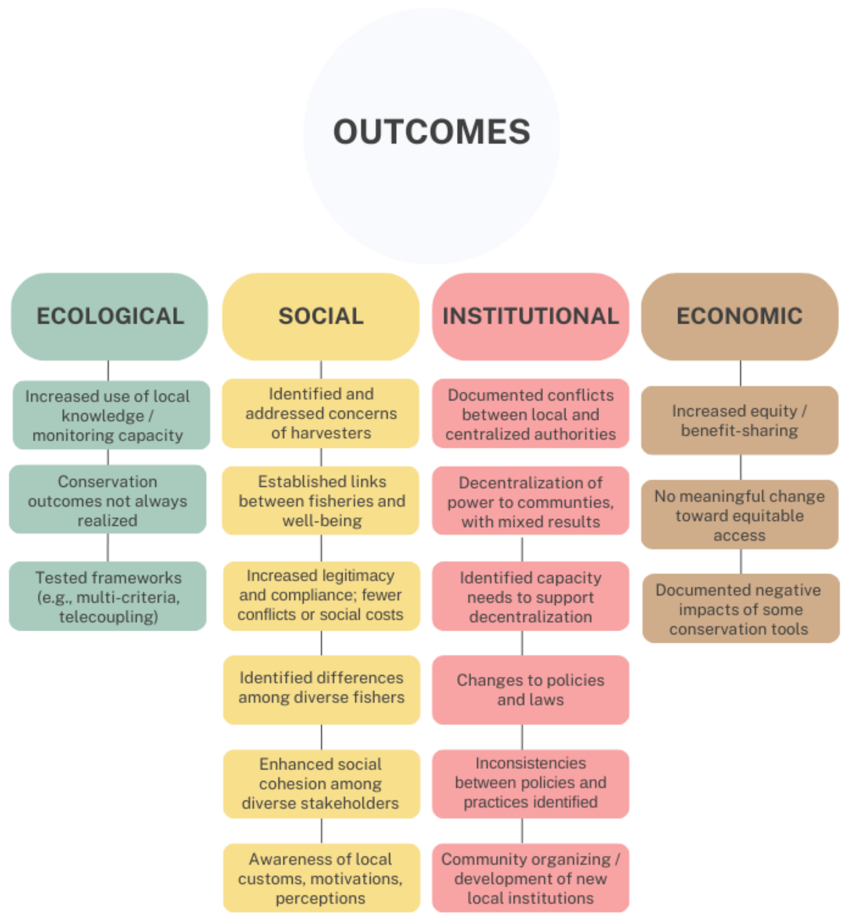

Figure 5.5: Ecological, social, institutional, and economic outcomes from community contributions to fisheries management

5.3.6 Setting the stage for success

Enablers and barriers to successful community knowledge engagement in fisheries management were here sorted according to the way in which they could be operationalized: conceptual, logistical, and communication factors, a comprehensive list of which is included in **Table 5.2**, and summarized here.

Conceptually, building and maintaining respect (e.g., Brown and Pomeroy 1999), trust, and a spirit of cooperation (e.g., Amarasinghe and Silva 1999, Jentoft 2000, Noble 2000, Sekhar 2007, Nasuchon and Charles 2010, Aswani and Ruddle 2013, Liao et al. 2019) based on local relevance and a shared vision/objectives (e.g., Noble 2000, Hawkins 2002, Leite and Gasalla 2013, Weigel et al. 2014) among all participants were enablers. A social normative rationale (e.g., Jentoft 2000, Santha 2008) and political will (e.g., Satria and Matsuda 2004, Nasuchon and Charles 2010, Owusu et al. 2023) in an area with perceived legitimacy and accountability (e.g., Kuperan et al. 1994, Pomeroy et al. 2001, Bergho et al. 2008, Weigel et al. 2014, Lieng 2018) were also important. Bringing a holistic (e.g., Noble 2000, Ahmed et al. 2013, Barclay et al. 2017, Oerther et al. 2022), inclusive, open approach (e.g., Noble 2000, Guanais et al. 2015, Mangubhai and Lawless 2021) to shared spaces helped facilitate community contributions and leadership as well. Conceptual barriers, on the other hand, included a lack of trust in authorities (e.g., Mulekom 1999, Kaplan and Kite-Powell 2000, Hamelin et al. 2022) (sometimes stemming from unbalanced power relations or unfairness in allocation/enforcement), conflicts between community development and conservation (e.g., Brown and Pomeroy 1999, Ahmed et al. 2013, Weigel et al. 2014, Owusu et al. 2023), inappropriate generalizations made across fishery sectors or between heterogeneous communities (e.g., Lowry et al. 2009, Freitag et al. 2018, Grace-mccaskey 2018, Tokunaga et al. 2019), and overall risk aversion or inflexibility to try something new or change existing management structures (e.g., Sekhar 2007, Chambers and Kokorsch 2017).

Logistical enablers included scale match and clearly defined boundaries for ecosystems, communities, and management jurisdictions and processes (e.g., Charles 1997, Sutinen and Johnston 2003, Satria and Matsuda 2004, Bergho et al. 2008, Lowry et al. 2009). Further enablers included organized rightsholders and stakeholders with effective leadership, including both labour systems (e.g., fishing associations, unions) and more traditional customary structures with strong local participation (e.g., elders and youth) (e.g., Pomeroy 1991, 1996, Noble 2000, Pomeroy et al. 2001, Soomai 2017b, Montgomery and Vaughan 2018). Contingent on adequate budgets, investments in capacity-building for the community were also a predictor of success, including suitable technical and human resources, and training to ensure skills and expertise for planning, implementing, monitoring, and evaluation (e.g., Pomeroy et al. 2001, Harris et al. 2002, Lowry et al. 2009, Rab 2009, Grace-McCaskey 2018, Dong and Guo 2022). Ideally, management systems will both demand long-term commitments and investments (e.g., Noble 2000), and allow for an iterative, adaptive process (e.g., Hviding and Baines 1994, Weigel et al. 2014, Soomai 2017b). Community participation typically works best when fisheries management structures and protocols work synergistically with existing community institutions and other development initiatives (e.g., Jentoft 2000, Alpizar 2006, Lieng 2018).

In contrast, logistically, centralized fisheries management agencies distant from communities affected by their decisions pose a challenge to community involvement (e.g., Jentoft 2000, Satria and Matsuda 2004, Herrera-Racionero et al. 2015), but likewise, decentralization without proper policies or adequate resources to ensure effective communication and implementation can lead to problems (e.g., Soomai 2017b). The time and resources required, particularly upfront costs, to build community capacity may act as a barrier to community involvement and leadership in fisheries management (Sekhar 2007, Lowry et al. 2009), particularly in developing or remote settings (e.g., Satria and Matsuda 2004, Alpizar 2006, Ahmed et al. 2013, Lieng 2018). Changes in demographics, socioeconomic factors, or institutional environment (e.g., population growth, technological development) can cause difficulties (e.g., Alpizar 2006, Maliao and

Turingan 2009), and communities where there has been a loss of traditional knowledge or customary institutions, such as those with a colonial history, are at a disadvantage (e.g., Pomeroy 1995, Satria and Matsuda 2004, Gauvreau et al. 2017). Even local organizations may perpetuate existing power imbalances, wealth discrepancies, and historical injustices within and between communities (Eythorsson 2000, Alpizar 2006, Lowry et al. 2009).

With respect to communication, strong social networks and opportunities for relationship-building, shared learning, and mentorship were enablers (e.g., Lowry et al. 2009, Hossain and Rabby 2019). Underlying this must be a sense of social cohesion and solidarity, with a willingness to participate in collective action as well as respect for pluralism, particularly with respect to diverse knowledge types (e.g., Ruddle 1998, Jentoft 2000, Noble 2000, Pomeroy et al. 2001, Gauvreau et al. 2017, Jyotishi et al. 2020, López-Juambeltz et al. 2020). Making clear the benefits of participating, or having self-evident benefits emerge during the process, were motivators for community member to engage (e.g., Pomeroy 1995, Schreiber 2001, Lieng 2018). However, this ideally comes along with clarity and consistency in acceptable rules, procedures, and schedules for how the participation or collaboration will take place (e.g., Pomeroy et al. 2001, Hawkins 2002, Weigel et al. 2014, Lieng 2018, Tokunaga et al. 2019). In some cases, having access to outside conflict resolution resources may be helpful (e.g., Lowry et al. 2009).

In contrast, "depersonalized" relationships within an environment of normative confusion (e.g., Hviding and Baines 1994, Eythorsson 2000, Jentoft 2000, Lowry et al. 2009, Salvadeo et al. 2021) or delegates/leaders who are not representative of the community can pose barriers for community participation and leadership (e.g., Sutinen and Johnston 2003, Bergho et al. 2008), in addition to problems stemming from influential forces external to the community (e.g., Hviding and Baines 1994, Schreiber 2001, Lowry et al. 2009, Maliao and Turingan 2009, Hossain and Rabby 2019).

5.3.7 Recommendations

Recommendations for management officials, community members / leaders, or researchers were frequently shared in the studies reviewed. In fact, some articles reviewed were, themselves, syntheses conducted with the goal of making recommendations for fisheries management (e.g., Weigel et al. 2014, Montgomery and Vaughan 2018). Across the board, studies generally recommended devolving fisheries management to the local level to at least some degree. In coding these recommendations, I observed a 'chronological' element, in that they tended to fall into three main stages in the process of designing an engagement or participatory process: 1) considerations when setting up the system, 2) guidance for working together, and 3) advice for achieving results, i.e., positive outcomes, recognizing that what is 'positive' will depend on the fishery objectives specific to the system in question (**Figure 5.6**). In setting up the system, many papers in our collection asserted that the defined community in question should be centred from the beginning, so they may take a proactive role, and such that the process will be grounded in local wisdom, including traditional or experiential understandings as well as local values (e.g., Jentoft 2000, Kaplan and Kite-Powell 2000, Hawkins 2002, Nasuchon and Charles 2010, Batista et al. 2011, Kabir et al. 2013, Dong and Guo 2022). In order to attain the trust required to even begin such a process, other papers recommended that the perception of fairness, e.g., via equitable and allocation of resources, be a priority – equity in both process and outcomes matters (e.g., Hawkins 2002).

Table 5.2: Enablers and barriers to community engagement, participation, and leadership in fisheries management

	Conceptual	Logistical	Communication
Enablers	• Shared vision and objectives • Holism • Inclusiveness and openness • Cooperation • Respect • Social normative rationale • Political will • Perceived legitimacy	• Power-sharing • Organized stakeholders with effective leadership • Investments in capacity-building • Equitable allocation of resource rights • Synergism between fisheries and community development • Monitoring and enforcement suitable for local cultural/social structure • Adaptive and iterative process • Long-term commitment • Adequate budgets and resources • Appropriate scale and defined boundaries	• Strong social networks and opportunities for relationship-building, shared learning, mentoring • Social cohesion and solidarity, willingness to participate in collective action • Respect for pluralism • Clear benefits from participating • Consistency in rules, procedures, and scheduling for engagement/participation • Outside assistance with conflict resolution, as needed
Barriers	• Lack of trust in authority or representatives • Opportunism and individualism • Real or perceived lack of socioeconomic exclusion • Real or perceived lack of enforcement • Community development vs. environmentality and uneven conservation burden • Risk aversion in making change • Inappropriate generalizations	• Loss of traditional institutions • High investments of resources • Discontinuities in fishing access • Rapid changes in socioeconomics • Lack of expertise or data availability • Distance from centralized management authority, or too much decentralization • Lack of resources in underserved communities • Existing power dynamics replicated	• Ignoring local needs and values • Weak social ties and normative confusion • "Depersonalized" relationships • Lack of community organization • Non-representative delegates • Groups too small (lack of capacity) or too large (lack of cohesion) • Lack of collaboration with others with synergistic expertise • Diversity of knowledge types without adequate knowledge coproduction mechanisms • Lack of public outreach for new policies • Influential forces external to community

Given that the process must be responsive, adaptive, and iterative (as opposed to linear) (e.g., Nasuchon and Charles 2010, Fletcher et al. 2016, Soomai 2017b, Apa et al. 2020, Salvadeo et al. 2021, Sari et al. 2022), the literature asserts that there must be a willingness to plan and commit for the long-term (e.g., Schreiber 2001, Oerther et al. 2022). Additional studies argue that it is important to acknowledge and analyze the costs of participation, secure external resources and assistance as needed, and perhaps to start with pilot projects until proof of concept can be established (e.g., Harris et al. 2002, Sutinen and Johnston 2003, Montgomery and Vaughan 2018).

Figure 5.6: Recommendations from community engagement, participation, and leadership in fisheries management from a scoping review of the academic literature

According to the literature reviewed, working together requires an understanding that with rights come responsibilities and with obligations come benefits (e.g., Sekhar 2007, Montgomery and Vaughan 2018). Strengthening networks within and across community groups and agencies to move beyond bilateral relationships and empower local leadership is recommended (e.g., Brown and Pomeroy 1999, Mulekom 1999, Noble 2000, Pomeroy et al. 2001, Hossain et al. 2006, Sekhar 2007, Maliao and Turingan 2009, Hoof 2010, Aswani and Ruddle 2013, Grace-mccaskey 2018, Tokunaga et al. 2019, Chitara-Nhandimo et al. 2022). In building such social connections, a number of articles assert that the identification of and inclusion of underrepresented rightsholders and stakeholders is essential, which may require investigating why they have been underserved in the first place (e.g., Barclay et al. 2017, Gauvreau et al. 2017, Marin-Monroy et al. 2020, Mpomwenda et al. 2022, Oerther et al. 2022). Spaces for shared learning and discussion (e.g., Harris et al. 2002, Heron et al. 2008, Gray et al. 2012, Ahmed et al. 2013, Feeney 2013, Weigel et al. 2014, Herrera-Racionero et al. 2015, Nakhshina 2016, Lieng 2018, Apa et al. 2020), and field workers willing to take a hands-on approach (Harris et al. 2002, Lowry et al. 2009), can assist in creating transparency, establishing trust, and building social capital.

Finally, across the literature, achieving goals involved meeting objectives of community concern (e.g., Ruddle 1998, Alpizar 2006, Leopold et al. 2013, Barclay et al. 2017, Mcneill et al. 2019, Marin-Monroy et al. 2020), which typically requires holistic fisheries assessments (e.g., social impact assessments, not just ecological assessments) (e.g., Harris et al. 2002, Aswani 2006, Bergho et al. 2008, Feeney 2013, Barclay et al. 2017, Chambers and Kokorsch 2017, Soomai 2017b, Boubekri et al. 2022, Hamelin et al. 2022). In order to move from idealistic to operational notions of community knowledge, an understanding of baselines and change / progress is essential (e.g., Charles 1997, Weigel et al. 2014, Liao et al. 2019). A broadening of the fishery system beyond "what men do on boats", as Barclay (2017) put it, will demand the inclusion of different sectors from the fishing industry (e.g., processing, sales, consumption) and more diverse 'stakeholders' at the table (e.g., Indigenous rightsholders, women) (e.g., Ikechukwu Uduji and Okolo-obasi 2020, Mangubhai and Lawless 2021). The body of research reviewed here recommends recognition that community knowledge (in all its forms) and community values are dynamic and thus understandings and key goals and concerns may evolve over time (e.g., Leite and Gasalla 2013, Sari et al. 2022). Further, in decision-making processes, a number of articles argue that assumptions and trade-offs must be made explicit (e.g., Bergho et al. 2008, Curry and Curry 2007), and there must be an understanding of how governance institutions at different scales impact or influence one another (e.g., Grace-McCaskey 2018, Mpomwenda et al. 2022) in order to ensure trust and avoid losing social capital through the process. Crucially, across systems, recommendations were made to consider fisheries in the context of other social, ecological, economic, and governance goals in the community, e.g., to consider how fisheries are used as a tool for rural economic development, and to embed fisheries management systems more thoughtfully in existing local institutions working toward such goals (e.g., Hviding and Baines 1994, Jentoft 2000, Weigel et al. 2014, Lieng 2018, López-Angarita et al. 2018).

5.4 Discussion

In fisheries management, 'communities' with relevant knowledge to fisheries management may comprise a wide range of individuals and groups, including local residents, stakeholders, rightsholders, and various experts. These communities hold myriad forms of knowledge, which may yield data or information for evidence-based decision-making. Furthermore, they have important perceptions and preferences that may ensure fisheries governance reflects the values and experiences of those affected by management practices. While a range of enablers and barriers influence the success of community involvement in fisheries management with respect to various conceptual, logistical, and communication-related dimensions, there are broad lessons to be learned and numerous relevant applications.

5.4.1 A community or an industry?

In many cases, the community members, stakeholders, participants, and other groups targeted for engagement in fisheries management were fish harvesters, based on their role as members of a commercial sector, and thus the fishing 'industry' (i.e., those with a financial connection to fishing, including harvesters) does often define the 'community' with desirable knowledge to inform management. This remains true, albeit sometimes to a lesser extent, in less industrialized settings. Some reports focused on fishers as a source of valuable biological or ecological data, which makes sense given the current and ongoing focus on biological stock assessment models as the evidence base for fisheries management decisions, despite ongoing criticism of this reliance on reductive natural science methodologies (see e.g., Silver et al. 2022). Indeed, this local and traditional ecological knowledge, broadly, represents an invaluable source of information at a time when natural history experience and taxonomic skills are becoming more rare, in favour of skills for the realm of 'big data' (see e.g., Able 2016). However, despite recognition of its value, by most involved in fisheries, in practice, it has not always be operationalized to the extent that it could make a large impact (Hind 2015, Stephenson 2016). Given that these individuals are defined by fishing as their livelihood, it was surprising that there was not more focus on 'outcomes' toward economic sustainability, although this may reflect researcher / author perspectives more than those of the fishers themselves.

It should be noted that within groups of fishers, there was some nuance with respect to different community roles. For example, depending on the management regime, active harvesters and quota holders were not necessarily synonymous, and captains and crew faced different opportunities and challenges, leading to power differentials within the fishing sector, in addition to between stakeholder groups. There was also some divergence in how fishers were engaged from industrialized, highly 'professionalized' fisheries (largely in the Global North) as opposed to recreational, or small-scale or subsistence fisheries (largely in the Global South), with highly organized, industrialized commercial fleets having more capacity to play a role as powerful stakeholders, albeit perhaps at the expense of valuable, localized, place-based knowledge of the fishery, as described by Murray et al. (2006) in their characterization of "Globalized Harvester Knowledge".

Importantly, the fishing 'industry' goes beyond harvesters. There were a smaller number of cases in which buyers, processors, and other supply chain actors were engaged as key 'community' members, but disproportionately few considering that they are surely key informants on socioeconomics of the fishery, impacts of governance regimes, and perhaps even biology of fishes (e.g., size distributions relating to life history). In some contexts (e.g., Canada), this disconnect may reflect an issue of jurisdiction, whereby fish harvest is managed federally, while fishery value chains and exports are largely managed by regional (i.e., provincial) agencies. Further, on the topic of scale, while community-based management has been suggested as a means to serve sustainability goals in small-scale artisanal fisheries (Charles 1994), I argue that fisheries on a wide range of scales could receive such sociocultural benefits.

It is significant to note that 'communities' – even 'fishing communities' specifically – do not consist exclusively of the fishing 'industry' – harvesters, supply chain actors, or otherwise. Members of the 'industry' are also, simultaneously, residents of a place-based fishing 'community'. While less commonly engaged in research and management initiatives, these place-based communities also involve the social networks of individuals from the industry - families, friends, peers, and neighbours, in addition to others more tangentially tied to the fishing sector, but nonetheless located close to it in terms of social or geographic proximity.

Perhaps a more holistic definition of community would be to combine the implicit place-based nature given in the Magnuson-Stevens Act (which refers to fishery-related actors "based in such community") with the definition derived from the Small-Scale Fisheries Guidelines (and arguably applicable across fisheries of various scales; https://www.fao.org/voluntary-guidelines-small-scale-fisheries/en/). This could produce a definition of fisheries-dependent communities as place-based "communities whose livelihoods are dependent on the natural marine, coastal or inland resources, with people actively involved in harvesting, processing and/or selling the resources as a primary means of income; **and whose social and cultural identity is integrated into these practices**" [emphasis added] and specifically including "fisheries-dependent families, equally affected by the same vulnerabilities, livelihoods shocks and threats in the fishing sector" (Béné et al. 2015, FAO 2021a).

Notably, there is a gendered component to this community focus, where many studies referencing 'fishers' noted that participants were majority male, while studies referencing social networks more broadly included more women, given their important roles in post-harvest processing and administration. These trends have been explored elsewhere as well (see e.g., Neis et al., 2013; Frangoudes et al., 2020; Knott et al., 2021; Syddall et al., 2022). Thinking about fishing communities beyond 'industry' leads to more diverse voices (who are potentially both highly knowledgeable and highly affected by fisheries management decisions, socioeconomically) being heard. It is interesting to note that, alongside 'community knowledge' in Canada's *Fisheries Act*, "the intersection of sex and gender" is also listed as a decision-making criterion for fisheries management, and thus there is potential overlap to achieve a win-win for inclusion by adopting a more holistic understanding of 'communities'.

Finally, it is interesting to examine the role of scientists and NGO staff as potential 'community members', given that they sometimes facilitate grassroots local representation while at other times appear to be conducting 'parachute' science or conservation work. There can be enormous potential for these groups to support fishing communities, through a community science approach (Charles et al. 2020) that builds a knowledge base and may give voice to underappreciated points of views, or even to play a larger role in 'bridging' or 'broker' advocacy positions (Cadman et al. 2020). However, these positive roles contrast with the risks of (sometimes unintended) negative approaches, which may result in "environmentality" (whereby a community adopts ecological values that undermine its own socioeconomic needs and sociocultural values – see e.g., Quintana et al. 2020).

5.4.2 From inputs to engagement

In considering the community 'knowledge' held by the community members described above, it is important to recognize the data – information – knowledge - wisdom spectrum. In a number of the cases reviewed, community 'knowledge' is considered a key source of data and information, which is why it is deemed in a large number of reports to be seen as particularly valuable in resource-poor contexts, e.g., developing countries with limited scientific capacity (Drew 2005). Despite decades of acknowledgement that local and traditional ecological knowledge hold more value than simply data inputs (Ruddle 2000, Haggan and

Neis 2007, Johannes and Neis 2007, De Young et al. 2008, Berkes 2009, Berkes and Nayak 2018), this remains a primary reason, particularly for natural scientists, to work with fishing communities. However, deeming these data sources "low cost" (Mamun and Natcher 2023), presumably relative to costly technological equipment and professional scientific staffing, fails to acknowledge the social resources required to do proper relationship building and co-development work with communities – identified as enablers in the present study. There has been emphasis on the need to budget for resources before, during, and after any knowledge exchange process (Karcher et al. 2022b). Interestingly, trust in the evidence base from the perspective of the communities was discussed much more frequently than the perceived salience, relevance, and credibility of 'community knowledge' from the perspective of e.g., fisheries managers. This is likely an artifact of our search focus, given that this is an important outcome documented elsewhere in the literature (Cash et al. 2003, Karcher et al. 2021).

Ultimately, 'community knowledge' means 1) communities can give us salient, credible, legitimate information to inform all or some of the pillars of fishery sustainability objectives, and 2) communities have values, norms, cultural interests, and other complexities that need to be recognized in governance. This second point is another reason why one must think beyond fish harvesters in engaging with communities – often times, the values, norms, and priorities of harvesters do not originate within the fishing industry itself, but come from higher-level social or cultural contexts and traditions. Stephenson et al. (2016) conceive of both a knowledge/information gradient from basic observations to experiential knowledge, as well as a spectrum with respect to integration, from 'extractive' data collection practices to information contributions to regimes grounded in participatory governance. More holistic values and norms from communities may be particularly relevant in “strategic” management processes (i.e., where long-term goals and objectives are determined), whereas knowledge as a (perhaps overly simplistic) data input is still useful in “tactical” processes (e.g., year-to-year quota setting). Novel methods such as ‘storylistening’ put forward by Craig and Dillon (2023) may be an effective way to consider community knowledge more holistically within a conventional science-policy space. Importantly, ethical considerations are imperative given that community knowledge of all kinds is proprietary knowledge, and communities and/or individuals within those communities have intellectual property rights, demanding consent and confidentially as needed (see e.g. Silvano et al. 2022).

As non-Indigenous researchers, I recognize that these concerns over rights to data sovereignty are particularly heightened for Indigenous communities, given legacies of colonialism and the prevalence of extractive research practices around the world (Carroll et al. 2020), including within the Canadian context referenced here. In Canada’s *Fisheries Act*, Indigenous knowledge is distinct from community knowledge for important reasons related to the unique and diverse forms of knowledge held by these groups, and the inherent and court-affirmed status of Indigenous Peoples in Canada as sovereign political entities. At the same time, Indigenous Peoples certainly also hold ‘community knowledge’ as well, and conclusions here about how best to engage with community knowledge may help to advance goals around reconciliation in the fisheries sector. On the other hand, management approaches based on community rights favoured by some Indigenous communities in Canada (e.g., communal commercial licences based on principles of community sharing and cooperation to achieve wellbeing, https://laws-lois.justice.gc.ca/eng/regulations/sor-93-332/page-1.html), which are admittedly a small stepping stone on a longer journey toward true decolonization of natural resource management in Canada, could serve as inspiration for frameworks that might work for other types of fishing communities in different cultural contexts (Boyd and Charles 2006).

5.4.3 Overcoming challenges

One must not be naïve in thinking that myriad community members working in collaboration with other governance actors will automatically lead to improved fishery outcomes. Decades ago, Jentoft (2000) noted that when discussing human dimensions of fisheries, overfishing is often attributed to “market failure”, but instead argues it could be better conceptualized as “community failure”. After all, fishing communities do not always fulfill the criteria of an ideal community with respect to shared beliefs, a stable membership, continuing interaction and a direct pattern of relations, and in fact are sometimes characterized by conflicts and inequities, which could become entrenched or magnified if management authority was yielded to the local level. Unfortunately, modern fisheries management (perhaps particularly systems in which harvesters are engaged under the umbrella of ‘industry’ and thus disconnected from their place-based context; Berkes and Nayak, 2018) may exacerbate this issue. Clay and Olson (2008) describe the process of ‘modernization’ in fisheries management which has replaced interpersonal connections and shared identities with “market relationships” which are by their nature “fleeting, impersonal, task oriented and without inherent value”. The result can be weakened social bonds, solidarity, and social responsibility within the fishing community in favour of individualistic profit-seeking, and conflict between the fishing community and management authorities. Potentially slow and challenging interpersonal work will undoubtedly be required to correct for decades of centralization and commercialization of many fisheries, including within Canada.

5.4.4 Moving forward together

It is clear that community knowledge can, in fact, form the basis of many important ecological, social, economic, and institutional considerations relevant to fisheries management, and thus is of critical importance, including in Canada where it is formally recognized within the *Fisheries Act*. Based on the synthesis here, I highlight key considerations for the Canadian context in operationalizing 'community knowledge' in the pursuit of full-spectrum sustainability:

1) Language matters

It is clear that we must reckon with the distinction between fishing 'communities' (per the *Fisheries Act*) and 'industry' (per regular parlance within DFO) – if we say 'community', but mean 'industry', we are using the wrong language; if we say 'industry', but mean 'community', we are not speaking to the right people and need to broaden the scope of who is brought to the table. There are implications for whose knowledge matters in each definition, given that not all resource users are financially tied to fishery resources (e.g., recreational harvesters). Place-based communities may be challenging to define, leading to current debates in Canadian fisheries management about what constitutes 'adjacency' with respect to access priority (see e.g., https://www.dfo-mpo.gc.ca/fisheries-peches/consultation/shrimp-crevette/presentations/FFAW-Presentation-St.Anthony.pdf). After all, where one fishes and where one lives may be close together, but it is not uncommon for a community to live together on land but fish in distant waters, or for 'communities' to come together at sea, but originate from different land-based communities (McCay 1978, Clay and Olson 2008). This leads to the potential need to consider a 'communities of the mind' framework and perhaps, ultimately, a bottom-up derivation of who is the 'industry' versus the 'community' and how these overlap or interface, by those who belong to such groups. In one example from the United States, Sepez et al.

(2006) used cross-scale approaches to do fishing community profiling based on ethnographic site visits, combined with a nested framework that both embeds community-level units within macro-level regional or global contexts, and recognizes micro-level intracommunity heterogeneity.

2) Creating connections

Putting community knowledge into action firstly requires capacity-building to enable collective action, and the design of management structures that "encourage cooperation, build networks, and improve trust within and among local communities" (Jentoft 2000). This may function as a bi-directional process, whereby trust and solidarity are required to facilitate a successful participatory process, and the more localized or participatory the management process, the more individuals involved in management may strengthen their networks and experience a form of 'moral pressure' to cooperate. After all, if the various players in fisheries management - managers, harvesters, buyers, and scientists, as well as others in fishing communities - could encounter each other casually in social spaces in their community, there would be stronger incentive to maintain a civil and fair process than if management agencies and processes are located at a distance. This is relevant in a literal geographic sense, but can also apply in cases where the community is less spatially delineated, but may be united (and therefore isolated) based on socioeconomic status or cultural context.

3) Tracking wins and losses

Just as in conservation (Catalano et al. 2019, Ray et al. 2021), there is an increased need for reflexivity in this space to monitor outcomes over long-term time scales, and to acknowledge, document, and share both successes and failures more clearly. Kearney et al. (2007) already highlighted "evaluation, reflection, and documentation" as key for building the capacity of communities. There could also be greater emphasis on raising the profile of successful cases of fishery stewardship (e.g., Charles 2023; Gasalla and Castro 2016), in the same way that successful NGO or academic partnerships are sometimes lauded.

4) Explicitly recognize community wellbeing

Maintaining legitimate partnerships will require making concerted efforts to achieve community goals related to fisheries (e.g., livelihoods, economic and social well-being). While there is debate within DFO about the extent to which on-land aspects of the fishery (i.e., place-based fishing communities) should be within their purview, "continued prosperity" with respect to fisheries is explicit in their mandate. While I highly recommend the implementation of Social Impact Assessments in the fishery assessment process (per Feeney [2013], analyzed here), I acknowledge the limited resources to conduct socioeconomic research within DFO at this time. Achieving such objectives may therefore require interfacing with development institutions across both disciplinary and sectoral silos in order to achieve a holistic conception of community wellbeing and sustainable livelihoods (e.g., considering physical, social, human, and financial capital; see Charles 2012; Gurney et al. 2014).

5.5 Summary

The impact of community knowledge may come in the form of enhanced knowledge of a target species or the ecosystem, which is key for recent objectives towards the achievement of ecosystem-based management (Link et al. 2011, Curran et al. 2012, Bundy et al. 2021, Pepin et al. 2022), but also in establishing perceptions and priorities for management, assessing and explaining socioeconomic dynamics, and rebalancing power relations for enhanced fisheries governance. Community knowledge may be essential in decision-making situations in which scientific capacity is low, but it should not be seen as a 'last resort' source of information, as it is both unique and comprehensive in its scope, albeit subject to limitations (see e.g., Hill et al. 2010), just as scientific methodologies are. In strengthening the evidence base - while pursuing reconciliation, credibility, and legitimacy - for fisheries management decision-making in Canada, community knowledge can serve as a cornerstone.

CHAPTER 6 - Conclusion

One view of fisheries management is that its purview involves conducting assessments to set a desired level of fishing; designing robust, adaptive, precautionary management schemes; and developing appropriate institutions to govern such processes (Charles 1998, Hart 2021). This is no easy task. The uncertainty and complexity inherent to fisheries systems, and heightened in the context of the Anthropocene, demand ongoing reflection, drawing from diverse knowledge systems and participants, and implementation of adaptive and deliberative decision-making (Walters 1986, Chaffin et al. 2016, Berkes 2017, Clement 2022). In this thesis I respond to these needs by mapping current information use pathways relevant to rightsholder and stakeholder engagement in Canadian fisheries management, exploring patterns in recreational mackerel harvest based on both observation of and contributions from local anglers, surveying anglers of Atlantic mackerel to describe the social and cultural characteristics and priorities of their community, and scoping the fisheries literature to explore a working definition for the 'community knowledge' that may inform management. In this final chapter, I bring this work together to summarize my major findings, address caveats, and explore implications. In doing so, I envision a pragmatic path forward for Canadian fisheries management towards objectives that support full-spectrum sustainability.

6.1 Major findings

In Chapter 2, I explored recent *Fisheries Act* amendments regarding "Decision-making criteria" to assess current science-policy and advisory processes at Fisheries and Oceans Canada. Given a focus on decision-making criteria informed by rightsholders and stakeholders, I used a variety of science advising documents and briefs for decision-makers from a subset of commercial fish stocks to identify opportunities for information and knowledge contributions in DFO management processes. This yielded insights into how alternative knowledge forms are discussed in Integrated Fisheries Management Plans, how information types appear in stock assessment documents, who attends stock assessment peer review meetings, and what content is ultimately included in briefing notes. I identified the extensive, albeit sometimes superficial, engagement of the fishing 'industry' informing management, the apparent under-representation of Indigenous knowledge informing management, and the strong focus on biological and ecological dimensions of fisheries in both explicitly scientific and broader advising processes. Further, I explored the limitations of current practices on true mobilization of information contributed during consultative processes.

In subsequent chapters, I used recreational fishing of Atlantic mackerel as a case study, firstly to estimate patterns and volumes of catch from the recreational sector to address data gaps, which are especially pronounced in light of recent commercial and bait closures (Chapter 3). I developed and tested a dockside monitoring protocol, in combination with data collected and self-reported by mackerel angler collaborators, to document operational dimensions of the fishery such as catch, effort, and discards. It appears two primary cohorts of mackerel passed through the waters off HRM in that particular year in late July and early fall. This pattern of multiple pulses in catch over the course of the season was repeated to some degree (albeit with variation in timing and magnitude) in the interannual catch reported from one avid mackerel angler. His catch also varied year to year, likely in response to known mackerel population fluctuations and perhaps as a function of management regime. While overall catch rates were relatively low, particularly in recent years in response to restrictions such as the bag limit, I identified a substantial proportion of discards, highlighting the importance of future research into post-release survival of undersized or otherwise released mackerel.

Next, I sought to explore the social and cultural dimensions of fisheries in action by identifying fishing community members and their motivations for recreational mackerel fishing (Chapter 4). I conducted a questionnaire with mackerel anglers around Nova Scotia to document demographics, fishing practices, and preferences and priorities for this under-engaged stakeholder group. The result was the identification of food, sport, and bait as key benefits and motivations for fishing in a group that is male-dominated and majority working-age, but includes diversity with respect to ethno-cultural backgrounds across rural to urban fishing locales. In addition to perspectives I explicitly solicited, a wide range of opinions on the state of mackerel management were shared as free-form comments, including reasons for supporting, disagreeing with, and wanting to change existing regulations. Among these, concerns about the post-release survival of discarded mackerel were also raised. These insights may help inform engagement opportunities for recreational anglers in the future. As Klenk (2018) notes, "the stories that puncture our tidy methodologies" are not necessarily distractions from the primary research questions, but in fact reveal connections in how people think about or experience the topic at hand.

Finally, my exploration of current DFO advising practices, combined with my practice experience learning from fish harvesters, led to the need to delve deeper into a potential working definition of 'community knowledge' for decision-making, as referenced in the *Fisheries Act*. A scoping literature review was conducted (Chapter 5) to investigate who might constitute the 'community', what community knowledge might entail, and how outcomes from community involvement might contribute to full-spectrum sustainability, with recommendations for how best to engage and empower communities in fisheries management. I found that while fisheries management is largely framed as a bilateral process between governments and harvesters, there are many more individuals and groups who could be involved, including other members of the ‘industry’, value chain actors, as well as the broader place-based communities to which harvesters belong. Community knowledge can contribute both data for operational aspects of a fishery as well as perceptions, values, and norms essential to higher-level strategic aspects of management, with relevance to achieving social and institutional sustainability.

Together, these results show that current fisheries management and policy advisory systems in Atlantic Canada already engage rightsholders and stakeholders in numerous aspects of both assessment and governance. However, there are ongoing concerns about the extent to which these contributions yield credible information for decision-making, the extent to which science-policy processes align with stated fisheries management objectives, and the extent to which all relevant rights/stakeholders are participating in the system in a manner that is both fair and useful. To begin tackling these challenges, I demonstrated that there are additional stakeholders ready, willing, and able to participate in fisheries assessments informing management. Finally, I provided evidence that creative approaches to data collection can yield insights into fish species and fishery operations often considered difficult to study. These issues must be addressed if aspirations of ecosystem-system based management based on full-spectrum sustainability are to be realized in Atlantic Canada (Bundy et al. 2021).

This work also responds to and expands upon recent commentary on the extent to which DFO science advice meets standards for science advice to governments (Gluckman 2016, Hutchings and Stenseth 2016), summarized as the following four hallmarks by Godwin et al. (2023): impartial, evidence-based, transparent, and independently reviewed. It may seem controversial to explore options for enhanced engagement with stakeholders and rightsholders considering recent calls to remove "competing interests and ideologies" from DFO science advising (Godwin et al. 2023). However, the reality is that stakeholders are not simply attending peer review meetings, but are in fact producing large portions of DFO scientific data (Chapter 2), and it has been long-known that DFO relies on numerous collaborators to conduct surveys partly because of their practical expertise and partly because they provide resources and capacity that are too costly for the government to bear (DFO 2004). We literally cannot afford to remove this capacity from the fishery assessment process.

Calls for an independent scientific body to assess fisheries external to DFO (Godwin et al., 2023) align with recommendations here to include more scientists external to DFO in scientific peer review and to allocate separate data streams and consultation spaces to investigate socioeconomic data and industry or local concerns. Indeed, this is not a new concept, as the Fisheries Research Board of Canada (1937-1979) was such an independent entity, and the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) functions as an independent body that also explicitly considers (at least to some degree; see Turcotte et al. 2021) Indigenous knowledge (Hutchings 2022). In other jurisdictions, the International Council for the Exploration of the Sea (ICES) in Europe or the Scientific and Statistical Committees of Regional Fishery Management Councils in the United States offer other alternative science advising institutions (Hutchings 2022). In fact, since the publication of Chapter 2, and in response to recommendations from the Standing Committee on Fisheries and Oceans (DFO 2023b), DFO has now created a voluntary Registry for External Science Experts[57].

[57] https://www.dfo-mpo.gc.ca/csas-sccs/registry-external-experts-repertoire-experts-externes-eng.html

However, it appears this discourse also both downplays the value that harvesters and their communities can bring as partners in research (perhaps stemming from the 'fishing industry' conceptualization as opposed to the 'community' definitions explored here). Furthermore, it ignores the reality that fisheries management decisions are always, to some degree, political decisions (Röckmann et al. 2017), and this can occur either by externalization (via outside influence) or politicization (via internal partisan influence) (Craft and Howlett 2013). Like many interdisciplinary fisheries researchers, I instead argue that the solution is to embrace a social-ecological approach in which the various competing objectives in fisheries management are made transparent and explicitly assessed to facilitate the appropriate weighing of trade-offs in pursuit of a sustainable fishery (see also Rice 2011).

6.2 Reckoning with different forms of knowledge

By considering different ways to study and participate in fishery systems, I am by necessity considering different forms of knowledge, namely distinctions and synergies between scientific knowledge ("dominant science", per Liboiron 2021) and local or traditional knowledge, in addition to the consideration of Indigenous knowledge. As explored in Chapter 5, salient (e.g., community) knowledge (broadly defined) related to fisheries can both yield data and information to inform fisheries assessments and, from a larger participatory governance lens, can inform protocols and priorities for fisheries management. It can be challenging to speak about knowledge in a way that is not reductive. The natural sciences have been notorious for both treating experiential knowledge simply as a data input, and using a deficit model framing in science communication (i.e., citizens lack knowledge, are incapable of grasping scientific complexity, and therefore are in need of education; Pouliot and Godbout, 2014). Alternative models (Cooke et al. 2020), such as Two-Eyed Seeing (Reid et al.

2021), have been developed for drawing from Western and Indigenous knowledge systems, with “limits and possibilities” explored by Roher et al. (2022). While such approaches were not exactly within the scope of the goals of this thesis, efforts were made here to ensure that knowledge (including scientific knowledge) represents its full suite of practices, values, and beliefs.

Consistent with my findings in Chapter 2, Boyd and Charles (2006) identified that ecological indicators are most frequently monitored for and thus available to inform fisheries management, but they also articulated that ecological dimensions may be particularly difficult to assess with local-level monitoring owing to the spatial mismatch between ecological boundaries of a fish population and political boundaries of place-based fishing communities. This is not to say that fishing community members are not knowledgeable about marine ecology, as they are in fact experts in many facets (Hind 2015, Stephenson 2016). However, implementing scientific methodologies within or alongside community knowledge remain very useful in this domain, particularly for wide-ranging species or species that are less visible or socioeconomically significant (Berkes et al., 2012), such as Atlantic mackerel studied here (Chapter 3). However, in contrast, Boyd and Charles (2006) found that socio-economic and institutional indicators are particularly practical and salient at a local level. This is evidenced by the rich insights shared by mackerel anglers in Chapter 4 about their social community and cultural practice. Furthermore, Wiber et al. (2004) sought to co-develop research questions of interest with fish harvesters in Atlantic Canada and found research themes of power sharing, defining community boundaries, access and equity, effective management planning, enforcement, and scaling up solutions to be of great interest. Thus, achieving more holistic fisheries assessments in support of full-spectrum sustainability and involving more individuals, groups, and institutions from fishing communities in the management process may naturally go naturally hand-in-hand.

While Chapter 5 offers a highly detailed exploration of how best to engage with community knowledge toward the goal of full-spectrum sustainability, there remain some contradictions. For example, social organizing within the community can both help and subvert their role in fisheries management under different circumstances; group should be small, but not too small, etc. Furthermore, societal systems (e.g., systemic racism, misogynism), trends (e.g., globalization, inflation, precarious employment, climate change), and cycles (e.g., seasonality) may undermine community potential for contribution, participation, or leadership (e.g., Gutiérrez et al. 2011; Straka et al. 2018). Given this context-dependence, there might be a need for multiple local-level experiments with collaborative fisheries assessment and management strategies, particularly given that "exposure, susceptibility, and adaptive capacities of biophysical and human social marine systems vary immensely", e.g., under climate scenarios (Perry et al. 2010).

Acknowledging the full breadth of what knowledge can encompass can be an asset in a consultative or collaborative setting, as the recognition of the importance of beliefs and values can allow for a clearer articulation of objectives and how best to achieve them (e.g., Cadman et al. 2023), and pave the way in case of a need for conflict resolution. The reality is that while scientists define credibility with respect to sound experimental design and rigorous analysis, there is evidence that harvesters, for instance, instead evaluate credibility based on "communication style, relationships, and relatability" (Runnebaum et al. 2019). However, it can be difficult to use this relational form of communication and thus engage the full scope of various knowledge contributions in current fisheries management structures, given that, as Clement (2022) notes, "Status-quo bias is a well-known issue in institutionalized environments, but this is not just about habit. It is also about reluctance to scrutinise the relationship between science and values." Furthermore, even within the scope of a widely accepted form of knowledge like Western science, inclusion of information from the social sciences remains challenging due to perceptions that qualitative research is 'anecdotal', meaning unscientific or unreliable, which grossly underestimates the richness and value of documenting experiential stories ((Bennett 2019, McAleese and Kilty 2019). While analytical methods such as fuzzy logic cognitive maps, or the Bayesian techniques used here (Chapter 4), can effectively merge quantitative and qualitative insights (Ommer et al. 2012; e.g., Chapter 4), there is still the suggestion that to be considered valid, qualitative work must be translated into quantitative metrics. This remains a significant barrier to the inclusion of socioeconomic insights into fisheries management in Canada, especially for cultural dimensions not easily reduced to quantitative measures (Bennett et al. 2021b). Fortunately, there is work underway to develop guides for using social science in natural resource decision-making (Charnley et al. 2017). It should be a priority, as Fernández-Llamazares et al. (2021) argue for the need to develop assessments for 'biocultural status', explicitly linking biological and cultural value of natural resources toward actionable place-based practices.

Generally, there is a call for increased diversity in knowledge inclusion in natural resource management, partly based on a desire to have a richer, more timely evidence base for decision-making at the level of resource assessments (Murphy et al. 2022), as explored in this thesis, but also based on ethics, as a democratic principle with respect to governance. However, this goal is more complicated than it appears. Clement (2022) noted that "when decision-makers are faced with political and social realities of bringing in more voices, the result is often more populist than pluralist". Furthermore, variability in how different individuals and groups perceive ‘facts’ is a key driver of environmental conflict (Verweij et al. 2010), often rooted in the very differences in sociocultural information capture, processing, and life experiences inherent in collaborative information-gathering and decision-making settings such as those advocated for here (Atran et al. 2005, Bang et al. 2007).

Such a situation in which multiple witnesses experience an event differently, but nonetheless accurately based on their distinct point of view, has been termed the ‘Rashomon effect’ (Heider 1988) and has been demonstrated to exist in conservation settings, particularly where there is a compelling issue at play and significant uncertainty exists (Levin et al. 2021). A well-known example is ‘shifting baseline syndrome’, where successive generations of people accept their present state of the ecosystem as a baseline reference point (Pauly 1995, Dayton et al. 1998, Levin et al. 2021). Another example highly relevant in fisheries is variation in perceptions of trends of species abundance, which is an ongoing challenge for Atlantic mackerel management, particularly in light of recent commercial closures. While DFO assessments have indicated too low of an abundance to warrant continued commercial fishing, harvesters (particularly in Newfoundland) have been vocal in communicating how abundant their own mackerel observations have been during recent Atlantic Mackerel Advisory Committee meetings. Of course, both trends can be true simultaneously, i.e., there can be very low overall population numbers and unusually high local abundance in locations where mackerel would not normally congregate. However, the result is conflict over the degree to which harvest must be regulated to meet both ecological and economic goals (Levin et al. 2021).

It has been argued that the influence of dynamics like the Rashomon effect is the precise reason policy-makers frequently turn to scientific data in decision-making in order to provide objective evidence, assuming the conventional positivist view that scientific knowledge is generalizable, unbiased, and value neutral (Levin et al. 2021). However, science has at its essence continual improvement and competing hypotheses, which means scientists disagree as well, and often. This can be either because their information is incomplete, or they interpret a given set of information differently, and ignoring the Rashomon effect might affect the possibility of reconciling divergent ideas or successfully navigating complex options and outcomes (Levin et al., 2021).

In spite of these challenges, it is worthwhile to consider strategies to preserve plurality of world views and therefore diversity of possible information sources, partly because it nevertheless can be associated with positive outcomes (Conway and Pomeroy 2006) and also because consensus in any group is often conditional or transitory, and often requires some degree of exclusion, so eliminating all conflict may not be possible or even desirable (Mouffe 1999). This is relevant to the premise of agonistic pluralism, which suggests that with a balance between mutual respect and recognizing points of conflict, solutions to public problems (such as those tackled in fisheries management) can be advanced (Mouffe 1999, Levin et al. 2021). There is, however, some debate about whether it is best to engage with people as individuals such that they could best exercise personal judgement in an advisory role (i.e., a "hats off" policy, notably difficult or impossible for government officials) or with individuals as representatives of their stakeholder group, which might enhance accountability but limit inclusion (Parlee and Wiber 2018). Nonetheless, mapping out and considering differing points of view and how they arise can also facilitate important reflection on one's own ability to grapple with complexity (Levin et al. 2021). However, further research on navigating conflicts in marine governance spaces is required, as even within the social sciences, such studies tend to be limited in scope (Dahlet et al. 2023).

One can further question, in the context of a settler-colonial state such as present-day Canada, whether the intricacies of the science-policy interface and the associated decision-making processes are the most urgent concerns within the realm of community knowledge, or whether higher-level questions about natural resource sovereignty must be tackled first. Lanque Zonta et al. (2023) assert that sustainability science has not achieved its decolonial potential, regardless of the implementation of transdisciplinary approaches. Further, the Yellowhead Institute maintains that all recent amendments to the *Fisheries Act*, which are in fact much more extensive than those analyzed here (Chapter 2), at first glance appear to create frameworks to support Indigenous rights to fisheries, but in fact are inadequate to fully address past and ongoing environmental justice issues (Claxton 2019). This is partly because a federal act governing fisheries is itself contrary to the notion of Indigenous sovereignty (Claxton 2019). Ultimately, seeking one-size-fits-all solutions is likely to fail, and a focus on locally-relevant systems must be a priority given the diversity of circumstances and strategies in existence (Ostrom 2007).

Finally, while I regularly reference distinctions between scientific and local or traditional knowledge, a clear conclusion from my work is that these categories are not discrete (see also Bjordal, 2021; Beaulieu-Guay, 2022). Furthermore, even if one appreciates that these knowledge typologies can nonetheless be useful to understand epistemic differences, a given individual may hold multiple forms of knowledge simultaneously. For example, fish harvester Gary (Chapter 3) has demonstrated both local knowledge and scientific knowledge in his fishing practice and data collection protocols. I recognize that one perhaps does a disservice to individuals at the fisheries management table when grouping rightsholders / stakeholders into ‘categories’ and presuming expertise accordingly. While there are innumerable references to “integration”, “braiding”, and otherwise "combining" of knowledge types within the knowledge co-production or science-policy literature, there is a difficult balance to strike between avoiding both extractive and assimilative framings. Here, I favour the analogy of a patchwork (similar to the 'quilt' metaphor used by Stephenson et al., 2021), rich with variety and overlap.

For my own part, while I approached this work initially from the perspective of an ecologist with an interest in human systems, I also possessed local knowledge given my long-term residence in Nova Scotia. In this thesis, I also drew from training, collaboration, independent study, and mentorship in a diverse range of disciplines including political ecology, environmental economics, human geography, philosophy, and the health sciences. Nonetheless, a variety of metaphors from ecological theory may hold relevance here. After all, a 'community' is a key concept in ecology as well, defined in that field as a group of (potentially) interacting species living in a particular location. Community ecologists are broadly interested in factors that affect biodiversity, the structure and function of communities, and the diversity and abundance of species. While I hesitate to draw direct parallels between human societies and behaviour, and those of non-human organisms, one can, in theory, pose similar questions in fishing communities or science-policy systems that one would in any other type of ecosystem.

For example, in Chapters 2 and 4, I ask questions drawing from notions of both 'richness' (how many different groups exist within a rights/stakeholder community) and 'evenness' (how many individuals belong to each of these groups), with implications for dominance and function of the larger collective. Within or between rightsholder / stakeholder groups, one might consider distinctions analogous to ecological 'guilds', defined as "a group of species that exploit the same class of environmental resources in a similar way", sometimes more commonly known as a 'functional group' (Simberloff 1991). This concept encompasses the nuance that the identity of an individual and the role that they play in a group or system can be separate, but related, considerations. The potential 'roles' for these individuals or groups are perhaps analogous to niches, defined in ecology as "the set of conditions that permits a species to exist in a particular biotype" (Simberloff 1991). In a human system, (see e.g., Chapters 2 and 5), we can question what roles could or should exist, and how capacity-building can facilitate them. While outside the scope of my research, one can extend the metaphor to ask further questions, analogous to those in food web ecology, such as how different forms of diversity, relationships, or environmental context lead to stability or resilience in a community. While one must use caution in applying theory from one field to another in which different paradigms and methodologies exist, drawing inspiration from across disciplines can inform social-ecological systems research, similar to recent work by Curran et al. (2023) with respect to marine spatial planning.

However, what one cannot ignore are the ongoing power dynamics that accompany the current conceptions of knowledge types, and the ways in which decades of both formally prioritizing natural science and informally considering fishing industry and other stakeholder desires have distorted the way in which evidence is weighed and decision-making is perceived. Increasing use of management strategy evaluation tools will be critical to development of a more proactive, transparent, and inclusive process (Goethel et al. 2023). The development of social harvest control rules to explicitly recognize social objectives and assess social outcomes has been suggested by Barclay et al. (2023). These methods also support goals of implementing an ecosystem approach to fisheries, which must consider not only target fish species and fishing activity within the context of the ecosystem, but also the fishery within a larger context of households and communities, in a broader institutional context (De Young et al. 2008). Explicitly acknowledging information contributions, fully and transparently evaluating all dimensions of concern to rightsholders and stakeholders (including socioeconomic considerations), and making clear the trade-offs among options are essential as a starting point.

6.3 Considering wellbeing and sustainable livelihoods

Increasing interest in fair and sustainable responses to social-ecological change has led to questions about trade-offs with implications for equity and justice (Avelino et al. 2016, Avelino 2017, Bennett 2018, Friedman et al. 2018). Here, perceiving fisheries rightsholders and stakeholders as part of a 'community' as opposed to 'industry' members is a shift that is reminiscent of the concept of 'blue communities' which has emerged in reaction to the recent push for a 'Blue Economy' (Campbell et al. 2021), or the contrast between efforts towards 'blue growth' versus 'blue justice' (Bennett et al. 2021a). In fact, generally, there is expanding interest in 'humanizing' (e.g., Curran et al., 2023) the effects of environmental change and natural resource management planning, and a key theme emerging from my research is the link between fishery objectives and human wellbeing metrics (UNEP 2006, Breslow et al. 2016). Breslow et al. (2016) identified three reasons for increasing awareness of these connections: social-ecological systems thinking (McLeod and Leslie 2009, Mace 2014), the paradigm of ecosystem services (UNEP 2006, Hinson et al. 2022, Custodio et al. 2022), and a desire for a metric of social progress that is more effective than conventional economic measures (e.g., gross domestic product [GDP]; Cobb and Rixford, 1998; Gough and Allister McGregor, 2007; Stiglitz et al., 2009).

In many places, fisheries tend to have a disproportionately large political significance considering their economic contributions at a national scale. This happens for a variety of reasons, including historical and cultural significance, and geographic concentration in otherwise economically disadvantaged (often, but not necessarily, rural) areas (de Sombre and Larkin, 2011). One must also recognize the unique role of recreational fisheries, which are not only implicated in formal economies, but as described in Chapter 4, also have strong sociocultural dimensions (Fowler et al. 2023). A key impetus to achieving full-spectrum sustainability in fisheries, therefore, is to consider the objective of coastal community wellbeing more holistically. With that in mind, a framework such as the Sustainable Livelihoods Approach (SLA) (Serrat 2017) could be more widely used in a more holistic and participatory fisheries management paradigm. Finding the right balance between stakeholder participation and their allegedly problematic advocacy in science advising processes (e.g., Winter and Hutchings 2020, Godwin et al. 2023) could be appropriately addressed by internalizing the concept of livelihoods as part of the fisheries management process, keeping in mind the holistic definition of 'fishing community' explored in Chapter 5. While originating from an international development context, the SLA framework could hold relevance in more developed countries like Canada as well, whenever livelihoods and community wellbeing are considered fishery goals (Charles 2012, Stephenson et al. 2019).

The Sustainable Livelihoods Framework (**Figure 6.1**) supports a holistic definition of 'livelihood' that requires the consideration of not just financial, but also physical, social, human, and natural capital, and thus is inclusive of different fisheries with varying objectives. Reminiscent of the Doughnut Theory (Raworth 2017), this framework ensures that 'natural capital' (the current focus of fisheries assessments) is not sacrificed in the name of socioeconomic concerns, but also that a diverse range of social and economic considerations are prioritized. There are also separate 'wellbeing' frameworks which could expand on this premise (e.g., Coulthard et al., 2011). Ultimately, these frameworks offer "a perspective very different from the conventional one of humans as narrow-minded exploiters of the ocean, one that recognizes how livelihoods and well-being of people go hand in hand with resource sustainability and ecosystem health" (Charles 2012).

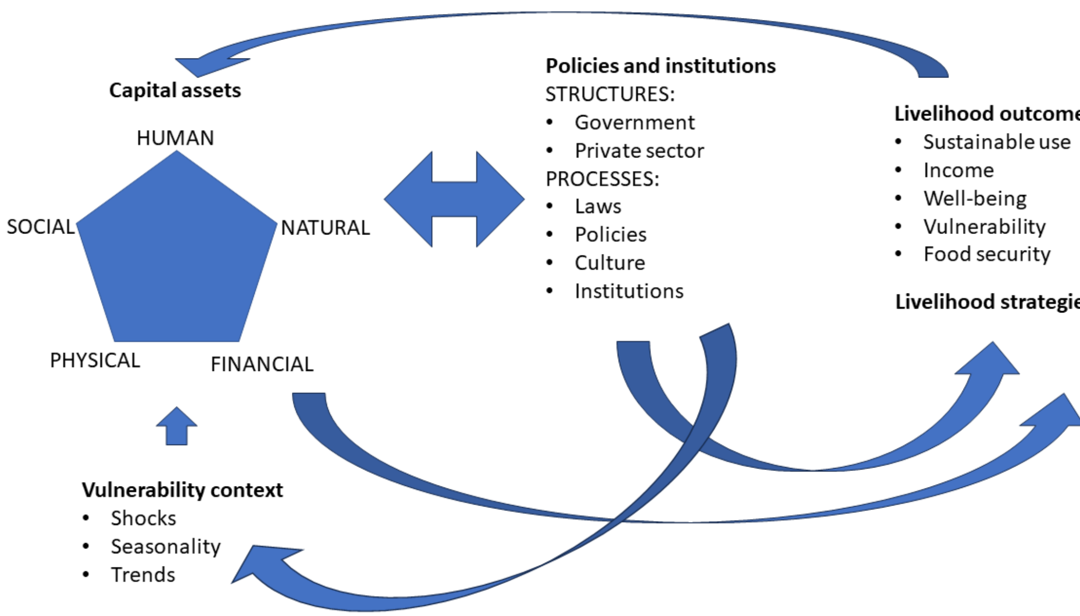

Figure 6.1: Sustainable Livelihoods Approach framework (adapted from Serrat 2017)

In fact, while it is widely accepted that 'healthy' fisheries and oceans can support human wellbeing and support livelihoods, it is perhaps less appreciated by some that the relationship can work in the other direction – that healthy coastal communities, where rights are acknowledged and social cohesion is strong, are essential to healthy fisheries and healthy oceans more broadly (Jentoft 2000, Allison et al. 2020). There is a dominant paradigm, and perhaps a false dichotomy, in Western culture that conceives of human relationships with ocean ecosystems as either exploitative and damaging, or highly romanticized. For example, in Braiding Sweetgrass, Kimmerer (2013) recounts an exchange she had with a university class in which they could not list any examples of humans living “in a good way with” (i.e., with reciprocal care for) the earth. On the other hand, from the world of urban planning, Jane Jacobs (1961) cautioned against overly romanticizing ‘nature’ such that one loses humility about one’s place in it: “Most sentimental ideas imply, at bottom, a deep if unknowledged disrespect.” In reality, it is clear that humans can simultaneously be both users and stewards of ocean resources (Ostrom 2007).

Consider, for example, the insights presented here in Chapter 4 from recreational mackerel anglers, who generally have great interest in and care for the species, while enjoying harvesting and consuming mackerel as a nutritious food. It is also possible to draw from the long histories of numerous customary and Indigenous traditional fisheries, yielding sustainable harvest over centuries and adequate benefit for local communities (Jones et al. 2010, Claxton 2019, Hessami et al. 2021). It appears that our colonial-capitalist history has severed the primal connection many Canadians might otherwise have to the ocean and its inhabitants (Campling and Colas 2021), sometimes including fishing communities and fish harvesters themselves who increasingly rely on modern technology and are under pressure to earn a living wage for themselves and their crew (Murray et al. 2006). However, I assert that it is not too late to rebuild relationships within and between our societies and ecosystems toward the goal of wellbeing and resilience, perhaps using emerging and resurging approaches that embrace the kind of relational thinking introduced here (Muhl et al. 2022, Eyster et al. 2023).

However, it is worth keeping in mind, in any case, that fisheries will never be a panacea for the wellbeing of coastal communities, and in fact reliance on a single fishery may be an economic disadvantage. Without wanting to frame fishing communities in a “damaged-centred” way that suggests an exaggerated sense of hopelessness and vulnerability (Tuck 2009), the reality is that many fishing communities, including in Canada, are vulnerable to socioeconomic and environmental shocks (e.g., Greenan et al. 2019). Therefore, it is worthwhile to consider work by Ouanian (2019), who asks whether fish harvesters are “staying to fish or fishing to stay”. Cases where fishers primarily live in their community because of the lifestyle and culture of fishing, despite other challenges, might benefit from different development strategies (within or beyond fisheries management), than those who live in a particular community and fish only because there are no other (lucrative) employment opportunities (what Ommer [1994] would call “the fishery as an employer of last resort”). We must also not ignore the relevance of community design and urban economic development in fisheries management, partly because some fisheries (including recreational mackerel fishing, as documented here) take place in urban waters (Chapters 3, 4), and partly because there is interplay between the socioeconomic conditions in urban and rural environments (Bennett et al. 2019). Reaching across disciplinary and sectoral silos within the realm of community economic development and social services will be essential.

One step toward social and economic sustainability already taken in a country with similar sociocultural characteristics as Canada would be the Social Impact Assessments conducted by NOAA Fisheries in the United States (Clay and Colburn 2020). Economic analysis is also now being given higher priority in other jurisdictions, e.g., ICES (Thébaud et al. 2023). Helpfully, Bennett et al. (2021a) recently summarized frameworks and resources to guide management agencies at all levels in conducting socioeconomic analysis of fisheries. Currently, while some socioeconomic analysis is conducted for fisheries within the Policy and Economics branch of DFO, and potentially within the new Blue Economy Secretariat[58], the results of such evaluations do not appear to be published, shared transparently in any DFO processes, or to consider less quantifiable sociocultural considerations, such as those evaluated here in Chapter 4.

[58] https://www.dfo-mpo.gc.ca/campaign-campagne/bes-seb/index-eng.html

6.4 Decentralization vs. unification

In considering a more holistic definition of fishing communities per Chapter 5, it is essential to understand that, generally, engagement with rights/stakeholders is presently done on the basis of individual or groups of target fish stocks and linked to a particular DFO regional jurisdiction (Chapter 2), which appears to be assigned based on the distribution of a given target species, the location of most harvesters, or the capacity of various DFO offices. Thus, geographic proximity of management officials and scientific assessment teams to fishing communities varies, with potential for significant social-ecological mismatch (Perry and Ommer 2003, Bodin 2017). Local-level human dynamics do not appear to hold relevance in current fisheries advising systems, as the focus appears to be engaging with the industrial sector as opposed to other fisheries (e.g., recreational) or with place-based communities (Chapter 5). However, many stakeholders and rightsholders choose to organize themselves in fishing associations based on region. For example, in advisory committee meetings for Atlantic mackerel I have observed stakeholders forming ad hoc coalitions (e.g., by province) when advocating for themselves.

Therefore, if the community knowledge of place-based communities is to be fully realized in fisheries management in Canada, there may be some degree of decentralization required within current institutional structures and processes. Stewardship is associated with knowing, caring, and having agency to take responsible for something, and decentralization is a means of shifting that responsibility (Hart 2021). There are three forms of administrative decentralization described by Pomeroy (1995): 1) deconcentration, where decision-making authority and responsibilities are transferred to local institutions, but remains supervised by a central ministry; 2) delegation, in which responsibility is transferred, but a central authority retains the right to reclaim power; and 3) devolution, a more complete transfer of authority without reference back to a central ministry. I propose that only when a significant number of the enablers identified in Chapter 5 are in place and when barriers identified are removed or reduced could such decentralization be successful. This process must also be realistic, in line with the extent to which local communities wish to be involved or have a leadership role. While some studies report stakeholders seeing positive effects of participation or leadership in collaborative processes, one cannot ignore the logistical, social, and emotional toll that co-management schemes can exert on their participants (Young et al. 2020). Furthermore, Gregory and Grant-Smith (2022) caution against processes which may result in a neoliberal "responsibilisation", in which the state divests itself of the responsibility of meeting the needs of the citizens. Appropriateness for various systems will likely vary across communities and fishing sectors as well.

These decentralization concepts also have relevance in navigating different approaches to achieving decolonized fisheries in Canada. Some Indigenous Peoples (e.g., Inuit in Nunutsiavut; Cadman et al., n.d.) have expressed interest in ongoing co-management with the federal government or have signed rights reconciliation agreements (e.g., Haida Nation [Jones et al., 2010]; Elsipogtog and Esgenoôpetitj First Nation, New Brunswick; Wolastoqiyik Wahsipekuk, Quebec[59]). On the other hand, other First Nations groups including some Mi'kmaq in present-day Nova Scotia and New Brunswick have made it clear that Indigenous sovereignty in fisheries for them is only possible through complete devolution to their communities (Waldron et al. 2020). Ultimately, the extent to which improving fisheries assessment and management strategies

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[59] https://www.dfo-mpo.gc.ca/transparency-transparence/briefing-breffage/2021/livelihood-subsistance-eng.htm#:~:text=Rights%20reconciliation%20agreements,group%20in%20the%20treaty%20process.

across communities might be sought within or external to government systems will vary.

One could argue that DFO is already decentralized within a deconcentration paradigm, in the sense that fisheries management activity is already largely dispersed to regional offices, as opposed to maintained within the National Capital Region. Furthermore, enforcement activities by DFO Conservation and Protection officers are centred in still smaller local offices in rural communities around Atlantic Canada, although one might question the optics and social dynamics associated with only spending time in fishing communities to maintain rules and regulations imposed on harvesters. In fact, Soomai (2017a,b) noted that poor communication and organization between DFO offices, branches, and regions sometimes leads to challenges in Canadian fisheries management. Discrepancies in approaches among regions were also identified here in Chapter 2, albeit not thoroughly explored. These limitations may lead to 'transboundary issues' more commonly found in international fisheries governance, yet taking place within a single country. In such a case there might be tension between both overly generalized and disjointed information at various scales throughout the organization. The result is a paradox in which DFO may currently be both too centralized to engage with local-level concerns adequately and not centralized enough to have consistency and clear communication within the institution.

It is also clear that while having fisheries management centred in DFO in a quasi-command-and-control setting is certainly about maintaining federal authority over fisheries (Silver et al. 2022), from a practical viewpoint, one could also argue that it is ultimately a cost-saving measure to streamline and reduce redundancy, especially in a marine space where even basic scientific capacity is extremely costly. The reality is that the federal government is balancing numerous priorities, of which "fisheries and oceans" is one, and the level of interest and investment in the department tends to vary as the political climate in Canada evolves (Hutchings and Post 2013, Bailey et al. 2016, Castañeda et al. 2020). However, there are often trade-offs between short-term cost savings and long-term resilience. I argue that, in the long-term, empowerment of local-level institutions would reduce the in-house resources required to support DFO operations, while also making fisheries governance more resilient to changes in the internal political climate.

Across democratic systems, there is a spectrum from "representative and technocratic" (wherein the government is prescriptive, and the community is advisory) to "participatory and empowered" (in which the government coordinates, facilitates, and supports, while the community leads inclusive and equitable decision-making) (Kearney et al. 2007). With this in mind, one could perhaps shift the perspective to conceive of government departments less as 'managers' and more as 'service providers'. From this point of view, the question shifts from 'how can communities contribute to ensure sustainable fisheries?' to 'what resources and services can the government provide to support communities in fishing sustainably?'

6.5 Complexity vs. efficiency

This tension between decentralization and amalgamation exists alongside, and is related to, another conflict that is inherent in some of the ideas I explore here – the balance between representing complexity in how we conceive of fishery systems, and being practical in terms of the extent to which we can reasonably assess and respond to such complexity. While he was a scholar worthy of critique (see McLemore 2021), E.O. Wilson's statement that "we are drowning in information while starving for wisdom" may aptly sum up the dilemma in fisheries science. While there are legitimate reasons to lament data limitations and deficiencies in the monitoring of many fisheries (e.g., as explored in Chapter

3), there is generally an ever-growing body of data / information / knowledge to consider, and I recognize that calling for inclusion of more dimensions of sustainability in fisheries assessment may in fact exacerbate this challenge in the short term. Indeed, decades ago, Hilborn and Gunderson (1996) asked to what extent acknowledging system complexity is truly necessary, and many others since have examined this, sometimes landing on the side of simplicity, at least within the realm of biological assessments (e.g., Geromont and Butterworth, 2014). It is very challenging to manage even a single species, and thus ecosystem models are never fit to raw data for more than a few species because of the increasing number of assumptions associated with increasing complexity.

With limited financial and human resources, and the reality that "we cannot improve everything all the time" (De Young et al. 2008), it may be strategic, then, to return to the concept of trade-offs, which should ideally be transparently acknowledged and weighed in fisheries management. In any management process there is an imperative to evaluate costs and benefits, e.g., when complexity adds value with respect to understanding, forecasting, and / or managing a given system, with the goal of capturing "the essential dynamics with minimum increase of complexity" (Garcia and Charles 2007). While increasing complexity undoubtedly increases realism, such realism will never be truly complete, and it likely comes at the expense of loss of universality and increased scientific uncertainty. Qualitative researchers may critique a desire for universality, but it is undoubtedly problematic when substantial investment in developing a model or framework is wasted because it has become useless upon a need for expansion or as conditions change. It is also essential here to appreciate that the level of complexity to be considered may vary by scale, e.g., to support higher-level strategic decision-making versus more specific tactical decision-making (Marentette and Zhang 2022). This also speaks to the need to better document successes and failures across fisheries management. One must ask, does complex systems-thinking yield better results? By what metrics? At what cost? It does not appear that we are yet able to make such evaluations currently with respect to full-spectrum sustainability approaches in practice, which remain in their infancy, but is an urgent consideration moving forward, particularly in the context of new frameworks for ecosystem-based management.

Perhaps most important to recognize, however, is that these notions of "complexity" in social-ecological systems are very specific to a Western science paradigm. The need to bridge silos and embrace interconnectedness is a relevant framing within academic research and government spaces precisely because the Western paradigm dictated compartmentalizing them in the first place. However, for those who actually live and work in coastal communities and marine industries, this interconnectedness exists as a matter of course. Dynamics among factors like market price of seafood, oceanographic conditions, fish populations, and human demographics may be perceived and understood quite seamlessly in these settings. This is perhaps one of the reasons why reductive scientific assessment methodologies can frustrate harvesters and their communities participating in scientific or consultative initiatives (Charles 2012, Hamelin et al. 2023).

Ultimately, underpinning the potential partnerships and collaborations toward holistic fishery assessments discussed here is the messy reality that fisheries management involves engaging with normative questions without technical answers. One cannot deny that scientific knowledge is not only "translated and diffused through society" but is in fact always undertaken with an audience in mind (Wynne 2005). As science is used to address issues that are highly value-laden and involve risk, there is an increasing desire to have society at large contribute more meaningfully to shaping processes, priorities, and directions (Garcia and Charles 2007). This applies to both natural and social sciences. While perhaps an anathema to some scientists, in accepting to engage with questions that are only partially answerable by science (including in fisheries), it is logical that stronger interactions with society, and its perceptions, values, and ethics, will be part of this process (Garcia and Charles 2007). In navigating the tension between engaging wholly in social issues while balancing the alleged objectivity demanded of scientific inquiry, Hutchings (2022) reminds us that “it can be humbling to be reminded that the personal value systems of scientists have no intrinsically greater merit than those of the decision-makers whom they advise or the citizenry who might be affected by the advice”.

6.6 Practical recommendations

In synthesizing key recommendations from my thesis work, pragmatic ideas to mobilize communities to enhance fisheries science informing management emerged, with relevance to the current Canadian context. Broadly, my findings align with work done by Long et al. (2017) to identify key priorities of harvesters in moving towards an ecosystem-based management approach, namely to focus on 1) sustainability, 2) stakeholder involvement, 3) developing long-term objectives, and 4) using all forms of knowledge. Now I refer back to a question I posed above: “How can the government support communities in fishing sustainably?” Others have made recommendations for best practices in knowledge exchange (Karcher et al. 2022a), and indeed here (Chapter 5), I explore what success looks like in mobilizing community knowledge. While truly transformative changes towards power-sharing and co-management are possible within Canadian fisheries, and arguably imperative in at least some contexts (Jones et al. 2010, Denny and Fanning 2016, Silver et al. 2022), in making several final, concrete recommendations, I focus on steps that are immediately actionable using resources and frameworks presently available:

- **Look back to the future:** Levin et al. (2021) noted that perceptions of environmental information are often framed with limited information about the historical context of the system, and thus to combat the Rashomon effect, incorporating historical information to create longer-term timelines for understanding system dynamics might yield improved outcomes (McClenachan et al. 2012, Thurstan et al. 2015, Beller et al. 2020). This need not be limited to the ecological realm, but could incorporate social, economic, and governance perspectives as well – providing much-need insights on the impacts of forces ranging from climate change to colonialism.
- **Improve transparency:** While there is a plethora of DFO science documents published on biology and ecology of fisheries each year, few statistics on socioeconomics are released. This is partly owing to confidentiality reasons stemming from the 'rule of 5' (Tomasic 2023), and partly because of a lack of mandate for and investment in comprehensive socioeconomic analysis. More well-rounded analysis and more timely release of documents (see Archibald et al. 2021b) would better facilitate the weighing of trade-offs in management decisions by all rights/stakeholders and provide more public justification for management decisions, resulting in better understanding and perhaps acceptance of results (see e.g., Berghofer et al. 2008). This could also address concerns about the ecological science base upon which decisions are made (Godwin et al. 2023), by providing more separation between assessment of fish species and their ecosystems, and assessment of human dimensions of the fishery system. To that end, the explicit incorporation of

socioeconomic objectives could help (Barclay et al. 2023), rather than burying these objectives in the black box of decision-making.

- **Reallocate more DFO services at the local level**: Having mechanisms available at the regional level across DFO is essential, but building capacity at local-level offices to contribute to scientific or other fishery assessments (see e.g., Charles et al. 2020), and perhaps conduct portions of advising processes, could rapidly enhance mobilization of more comprehensive community knowledge. At minimum, it would create a platform whereby more DFO personnel could spend time in the communities they manage, which might facilitate the relationship-building necessary to build trust (e.g., Holm and Soma 2016; Turner et al. 2016). This could, in turn, lead to the ability to delegate more management tasks at the community level.
- **Support knowledge exchange via formal, informal, and nonformal educational opportunities**: To help bridge barriers within and between groups, and ensure both individual and institutional capacity and empowerment in learning communities (see e.g., Wiber et al. 2009), investments in knowledge exchange should be a cornerstone of fisheries management. This could come in the form of training in stock assessment, policy analysis, and conservation for harvesters (e.g., "Introductory Fisheries Science for Stakeholders", Rutgers University: https://ocean.njaes.rutgers.edu/marine/introductory-fisheries-science-for-stakeholders-ifissh/) to getting fisheries scientists and managers the opportunity to spend time in coastal communities and aboard vessels (see e.g., Fisheries and Scientists Research

Society: https://fsrsns.ca/). Treaty education, highlighted in the Truth and Reconciliation Commission Calls to Action (Truth and Reconciliation Commission of Canada 2015), is also emerging as a much-needed component of fisheries knowledge exchange in Atlantic Canada (e.g., https://novascotia.ca/treaty-education/, https://educationalliance.ca/). However, one must be careful not take the deficit approach to learning, especially in light of the large body of evidence that "facts don't change minds" (Toomey 2023). Instead, dialogues are required throughout (Garrison et al. 2021). Learning opportunities also need not be in formal educational settings, as there is evidence that immersive, non-formal community-based education opportunities are particularly meaningful in building ocean literacy in Atlantic Canada (Ostertag 2021).

- **Support grassroots communities of practice to expand beyond bilateral fisher-manager communication (i.e., from fisher-manager to inter-stakeholder communications):** Community members can often work together effectively without government intervention required, or with minimal facilitation support (e.g., Harms-Tuohy 2021). Such communities of practice might solve problems in different ways that build social capital and ultimately streamline the development and acceptance of management regulations via adoption into local norms (Kearney et al. 2007). Crucially, these groups should ideally meet outside the context of management decisions (i.e., allocation decisions, quota setting) to ensure a low-stakes environment conducive to trust and relationship-building, where no one feels pressured to advocate to preserve their livelihood (Harrison and

Loring 2020). Stronger links horizontally (across the community) and vertically (with external organizations) may result.

- **Find common ground**: Numerous methods could be implemented, on a context-dependent basis, to facilitate shared understanding within groups where conflict cannot be overcome owing to a lack of social cohesion. Results chains, which visually represent the logic and theory underpinning an intervention and its expected positive or negative consequences (Levin et al. 2021), and mental models, which allow one to visualize relationships perceived based on an individual's knowledge (McClenachan et al. 2022), may be useful tools. The Community Voice Method has been used to share stories grounded in their place-based communities to foster legitimate, productive public participation in natural resource management settings (Cumming et al. 2021). Finally, considering positionality, privilege, and assumptions and biases (per Reed and Rudman 2022) in every step of the process will introduce an equity lens to ensure desired outcomes for all individuals and groups involved, especially for those historically and / or presently underserved.

Given the social, economic, and environmental challenges facing Canadian society, such as the current climate crisis, strengthening partnerships among scientific, societal, and governance institutions will be needed to address current resource and capacity gaps (Lomonico et al. 2021). Over the past four years of study, I have seen numerous changes to approaches in fisheries management in Canada, including the hiring of at least two DFO Maritimes research scientists from the social sciences and the humanities, the establishment of a DFO-OFI Social Sciences and Humanities Working Group, progress towards an ecosystem-based management framework for Maritimes fisheries, and serious reckoning with what it means for Indigenous harvesters to fish for a moderate livelihood. I remain optimistic that full-spectrum sustainability for Canadian fisheries is on the horizon. My hope is that parts of the work contained in this thesis help us to get there, recognizing that "the data pursue but never quite draw level with unfolding policy problems. The whole point is the steady conversion of 'unknowns' to 'knowns'" (Pawson et al. 2011).

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APPENDIX

Appendix 1 – Mackerel angler questionnaire

DALHOUSIE UNIVERSITY

***For the purposes of this survey, RECREATIONAL FISHING is defined as FISHING FOR SPORT, PLEASURE, OR PERSONAL USE (e.g., food).**

NOTE: In addition to the following structured questions, there will be an opportunity to add any other details, ideas, or concerns that you may have at the end of the survey.

SECTION 1: Recreational Fishing Activity

1. How were you first introduced to recreational fishing?
    a. I started fishing at a young age in Nova Scotia
    b. I started fishing at a young age somewhere other than Nova Scotia
    c. I learned to fish when I was older after growing up in Nova Scotia
    d. I learned to fish when I was older somewhere other than Nova Scotia
    e. I learned to fish when I was older after moving to Nova Scotia
    f. Other (please explain)
2. Approximately how many years have you been fishing in Nova Scotia?
    a. Less than 1 year
    b. 1-3 years
    c. 4-6 years
    d. 7-10 years
    e. 10-20 years
    f. More than 20 years
3. What species do you catch when you do recreational fishing in the ocean?
    a. I am only interested in catching Atlantic mackerel
    b. I aim to catch Atlantic mackerel, but sometimes I catch other things
    c. I aim to catch other fish, but sometimes I catch Atlantic mackerel
    d. I catch any fish I can get
    e. I am not sure what types of fish I catch
4. If you catch ocean species other than Atlantic mackerel while fishing for recreation, what types do you catch? Please list any types of fish you have caught that you were able to identify.
5. Where do you fish for Atlantic mackerel? Please select all that apply.
    a. Halifax Regional Municipality
    b. Halifax County, outside of HRM
    c. Lunenburg County
    d. Queens County
    e. Shelburne County
    f. Yarmouth County
    g. Digby County
    h. Annapolis County
    i. Kings County
    j. Hants County
    k. Colchester County
    l. Cumberland County
    m. Pictou County

n. Antigonish County
o. Guysborough County
p. Richmond County
q. Inverness County
r. Victoria County
s. Cape Breton Regional Municipality
t. Outside of Nova Scotia

6. How do you fish for Atlantic mackerel? Please select all that apply.
   a. From a wharf/dock
   b. From a beach/rocky shore
   c. From a boat
   d. Other (please explain)
7. What is the best time of year to fish for Atlantic mackerel? Check all that apply.
   a. January
   b. February
   c. March
   d. April
   e. May
   f. June
   g. July
   h. August
   i. September
   j. October
   k. November
   l. December
8. When it's a good time of year to fish for Atlantic mackerel, how often do you go?
   a. Every day (7 days per week)
   b. 4-6 days per week
   c. 1-3 days per week
   d. 1-3 times per month
   e. Just a couple of times per season
9. How have COVID-19 restrictions impacted your fishing activity?
   a. I fish more often/for longer periods of time
   b. I fish less often/for shorter periods of time
   c. I fish the same amount as usual
   d. Unsure
   e. Other (please explain)
10. Who tends to go fishing with you? Please select all that apply
    a. Neighbours
    b. Colleagues
    c. Friends
    d. Adult family members
    e. Children/youth family members
    f. I usually fish alone
    g. Other (please explain)
11. Have you noticed any changes in the NUMBER of Atlantic mackerel you tend to catch during a fishing trip over the years?
    a. I catch more fish now than I have in the past
    b. I catch less fish now than I have in the past
    c. I catch about the same number of fish compared to in the past
    d. Unsure
    e. Other (please explain)
12. Have you noticed any changes in the SIZE of Atlantic mackerel you tend to catch over the years?
    a. The fish are bigger now than they used to be
    b. The fish are smaller now than they used to be

    c. I haven't noticed any changes in fish size over time
    d. Unsure
    e. Other (please explain)
13. Have you noticed any changes to fishing regulations for Atlantic mackerel?
    a. Rules have become stricter over time
    b. Rules have become more relaxed over time
    c. I haven't noticed changes in regulations
    d. I didn't know there were regulations
    e. Unsure
    f. Other (please explain)
14. Do you share information about your fishing catch on any of these virtual platforms? Please select all that apply.
    a. iNaturalist
    b. eOceans
    c. Angler's Atlas
    d. FishBrain
    e. NovaScotiaFishing.com
    f. Other (please list)
    g. I do not use any virtual platforms
15. Why do you fish for Atlantic mackerel? Please describe your main reasons.
16. How important is this type of recreational fishing to your culture?
    a. Very important
    b. Important
    c. A bit important
    d. Not at all important
17. How important is this type of recreational fishing to you as a sport/outdoor activity?
    a. Very important
    b. Important
    c. A bit important
    d. Not at all important
18. Do you use the Atlantic mackerel that you catch for bait?
    a. Yes
    b. Sometimes
    c. No
    d. Other (please explain)
19. Do you eat the Atlantic mackerel that you catch?
    a. Yes
    b. Sometimes
    c. No
    d. Other (please explain)
20. If you eat the mackerel you catch, how important is this food source to you?
    a. Very important
    b. Important
    c. A bit important
    d. Not at all important
    e. Not applicable – I don't eat the mackerel
21. If you eat the mackerel you catch, what role does this food source play in your diet? Please select all that apply
    a. It is a food that I can afford
    b. It is a healthy food
    c. It is a food that is part of my culture or tradition
    d. It is an ethical food
    e. It is an environmentally friendly food
    f. Not applicable – I don't eat the mackerel
    g. Other (please describe)

22. If you eat the mackerel you catch, how much money do you save on grocery bills because of your fishing catch? (Please estimate dollars [$] per week during mackerel season)
23. How would your health or nutrition be affected if you could not catch and eat mackerel?
24. Is there anything else you would like to share about your fishing experience?

SECTION 2: Demographics

Please tell us a bit more about yourself, so we can learn about who likes to fish in Nova Scotia.

1. In which region do you live?
    a. Halifax Regional Municipality
    b. Halifax County, outside of HRM
    c. Lunenburg County
    d. Queens County
    e. Shelburne County
    f. Yarmouth County
    g. Digby County
    h. Annapolis County
    i. Kings County
    j. Hants County
    k. Colchester County
    l. Cumberland County
    m. Pictou County
    n. Antigonish County
    o. Guysborough County
    p. Richmond County
    q. Inverness County
    r. Victoria County
    s. Cape Breton Regional Municipality
    t. Outside of Nova Scotia
2. Did you immigrate to Canada or come as a refugee?
    a. Yes
    b. No
    c. Prefer not to say
3. How would you describe your ethnic background? Please select all that apply.
    a. Indigenous/Aboriginal (e.g., First Nations, Metis, Inuit)
    b. White (e.g., European descent)
    c. Black (e.g., African, Afro-Caribbean, African Canadian, etc)
    d. Latinx (i.e., Latin American, Hispanic descent)
    e. West Asian (e.g., Iranian, Afghan)
    f. Arab (e.g., Syrian, Lebanese, Egyptian)
    g. South Asian (e.g., Indian, Pakistani, Sri Lankan, Indo-Caribbean)
    h. East Asian (e.g., Chinese, Korean, Japanese)
    i. Southeast Asian (e.g., Vietnamese, Thai, Cambodian, Filipino)
    j. Other (please specify)
    k. Prefer not to say
4. How would you describe your experience with the English language?
    a. I am a native English speaker
    b. I am a fluent speaker of English as an Additional Language
    c. I am in the process of learning English as an Additional Language
    d. Other (please explain)
5. What other languages do you use at home or in your community? (Please select any that apply)
    a. Mi'kmaq

b. French
c. Russian
d. German
e. Dutch
f. Spanish
g. Portuguese
h. Greek
i. Arabic
j. Persian
k. Mandarin
l. Cantonese
m. Korean
n. Japanese
o. Tagalog
p. Hindi
q. Bengali
r. Punjabi
s. Indonesian
t. Other (please specify)

6. What is your gender identity?
   a. Male
   b. Female
   c. Non-binary
   d. Prefer to self-describe (Other)
   e. Prefer not to say
7. Do you identify as a member of the LGBTQIA2S+ community?
   a. Yes
   b. No
   c. Unsure
   d. Prefer not to say
8. Do you self-identify as having a disability? If yes, which of the following best describes your disability(ies)? (Please select all that apply)
   a. Sensory (seeing or hearing)
   b. Physical (mobility, flexibility, dexterity, pain)
   c. Cognitive (learning, developmental, memory)
   d. Psychological (mental illness)
   e. Other: please explain
   f. Prefer not to say
   g. Do not self-identify as having a disability
9. What is your age?
   a. Under 20
   b. 20-29
   c. 30-39
   d. 40-49
   e. 50-59
   f. 60-69
   g. 70-79
   h. 80-89
   i. 90 or older
10. What is the highest level of education you have achieved?
    a. No certificate, degree, or diploma
    b. High school diploma or equivalent
    c. Apprenticeship or trades certificate or diploma
    d. College, CEGEP or other non-university certificate or diploma
    e. University certificate or diploma below Bachelor level
    f. Bachelor’s degree

g. Graduate degree (e.g., Master's, PhD, etc)
h. Professional degree (e.g., JD, MD, DVM, etc)

11. Roughly how much is your total annual income during an average year?
    a. $0-25 000
    b. $25 000 – 50 000
    c. $50 000 – 75 000
    d. $75 000 - $100 000
    e. $100 000 - $150 000
    f. $150 000 - $200 000
    g. $200 000+
12. What is your employment status?
    a. Working full-time
    b. Working part-time
    c. Working seasonally
    d. Studying full-time
    e. Studying and working
    f. Taking a break from work
    g. Looking for work
    h. Retired
    i. Other (please explain)
13. In which field do you (or did you) primarily work or study?
    a. Accountancy / banking / finance
    b. Business / consulting / management
    c. Charity / voluntary work
    d. Child care
    e. Communications
    f. Creative arts and design
    g. Education
    h. Emergency and security services
    i. Energy and utilities
    j. Engineering and manufacturing
    k. Environment and agriculture
    l. Fishing or fisheries
    m. Healthcare
    n. Hospitality and events management
    o. Information technology
    p. Law
    q. Leisure, sports, and tourism
    r. Marketing, advertising, and PR
    s. Media and internet
    t. Public services and administration
    u. Recruitment and HR
    v. Sales
    w. Science and pharmaceuticals
    x. Social services
    y. Transportation
    z. Other (please explain)
14. Thanks for your participation! Is there anything else you'd like to share with the research team?

Thank you for contributing to this research!

Appendix 2 – Copyright release

July 24, 2023

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October 25, 2023

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