AN EXAMINATION OF RECOVERY FEASIBILITY DETERMINATION, AND FACTORS AFFECTING ITS REASSESSMENT, FOR INNER BAY OF FUNDY ATLANTIC SALMON UNDER THE SPECIES AT RISK ACT

by

Simon-Luc Noël

Submitted in partial fulfilment of the requirements
for the degree of Master of Environmental Studies

at

Dalhousie University
Halifax, Nova Scotia
August 2024

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

Table Of Contents

List of Tables

List of Figures

Abstract

Determining the feasibility of recovering an endangered species is an explicit component of recovery planning in the Species At Risk Act (SARA), Canada. This exploratory study addressed a key knowledge gap—the limited research on recovery feasibility under SARA—by examining whether and how perceptions of recovery feasibility have changed over time for inner Bay of Fundy (iBoF) Atlantic salmon, and the factors affecting the reassessment of feasibility. I used a mixed-methods, qualitative approach analyzing policy documents and semi-structured interview responses. The findings indicated growing uncertainty about the feasibility of recovery and whether the current recovery objectives remained appropriate for the species. The logistical, organizational, and policy complexity of iBoF salmon management were barriers to reassessing recovery feasibility, though the Recovery Team expressed support for reassessment, viewing it as an opportunity to re-examine the objectives of recovery efforts and to chart a course for the future of this iconic species.

iBoF salmon have been the subject of recovery efforts for over 20 years, yet they remain endangered as their abundance and rates of return have failed to improve since their listing in 2003. The Department of Fisheries and Oceans (DFO) determined in 2010 that the recovery of iBoF salmon was feasible if threats to the species could be better understood, and if those threats could be mitigated or avoided. While more recent recovery planning documents maintained that position, and the majority of Recovery Team members that I interviewed believed recovery was still achievable for iBoF salmon, their perspectives also expressed greater concern than in 2010 about the feasibility of achieving the objectives set out in the Recovery Strategy. The continued endangerment of the species raised questions about whether the population was suffering from Allee effects; whether portions of the Bay of Fundy and its watersheds had become inhospitable to salmon; and whether current recovery efforts could even lead to recovery for the species in current conditions. The fact that financial and capacity resources had declined for iBoF salmon recovery compounded these concerns.

In the 2010 Recovery Strategy, DFO committed to reassessing recovery feasibility of iBoF salmon every five years, yet no such reassessment has been completed as of August 2024, partly due to a lack of new information about threats to the species. The current organizational culture of the Recovery Team, and the declining support for iBoF salmon at the governance level, were also identified as barriers to reassessment. Conversations with the interviewees revealed divergent definitions of “recovery” and “feasibility” for the species among Recovery Team members, further hindering reassessment efforts. However, members of the Recovery Team stated that reassessing recovery feasibility was important for the present management of iBoF salmon and identified avenues for undertaking such a reassessment including supporting the Recovery Team’s role as a hub for recovery efforts, improving the uptake and use of non-DFO information, and establishing clearer guidelines for determining recovery feasibility. The complexity of iBoF salmon recovery is matched by the interest expressed by stakeholders and rights holders involved in recovery efforts. Gaining a better understanding of the stakeholders’ perceptions of the feasibility of recovery for iBoF salmon, as well as the challenges to reassessing that feasibility, presents opportunities to improve recovery planning efforts for this iconic species.

List of Abbreviations Used

COSEWIC – Committee on the Status of Endangered Wildlife in Canada

DFO – Department of Fisheries and Oceans Canada

ECCC – Environment and Climate Change Canada

FFHRP – Fort Folly Habitat Restoration Program

FSR – Fundy Salmon Recovery Program

iBoF – Inner Bay of Fundy

LGB – Live Gene Banking Program

PC – Parks Canada Agency

RENEW – Committee for the Recovery of Nationally Endangered Wildlife

RPA – Recovery Potential Assessment

SARA – Species At Risk Act

Acknowledgements

I want to give my deepest and sincerest thanks to my supervisory committee, Dr. Karen Beazley and Dr. Bertrum MacDonald, for all of the guidance you've given me throughout my research. You not only helped shape this project, but your steadfast support and valuable insights throughout were vital to its completion. I would also like to extend my thanks to the external reader, Dr. Megan Bailey of Dalhousie's Marine Affairs Program, for helping bring my thesis across the finish line with insightful questions and helpful suggestions.

I would like to say thank you to all the individuals I interviewed for this research, I greatly appreciate the time and knowledge you have shared with me. I would also like to extend my thanks to the Atlantic Canada Coastal and Estuarine Science Society and the Bay of Fundy Ecosystem Partnership for letting me present my research poster at the 2022 ACCESS/BoFEP Conference. Finally, thank you to the individuals who took the time to chat with me in my preliminary discussions for the thesis. In particular I want to thank the late Dr. Jeffrey Hutchings for taking the time to meet with me and talk about this project. I am glad to have been able to share time and insights with you.

To my MES cohort and all the people I met in Nova Scotia, thank you for your support and friendship as I continued my work on my thesis even after I went back to British Columbia; all our adventures in Kejimkujik, Tatamagouche, the Margaree Valley, and elsewhere made my stay in Atlantic Canada memorable and fantastic. To my friends in BC, who kept me grounded, reminded me to take time to roll some dice or enjoy the outdoors, and took me to task as needed, thank you. Your friendship means so much to me. Thank you to my family in Edmonton and Montréal, you've been cheering me on my academic career since before I started my Master's and I'm excited to finally be able to share it all with you. And finally, to my partner Matias: you cheered me on through the highs and supported me through the lows, during the busiest time of both our lives. Your music is the soundtrack to this thesis. Thank you, and I love you.

This research would not have been possible without financial support from the Social Science and Humanities Research Council (SSHRC), the Nova Scotia Graduate Scholarship, and the 2021 Neil Munro Parks and Protected Areas Award.

Chapter 1: Introduction

1.1 Research Statement

Atlantic salmon (*Salmo salar*) of the inner Bay of Fundy, or iBoF salmon, have been designated as Endangered on Schedule 1 of the Species At Risk Act (SARA) since it came into force in 2003. Their endangerment is due to a major decline in both abundance and rates of return of spawning adults to their native rivers in the Bay of Fundy in the mid- to late 20th century (Committee on the Status of Endangered Wildlife in Canada (COSEWIC), 2006; Department of Fisheries and Oceans (DFO), 2010b). This decline is thought to be primarily driven by high mortality rates of salmon in the marine phase of their life cycle. A Recovery Strategy for the population was finalized in 2010, seven years after its initial listing; a finalized Action Plan based on the Strategy was published nine years after that (DFO, 2010b, 2019). As part of the process of drafting the Recovery Strategy in partnership with Parks Canada (PC) and a multi-stakeholder Recovery Team, the Department of Fisheries and Oceans (DFO) determined that the recovery of iBoF salmon, defined as "re-establish[ing] wild, self-sustaining populations as required to conserve the genetic characteristics of the remaining anadromous iBoF Atlantic salmon," was both biologically and technically feasible (DFO, 2010b). This determination was informed in part by a recovery potential assessment, which gathered scientific information on the population's current and historical state, its habitat requirements and availability, the threats it faces, and options to address these threats (DFO, 2008).

However, there are two caveats to that determination, which are outlined by DFO in the Recovery Strategy (DFO, 2010b). First, iBoF salmon recovery is contingent on the ability to understand the causes of the population's low marine survival rates, and the subsequent ability to improve that survival via management (DFO, 2010b). Several potential natural and anthropogenic threats to iBoF salmon have been identified; however, the specific causes of high at-sea mortality remain poorly understood even as mortality rates have not improved (DFO, 2008, 2010b, 2021). Second, the continued survival of iBoF salmon depends on the Live Gene Bank (LGB) program, which supplements rivers with hatchery fish bred specifically to preserve the genetic

characteristics of the population (DFO, 2008, 2010b; Gibson et al., 2008). The LGB is the primary activity used to support iBoF salmon, which would likely go extinct within a decade without it; however, it is considered insufficient to promote the recovery of iBoF salmon populations on its own (DFO, 2018; Gibson et al., 2008). Additionally, there are concerns about the effects of long-term hatchery supplementation on the overall fitness of wild salmon populations (Bordeleau et al., 2018; Milot et al., 2013). These caveats create significant uncertainty in the feasibility of recovering iBoF salmon.

As part of its approach to addressing this uncertainty, DFO set an explicit objective in the Recovery Strategy to perform reassessments of recovery feasibility every five years, following the species' reproductive cycle (DFO, 2010b). The Action Plan for iBoF salmon, published in 2019, indicates that DFO continues to consider recovery to be feasible for this population; however, an updated assessment of recovery feasibility was not completed in 2015, and no new feasibility assessments have been published or documented by DFO as of 2024 (DFO, 2019, 2021). Nearly 20 years after the listing of this iconic species in SARA, their abundance and rates of return have not significantly increased, and self-sustaining populations are no closer to being established, even in the rivers being supplemented by the LGB program (DFO, 2020, 2021). Because of these factors, the feasibility of recovery for iBoF salmon warrants reassessment.

As the primary law governing the management and conservation of aquatic endangered species in Canada, SARA's performance in halting decline and promoting recovery for listed species has been scrutinized throughout the nearly two decades since its promulgation. Issues such as taxonomic biases in listing and slow action on identifying critical habitat during recovery planning have been highlighted by others (Bird & Hodges, 2017; Creighton & Bennett, 2019; Mooers et al., 2007); however, little research exists that examines the process of determining recovery feasibility under SARA. The content of an endangered species' Recovery Strategy is shaped in part by its determination of recovery feasibility, and while only biological and technical feasibility are to be considered in the determination, the factors entailed in assessing recovery feasibility warrant exploration, to identify influential informational and institutional dynamics that shape the assessment process.

1.2 Objectives and Research Questions

The objective of this case study on inner Bay of Fundy Atlantic salmon is twofold: to chart the evolution of perspectives on the feasibility of its recovery; and identify barriers and enablers experienced by the iBoF Salmon Recovery Team with regard to re-evaluating recovery feasibility. The objective is addressed by answering the following research questions:

- Have the perspectives on recovery feasibility for iBoF salmon changed since the publication of the 2010 Recovery Strategy, and if so, how and why have they changed?
- What barriers or enablers are experienced by the Recovery Team members regarding reassessment of recovery feasibility for iBoF salmon since 2010?

Addressing these research questions will fill a gap in understanding of the factors that influence recovery planning for iBoF salmon and identify opportunities to improve the implementation of SARA for iBoF salmon and other endangered aquatic species in Canada.

1.3 Research Background and Context

1.3.1 Inner Bay of Fundy Atlantic Salmon

Historically native to over 40 rivers of the Bay of Fundy that drain into the Minas Basin and Chignecto Bay (Figure 1.1), iBoF salmon are considered genetically distinct from other Atlantic salmon populations due to their unique localized migration strategy and a higher proportion of adults that reach maturity after one year at sea (COSEWIC, 2006). While their maximum abundance is estimated to have been approximately 40,000 adults in iBoF rivers earlier in the 20th century, by 1999 the population is thought to have been reduced to 250 adults, representing a >99% decline in that time (DFO, 2008). The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) evaluated the extinction risk of iBoF salmon in 2001, designating it as endangered, and upheld that designation after its second evaluation in 2006 (COSEWIC, 2006). In these evaluations, the primary limitation to the population's recovery was identified as poor survival of

salmon that migrated out to sea, resulting in a greatly diminished number of adults returning to spawn.

Extensive management efforts have been undertaken by DFO, Parks Canada, and various non-governmental organizations (NGOs) since at least the 1990s in response to the precipitous decline in the abundance of iBoF salmon (Irvine et al., 2005). These efforts include the complete closure of any fisheries in iBoF rivers except the Gaspereau River (Chase, 2007; DFO, 2010b); the establishment of the Live Gene Bank program in the early 2000s to preserve the population's distinct genetics and supplement numbers in the few rivers that still contain the species (Gibson et al., 2008); and the preparation of a National Recovery Strategy for iBoF salmon by a multi-stakeholder Recovery Team in 2002 (VanderZwaag et al., 2011). Once SARA came into force in 2003, iBoF salmon were automatically added to the official list of Canadian species at risk, also known as Schedule 1, and the existing strategy was modified to conform to the new requirements imposed by the Act (Irvine et al., 2005; VanderZwaag et al., 2011). These extensive management efforts underscore the importance of iBoF salmon to Atlantic Canada. In particular, the Mi'kmaq, Wolastoqey, and Peskotomuhkati Peoples view the abundance of *plamu* (Atlantic salmon) as a barometer of the overall health of the waters in Nova Scotia and New Brunswick and consequently share deep concern about iBoF salmon's dramatic decline (DFO, 2010b; Maritime Aboriginal Peoples Council, 2014).

1.3.2 Issues with Recovery Planning Under SARA

When an aquatic species or population is listed as endangered under SARA, it gains certain automatic legal protections from harm or capture, and the process of recovery planning begins, led by DFO (and PC if the species occurs in any parks managed by that department) (SARA, 2002; VanderZwaag et al., 2011). Recovery planning under the Act consists of drafting a Recovery Strategy identifying an endangered species' status, recovery feasibility, threats, critical habitat, and conservation needs, and one or more Action Plans that lay out the specific actions that will be taken to implement the Recovery Strategy (SARA, 2002, Section 37 (1), 47). Recovery planning is meant to be an adaptive process. SARA explicitly states that the implementation of a Recovery Strategy and progress towards meeting its objectives must be reviewed every

five years at least, until either the objectives have been reached or recovery is no longer considered feasible (SARA, 2002, Section 46).

Since SARA's promulgation, however, several concerns have arisen regarding the Act's implementation of recovery planning. For species designated as endangered under the Act, a proposed Recovery Strategy must be prepared within one year of listing. However, it is common for Recovery Strategies to be delayed by several years (Brassard, 2014; Turcotte et al., 2021). Identification of critical habitat in Recovery Strategies is often delayed or incomplete as well (Bird & Hodges, 2017). Although there are no restrictions on implementing recovery actions for an endangered species while these documents are being drafted, the lack of a clear strategy can hamper conservation efforts, especially for species with complex life cycles that span multiple jurisdictions (Clark et al., 1989). In addition, such delays run counter to both the precautionary approach espoused by DFO and SARA as well as the wider consensus in the scientific literature that timely action is key to preventing extinction in threatened species (Bird & Hodges, 2017; Ferreira et al., 2019; VanderZwaag, 2002; Westwood et al., 2019).

iBoF salmon is a unique case for an aquatic endangered species: its automatic addition to Schedule 1 when the Act came into force allowed it to circumvent the barriers that often prevent aquatic species from being listed at all (Creighton & Bennett, 2019; Mooers et al., 2007). In addition, though the development of both the Recovery Strategy and Action Plan were significantly delayed, the fact that both documents exist for the population, as well as an identification of critical habitat, make its recovery planning appear more complete at first glance (Canada Gazette, Part 2, Volume 153, Number 19, 2019).

1.3.3 Determining Recovery Feasibility Under SARA

One explicit yet little-examined component of recovery planning under SARA is outlined in section 40 of the Act: determining whether the recovery of a listed species is technically and biologically feasible. The text of SARA does not explicitly define feasibility of recovery or describe a process by which that feasibility is determined. In addition, while it explicitly mentions biological and technical considerations as the sole components of determining recovery feasibility for the purposes of recovery planning

under the Act, it does not provide criteria to define either of these considerations. DFO developed its own definitions in a guidance document published in 2010:

> *Biological feasibility* is defined as a function of the intrinsic ability of a population/species to achieve the status of a viable, self-sustaining population that persists in the wild for multiple generations without human intervention. *Technical feasibility* can be considered the ability of management to successfully implement any actions required to achieve species recovery, regardless of cost. The feasibility of recovery should, therefore, be based on the best available biological and technical information, and not socio-economic information (DFO, 2010a, p. 6).

The determination of recovery feasibility for a threatened, endangered, or extirpated species affects the content of its subsequent Recovery Strategy: if recovery is found to be not feasible, the Strategy only needs to include information on the species and its needs, identification of critical habitat to the extent possible, and the reasons why recovery is not considered feasible. Conversely, a Strategy for a species whose recovery is feasible contains much more information, including descriptions of threats it faces, objectives for recovery, and actionable steps to be taken that will help accomplish these objectives (SARA, 2002, Section 40 (2)).

1.3.4 Why Does Recovery Feasibility Matter?

Assessing the feasibility of recovery for an endangered species, in essence, involves answering the following question: given the current state of the species, its native environment, and the technology available to us, is it possible for the species to recover? This assessment is shaped by two key considerations that can provide insight into the recovery planning process under SARA.

First, the presence of a process to determine the feasibility of recovering an endangered species suggests that recovery is a fundamental aspect of success for SARA. Conservation success means different things to different groups, stakeholders, and individuals. For instance, many laws and programs concerning endangered species operate reactively, with protections coming into effect when a species is identified as being at risk of extinction: in this case, success stops at preventing further decline and/or

extirpation (Pawluk et al., 2019). Many conservation biologists criticize this approach, with scientific literature on the subject supporting the idea that successful recovery for an endangered species should involve rebuilding depleted populations to a reasonable level of abundance, reducing or eliminating anthropogenic threats such that the population's risk of extinction falls within its natural level, and ensuring that the species' function in the ecosystem is restored (Akçakaya et al., 2020; Redford et al., 2011; Westwood et al., 2014). Even when recovery is explicitly identified as a component of success, as it is for SARA, varied conflicts between stakeholders' perspectives on what constitutes the "best" approach for managing a particular species can and do occur, leading to challenges in communication and governance in endangered species management (Bellanger et al., 2020; Chapman et al., 2020). Organizational inefficiencies and competing value judgments within and among conservation groups engaged in or responsible for recovery, including government agencies, non-governmental organizations, and academic research initiatives, have played a major role in hindering the implementation of recovery actions for many endangered species, and are especially prevalent for species whose range throughout their life cycle spans multiple jurisdictions (Carolan, 2008; Flye et al., 2021; Hart, 2018). Because the determination of recovery feasibility speaks to the underlying definition of success that SARA strives towards, examining that process can uncover the underlying value conflicts that shape implementation and outcomes for a managed species, identify where organizational problems may be occurring, and where solutions could be applied (Gregory et al., 2012; Hughes et al., 2020; Soomai, 2017a).

Second, any assessment of feasibility involves the question of how much is enough for a given species to be considered successfully recovered. Under SARA, answering this question requires the use of the best available information about the species' historical and current condition, the threats it faces, and how those threats can be addressed, if at all (DFO, 2008). Determining recovery feasibility is thus guided by principles of evidence-based or evidence-informed decision-making, ostensibly prioritizing evidentiary criteria over ideologically-based decision-making (MacDonald et al., 2016b; Nutley et al., 2007). In most cases, the "best available information" refers to research-based information, but the opinions and judgments of experts and managers often play a significant role as research-derived data can be limited (DFO 2007; Gregory

et al. 2012; Martin et al. 2012; Tear et al. 2005). For DFO in particular, this information is gathered when preparing a Recovery Potential Assessment (RPA), and the information used to set recovery objectives is also used to determine the feasibility of recovery for a species (DFO, 2007). However, unlike the processes used by COSEWIC to produce and gather information to evaluate a species' extinction risk, the input of information into recovery planning processes, including the determination of recovery feasibility, is not always clear (Mooers et al., 2010). Prior research on other science-policy interfaces within resource management and conservation organizations identified a number of potential factors that could affect the uptake and communication of information for determining recovery feasibility. These include dynamics between actors present at the interface (Chapman et al., 2020; MacDonald et al., 2016b), organizational factors such as bureaucracy and de-centralization that hinder communication between scientists and managers (Lemieux et al., 2018; Soomai, 2017a), or shifting perceptions among managers and policymakers about what types of information to prioritize (Pullin et al., 2004; Shelton, 2007). The tension between taking rapid action to protect species, and collecting information to better understand their condition, has also been a major theme of research on the subject (Grantham et al., 2009; Lindenmayer et al., 2013; Pullin et al., 2004). Investigating the way that recovery feasibility is determined under SARA can help reveal the processes that shape which information is considered, how objectives are set, what barriers may prevent the flow of information in recovery planning, and what steps can be taken to improve the state of knowledge of science-policy interfaces within SARA.

1.3.5 Status and Recovery Feasibility of iBoF Salmon

The determination of recovery feasibility for iBoF salmon was made as part of drafting the SARA-compliant Recovery Strategy, a proposed version of which was published in 2009, and a final version in 2010—six and seven years after iBoF salmon was added to Schedule 1, respectively. Based on the information collected in the RPA for iBoF salmon, DFO determined that "recovery may be feasible" if the causes of salmon mortality at sea could be better understood, and measures to improve marine survival could be implemented or new life history strategies for the population could be identified

and promoted (DFO, 2009). Due to the uncertainties associated with these conditions, DFO committed to re-evaluating recovery feasibility for iBoF salmon every five years as an explicit objective of the Recovery Strategy and consistent with SARA provisions (SARA, 2002, Section 46). In the interim, recovery planning would proceed as though recovery is feasible (DFO, 2010b).

Since the publication of the final Recovery Strategy in 2010, the abundance and rates of return of iBoF salmon have not improved. The latest abundance estimate prepared by DFO indicates that fewer than 105 adults returned to all monitored streams between 2013 and 2017, most of which grew from smolts released via the LGB program, as opposed to wild-origin fish (DFO, 2020). The LGB program has been successful in preserving iBoF salmon's distinct genetics but, in the absence of any improvement in marine survival, supplementation continues to be necessary for the species' continued survival. It is likely that range-wide extirpations have occurred in rivers that do not receive LGB supplementation (DFO, 2018).

Despite the prevention of the population's complete extirpation, concerns have arisen regarding the implementation of recovery planning for iBoF salmon since 2010. The information used to identify threats to the population and set recovery goals has been scrutinized, with several analyses identifying biases for certain types of information—primarily research produced and published by DFO—and potential exclusion of other types—primarily research from external stakeholders, or wider research on potential threats such as aquaculture (Hart, 2018; VanderZwaag et al., 2011). In addition, due to having failed to achieve the five-year target set in the Recovery Strategy, as well as the lack of progress in discovering the causes of low marine survival and potential measures to mitigate it, DFO itself has begun to question the appropriateness of the recovery objectives it has set for iBoF salmon (DFO, 2021). Significant delays have also occurred in publishing additional recovery planning documents. The Action Plan was finalized in 2019, nearly a decade after the Recovery Strategy, and one five-year progress report on the implementation of the Strategy was published in 2021, covering the period from 2010 to 2015. All of these concerns have implications for the feasibility of recovery for iBoF salmon; however, no new feasibility determination has been completed since 2010.

1.3.6 Study Area

Unlike other Canadian populations of Atlantic salmon, whose range extends outside of Canadian borders due to migration to Greenland, the native range of iBoF salmon remains almost entirely within Canadian waters (Figure 1.1). The freshwater range of iBoF salmon spans from the Mispec River in New Brunswick, extending northeastward around the Bay of Fundy to the Pereaux River in Nova Scotia (COSEWIC, 2006). In the marine phase of its life cycle, populations from all rivers in the inner Bay of Fundy are thought to remain in the Bay of Fundy and parts of the outlying waters in the Gulf of Maine, except for the specific population from the Gaspereau River, which follows the more common migration route to Greenland. The reasons for the Gaspereau River iBoF salmon's divergence in migration strategy from the rest of the iBoF salmon population are uncertain.

The research for this thesis was conducted at Dalhousie University, which operates in the ancestral and unceded territories of the Mi'kmaq, Wolastoqey, and Peskotomuhkati Peoples. These sovereign nations hold inherent rights as the original peoples of these lands, and we each carry collective obligations under the Peace and Friendship Treaties. Section 35 of Canada's Constitution Act, 1982 recognizes and affirms Aboriginal and Treaty rights in Canada. Salmon have long been culturally and spiritually important to the Indigenous Peoples of this region (Denny & Fanning, 2016; Maritime Aboriginal Peoples Council, 2014). The research was conducted within the context of the Indigenous peoples territories and the iBoF salmon's geographical range, and it engages members of the iBoF Salmon Recovery Team as research participants, variously located in Nova Scotia, New Brunswick, and Ontario, Canada.

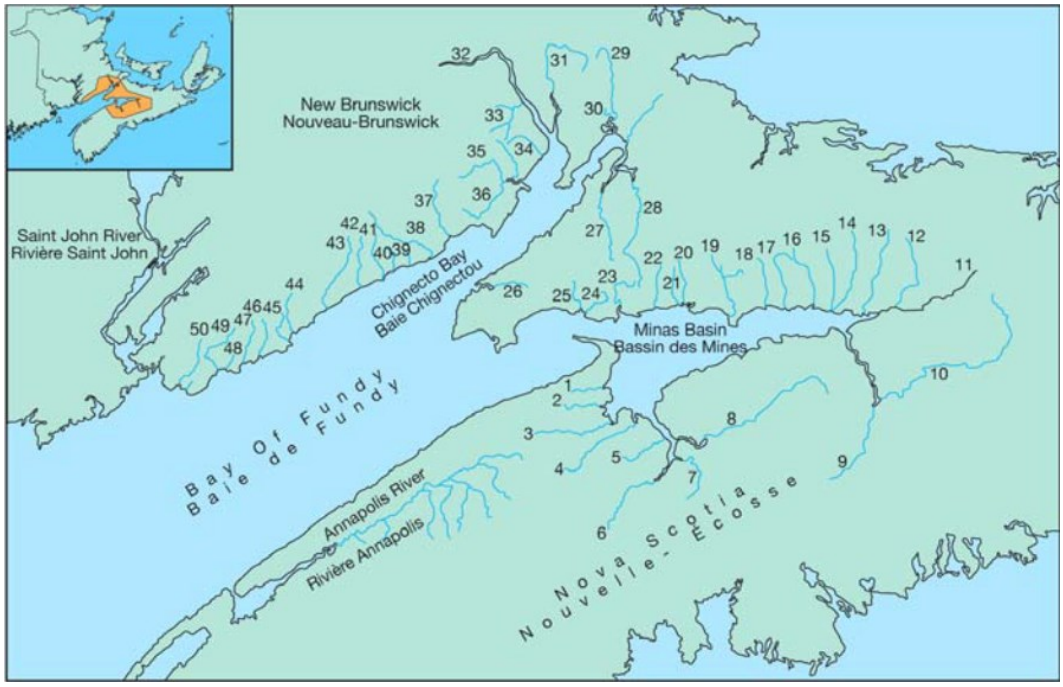

Figure 1.1: Inner Bay of Fundy watershed.
Numbers 1-50 indicate rivers that iBoF salmon are thought to have historically occupied. Reprinted from *Recovery Strategy for inner Bay of Fundy Atlantic Salmon* (p. 9), by Fisheries and Oceans Canada, 2010. © Fisheries and Oceans Canada, 2010. Reprinted with permission.

1.4 Research Design Summary

Effective management of protected species and their habitat is a requirement for their successful conservation, and where management does not result in progress towards recovery objectives, it is important to identify what gaps exist between planning and implementation, and where they occur (Archibald et al., 2021; Barr & Possingham, 2013; Cook et al., 2010; Wistbacka et al., 2018). Quantitative research approaches are often used to answer such questions. For instance, collecting quantitative ecological data can help identify the gap between an endangered species' habitat needs and the protections they receive from policy instruments (Buddendorf et al., 2019; Wistbacka et al., 2018). However, it is not enough to simply identify the gaps, but also to understand why they occur: otherwise, attempts at redress may not actually lead to improvement, even in recovery planning processes that are designed to be adaptive (Aylesworth et al., 2020; Gregory et al., 2012; Wistbacka et al., 2018).

A qualitative approach is often used when the aim is to better understand the context in which management decisions are made, and has often been used in analyses of

the science-policy interface in conservation or resource management (Chapman et al., 2020; Clark et al., 1989; Martín-López et al., 2009; Soomai, 2017a). Typical methods used in this type of research include surveys, interviews, and/or document analysis, often in combination with one another and direct observations (Bowen, 2009; Carolan, 2008; Sayre, 2004). Surveys are useful to explore opinions and beliefs on issues that may be recognized as significant to the average person and conservation managers. For instance, Farrar et al.'s 2020 study addresses the assumption that grassland management in southeastern Australia is partially hindered by negative public attitudes—information that a survey is well-suited to collecting. Interviews, on the other hand, provide the opportunity to more directly engage with key actors or stakeholders in a conservation issue, and can be designed to allow the researcher and participants to delve into the dynamics between specific groups or individuals on a particular conservation issue (Young et al., 2018). Document analysis can be used to provide context and identify key questions to explore during interviews. This method also provides the means to track changes in planning processes over time, whether between a draft and final version of one document, or examining a series of documents published on the same topic over time (Bowen, 2009). All three methods produce data that can then be analyzed for key themes related to the research questions being explored.

In this study, I employed a mixed-methods case-study approach, collecting and analyzing textual data. Due to constraints imposed by the coronavirus (COVID-19) pandemic and responses to it (Cornejo et al., 2023), I designed the project to allow remote data collection, for greater flexibility and minimization of risk for participants . Two major data types were collected and analyzed: policy documents related to iBoF recovery planning, such as the Recovery Strategy, Action Plan, and other relevant reports; and responses to semi-structured interviews with key individuals and staff of organizations involved in recovery planning for iBoF salmon, primarily as members of the Recovery Team. I performed a separate thematic analysis of each collected data type to identify key themes and subthemes relating to each of my two research questions. I then integrated the results of these analyses to present a broad account of the changes in perspectives on recovery feasibility for iBoF salmon over time. In using this qualitative approach to perform this research, I maintained a reflexive approach to data collection

and analysis, with the aim of minimizing the influence of my own biases on the data analyses and helping to ensure that the perspectives and insights shared by the interview participants were accurately represented and respected.

1.5 Thesis Structure

While the overall methodological approach has been briefly introduced above, I will describe the data collection and analysis methods in greater detail in Chapter 2, including the list of documents collected and the rationale for their selection; the identification and recruitment of key informants for semi-structured interviews; and the thematic analysis methods, from the identification of codes to the development and selection of key themes and sub-themes presented in this thesis. In Chapter 3, I present and discuss the major findings related to research question 1: how perspectives on the recovery feasibility for iBoF salmon have changed since 2010, and why these changes have occurred. In Chapter 4, I focus on research question 2, discussing the barriers and enablers expressed by Recovery Team members in the context of evaluating the feasibility of recovery for iBoF salmon since 2010. In Chapter 5, I synthesize and discuss the findings from the previous two chapters, describe the limitations of the research, propose areas for future research, and present key conclusions.

Chapter 2: Methods

2.1 Methodological Approach

This research is a case study exploring the process of determining recovery feasibility for an aquatic species under SARA, focused on the case of iBoF salmon. The specific research questions being posed are: 1) whether perspectives on the feasibility of recovery of iBoF salmon have changed since 2010, and if so, how and why they have changed; and 2) what barriers and enablers Recovery Team members have experienced to reassessing recovery feasibility for the species. I focus on the perspectives of various stakeholders involved in iBoF salmon management on the feasibility of recovery for the species and the process of determining that feasibility, including the barriers and enablers to its reassessment. To achieve my research objectives, I employed a qualitative mixed-methods approach, focusing on the thematic analysis of policy documents as well as responses to semi-structured interviews (i.e., transcriptions of oral interviews, and written responses).

2.2 Data Collection

2.2.1 Data Required and Sources

The recovery planning process is accompanied by the creation of several research and policy documents. By collecting and analyzing these documents, I situated my research within the historical and current context of recovery planning for iBoF salmon; directly collected perspectives on recovery feasibility of iBoF salmon contained within the documents; and compared them across publication dates. These analyses allowed me to chart changes in the perspectives expressed in published documents over time, comparing and contrasting them to stakeholders' perspectives (Bowen, 2009; Koubrak et al., 2021). The data I obtained through the collection and analysis of these documents primarily addressed research question 1: whether perspectives on the feasibility of recovering iBoF salmon changed between 2010 and 2023, and if they did, how and why they changed. Through this process, I identified official statements on the recovery feasibility of iBoF salmon, guidelines used by DFO to determine that feasibility, and changes in those statements and guidelines over time.

I chose to collect data on the experiences and perspectives of key stakeholders on the topic of iBoF salmon recovery feasibility by conducting semi-structured interviews. As a data collection method, interviews are well suited to research that focuses on participants' views and have been employed in other studies exploring the factors that influence decision-making in policy processes (e.g., Soomai, 2017; Young et al., 2018). Interviews are also useful in accessing information that may not be readily available via publicly available documents or reports, such as discussions that led to the final decisions or statements made in recovery planning documents. Conducting interviews allowed me to gather deep and rich insights from participants through reciprocal conversations, better capturing and respecting the nuances in their perspectives on the research topic. Data collected through interviews were suited to addressing both research questions. For question 1, analyses of these data revealed the interviewees' opinions on the feasibility of recovering iBoF salmon and how these opinions have changed over time. To answer research question 2, the analyses focused on the interviewees' identification of barriers and enablers experienced in the process of reassessing recovery feasibility for iBoF salmon. To facilitate these analyses, I developed an analytical framework based on the major components of each research question, the sources of data to be analyzed to answer the research questions, and the methods chosen to collect these data (Table 2.1). This framework provided the basis for developing a coding system for thematic analysis of the data (see section 2.3.1).

Table 2.1: Framework for data collection and analysis for each research question

Research question	Components of the research question	Data sources	Collection methods
Have perspectives of recovery feasibility for iBoF salmon changed since the publication of the 2010 Recovery Strategy, and if so, how and why have they changed?	Past and current assessments/opinions on feasibility of recovery of iBoF salmon (e.g., biological; technical; more feasible; less feasible; unchanged; uncertain)	Recovery planning documents and reports for iBoF salmon Recovery Team members' opinions and experiences	Literature search Semi-structured interviews with key informants
What barriers and enablers have Recovery Team members experienced in terms of reassessing recovery feasibility for iBoF salmon?	Perspectives on barriers to evaluating recovery feasibility for iBoF salmon (e.g., access to information; organizational structure; institutional norms; complexity)	Recovery Team members' opinions and experiences	Semi-structured interviews with key informants
	Perspectives on enablers to evaluating recovery feasibility for iBoF salmon (e.g., commitment; collaboration; partnership)		

2.2.2 Document Search and Review

Many documents produced throughout the recovery planning process under SARA are available to the public. The various departments and ministries involved in administering the Act maintain online libraries of digital versions of these documents. I performed a broad literature search by consulting the databases maintained by COSEWIC, the Canadian Science Advisory Secretariat (CSAS), DFO, and Environment and Climate Change Canada (ECCC), using keywords such as "inner Bay of Fundy," "Atlantic salmon," "Recovery Strategy," and "Species At Risk Act," alone and in combination. From this broad search, I collected a total of 22 PDF files of policy and recovery planning documents, primarily authored by DFO staff, published between 1997 and 2021. I then established the following selection criteria to identify the most relevant documents for my research:

1. All documents that are products of the recovery planning process described by SARA, which includes the Recovery Strategy and Action Plan, as well the Report on the Progress of Recovery Strategy Implementation for [iBoF salmon] for the period 2010 to 2015 (hereafter, the Progress Report);

2. All documents that explicitly mention recovery feasibility and its determination, which includes SARA itself as well as guidance documents published by DFO and ECCC;
3. Documents that address the recovery objectives set out in the 2010 Recovery Strategy, which includes a report reviewing science associated with the LGB program.

These selection criteria allowed me to choose documents that either include discussion on recovery feasibility or are core components of the recovery planning process and therefore served as data to track changes in perspectives expressed throughout that process. After applying the selection criteria, the final list numbered 10 digital documents, published between 2002 and 2021 (Table 2.2; Figure 2.1). I compiled these documents into a folder for use in my data analysis.

Table 2.2: Key iBoF salmon policy and research documents collected for thematic analysis

Document name	Short name(s)	Publication year	Responsible department
Species At Risk Act	SARA	2002	Legislative Services Branch
Recovery Potential Assessment	RPA	2008	DFO
Recovery Strategy, final	Recovery Strategy	2010	DFO
Guidelines on terms and concepts used in the Species At Risk Act	DFO Guidelines	2010	DFO
Proceedings of the regional science peer review of the iBoF salmon science associated with the LGB	LGB Proceedings	2018	DFO
Review of the science associated with the iBoF salmon LGB and supplementation programs	LGB Review	2018	DFO
Action Plan, final	Action Plan	2019	DFO
iBoF Salmon Population Abundance Estimate	Abundance Estimate	2020	DFO
Species at Risk policy on survival and recovery	Policy on Survival and Recovery, ECCC Policy	2021	ECCC
Progress Report, 2010-2015	Progress Report	2021	DFO

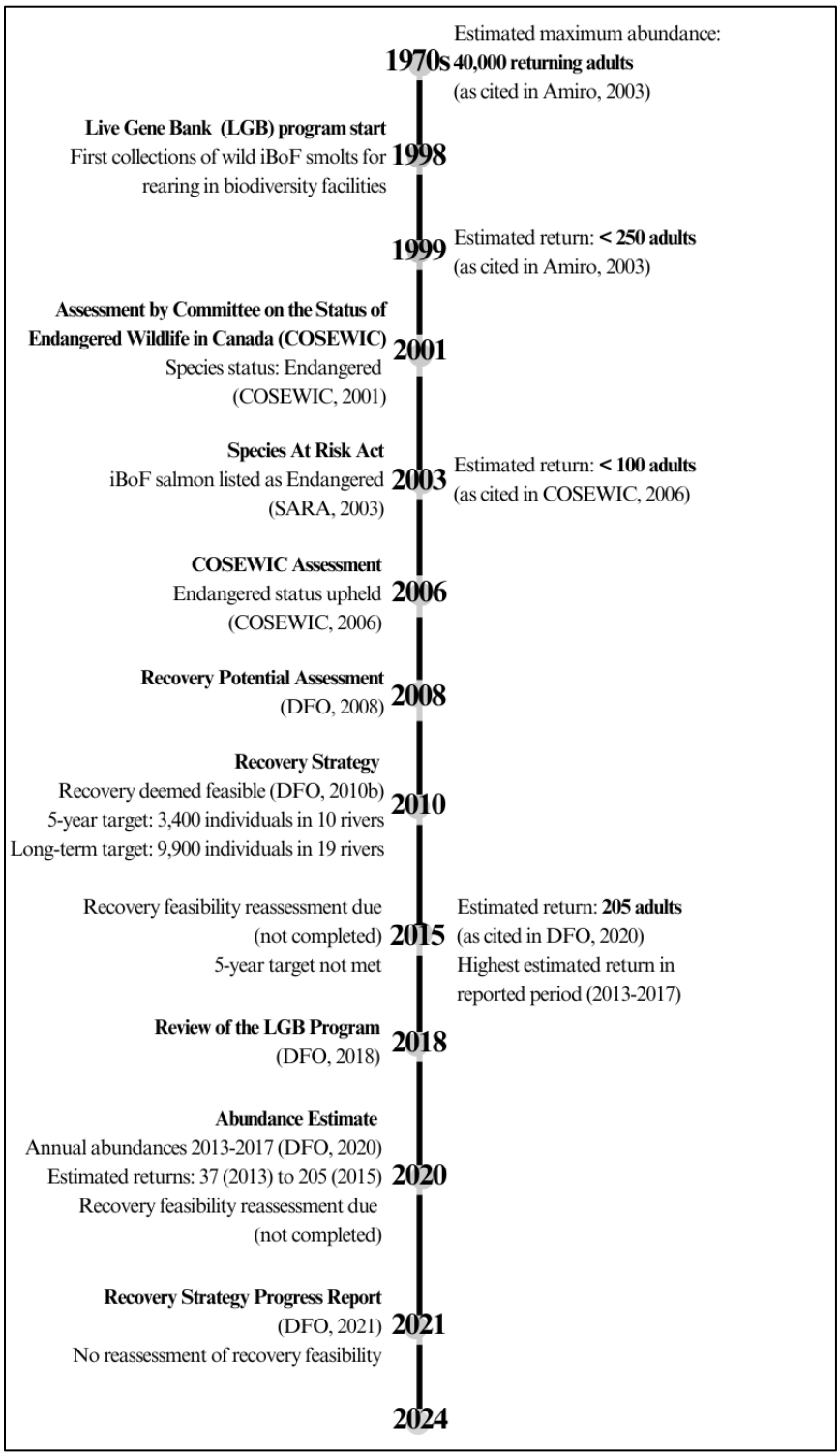

Figure 2.1: Timeline of iBoF salmon recovery planning documents and abundance estimates. Recovery planning milestones and publications are presented on the left; estimates of abundance and adult returns to iBoF rivers are presented on the right.

2.2.3 Semi-Structured Interviews

2.2.3.1 Recruitment Strategy and Process

I received approval from Dalhousie University's Research Ethics Board (REB; file no. 2021-5599) to conduct semi-structured interviews for my research in June 2021 and proceeded with participant recruitment thereafter. I recruited potential participants from the iBoF Salmon Recovery Team, as it represents stakeholders with knowledge, expertise, and involvement in iBoF salmon conservation and recovery planning. A purposive sample of individuals was identified in two stages: first, from lists of members of the Recovery Team found in documents; and second, in referral via recommendations by interviewees (details follow).

The Recovery Strategy, Action Plan, and Progress Report each include a list of individuals who were active members of the Recovery Team during the drafting period of each document, including individuals who chaired the Recovery Team. By comparing these lists, it was possible to see how the size and composition of the Recovery Team has changed between 2005 and 2019. In that span of time, the Recovery Team has counted between 50 and 71 members from over 30 different stakeholder groups, including DFO, PC, provincial government departments, non-governmental organizations (NGOs), and private companies. The Recovery Team also includes several First Nations individuals and organizations, who are recognized rights holders in Canada, as enshrined in the Constitution Act and upheld by the Supreme Court of Canada. They have a nation-to-nation relationship with the Government of Canada, and the federal government has a legal duty to consult with First Nations when they may be affected by their decisions or actions (*Haida Nation v. British Columbia (Minister of Forests)*, 2004). While my research is not specifically aimed at investigating the experiences of First Nations rights holders in the iBoF salmon Recovery Team, it was nonetheless important to include their perspectives in this study and deliberately consider their position in relation to other stakeholders.

From the combined list of members of the Recovery Team, I selected 29 potential candidates for interviews according to the following criteria:

1. Recovery Team members who were also authors of the Recovery Potential Assessment, who would likely have knowledge of the information used to inform the feasibility determination;
2. Individuals who chaired the Recovery Team at any point between 2005 and 2019, whose role in managing meetings could provide key insight on organizational dynamics and the Recovery Team's overall role;
3. Individuals who were present on the list of Recovery Team members across all documents, who could provide perspective from their extensive involvement with the Recovery Team.

I contacted the candidates by e-mail or telephone to request their participation in the study. Of the candidates who were purposively sampled from the Recovery Team, 10 completed interviews; an additional four candidates who meet the selection criteria were recommended by interview participants, two of whom completed interviews, for a total sample size of 12 individuals. These were distributed among the following stakeholder group types: five from federal government departments, four from non-governmental organizations, one from a provincial government department, one from an academic institution, and one from industry (Table 2.3).

Table 2.3: Interviewees by participant code and organizational affiliation.

Participant code	Affiliation
AC1	Academic
DFO1	Federal government (DFO)
DFO2	Federal government (DFO)
DFO3	Federal government (DFO)
DFO4	Federal government (DFO)
IN1	Industry
NGO1	Non-governmental organization
NGO2	Non-governmental organization
NGO3	Non-governmental organization
NGO4	Non-governmental organization
PC1	Federal government (Parks)
PROV1	Provincial government

During the recruitment stage and prior to conducting interviews, I informed each respondent of the study's purpose, the ways that their privacy would be protected during the research, and their rights as participants, including their right to withdraw from the research study at any time during the interview or written response process, or up to four weeks after their response. I provided an REB-approved informed consent form for them to sign and return prior to the interview and gave them the option to provide their verbal consent to participate before beginning the interview. The participants were encouraged to ask any questions they had about the research before, during, and after completing their interview.

2.2.3.2 Data Collection

The interviews were carried out between April and June 2022, were completed via the Microsoft Teams video-conferencing software or by telephone and lasted between one-and-a-half and two hours each. Two participants opted to divide their interviews into two calls lasting 30 to 45 minutes each. The interviews were audio-recorded with the participants' consent via Microsoft Teams' built-in recording and transcription function, or a digital voice memo software, depending on the interview platform. One participant declined to have their interview recorded and I took digital written notes throughout the interview. The interview guide (Appendix A, Table A.1) consisted of seven open-ended, primary questions with 29 secondary questions for prompting, if necessary. These questions were organized within four broad topics: 1) context of the participants' involvement and role in the Recovery Team; 2) their perspectives on the feasibility of recovery for iBoF salmon, and how their perspectives may have changed over time; 3) barriers and enablers to re-evaluating recovery feasibility that they experienced as members of the Recovery Team; and 4) their perspectives on the newest published policy and definitions for survival and recovery that changes how feasibility is evaluated.

One potential participant contacted for an individual interview requested to participate via a collective written response from their stakeholder organization. I received approval from the REB in May 2022 for an amended proposal that included this data collection method before confirming the group's participation in this research. Then, this group participated via a written response to a questionnaire I created by modifying

the interview guide (Appendix A, Table A.2). The group's participation was facilitated through the individual who was initially contacted as a potential candidate. Because multiple individuals from the group could participate in drafting the written response, I modified the informed consent process to ensure all participants were properly informed of the research and its purpose, as well as identifying a process by which individuals could withdraw from participating in the study.

The transcripts and written questionnaire response were de-identified, replacing all names with participant codes. I reviewed each transcript alongside the interview recording to ensure the text was accurate. I stored the recordings and transcripts in an encrypted folder on a password-protected drive, backed up to an external hard drive as well as a secure Dalhousie One Drive repository.

2.3 Data Analysis

In qualitative research, thematic analysis refers to a process in data analysis wherein patterns within the data are identified, explored, and reported—these patterns are generally referred to as "themes" (Braun & Clarke, 2006). While thematic analysis is broadly defined, this analytical approach differs in important ways from other methods such as interpretive phenomenological analysis or grounded theory. In the former approach, the focus of the analysis is on the participants' descriptions of shared lived experiences; in the latter approach, the main goal is the development of a usable theory of process or action from discovered themes (Braun & Clarke, 2006; K. Moon et al., 2016). Thematic analysis is appropriate for this case study, as the objective was to explore the recovery planning process for iBoF salmon in particular. The themes uncovered and explored here may not necessarily be broadly applicable to other SARA recovery planning processes, or stakeholders involved in such processes, without further research and analysis of other, similar cases (K. Moon et al., 2016).

2.3.1 Data Organization and Analytical Approach

After the data collection process, I organized the data into three categories based on the type of data source: documents as outputs of the recovery planning process; interview transcripts as individual stakeholder perspectives; and written responses as perspectives from the organization that prepared them. This categorization of data types

ensured that I was always explicitly mindful of the context in which my thematic analysis took place. For instance, policy documents represent official statements prepared by the participating and responsible organizations and agencies. In contrast, the interview and written responses represent stakeholder perspectives emerging from the same set of questions from the interview guide. The context in which these responses were obtained, however, was quite different. Written responses were collectively crafted by a group of individuals from a stakeholder organization and may have been scrutinized and revised by the organization's managers and staff before being submitted for the study. Thus, the responses may or may not account for differing opinions of individuals who contributed to the submission. Conversely, interview data were expressed by individuals in the moment as a result of an ongoing conversation between the researcher and each participant, and the participants were free to give opinions that may not align with the official positions of the organizations they belong to or those stated in official recovery planning documents. My own experience of each interview also informs my interpretation of these data and the subsequent identification of themes within and across the interviews.

All of the data for this study were analyzed through an inductive-deductive hybrid approach to thematic coding of qualitative data to explore key themes related to each research question, using NVivo text-analysis software (Jackson & Bazeley, 2019; Lumivero, 2023). Coding involves the process of finding terms or phrases to categorize portions of data into units of meaning, with the resulting codes representing categories or themes attached to pieces of data (Cope, 2010; Elo & Kyngäs, 2008). The analytical process I used for each research question is summarized in the following steps (see also Tables 2.4 and 2.5):

1. Iterative open coding of the data within each data category (documents, interviews, written response) to identify emergent codes related to the research question in an inductive fashion and grouping the codes into themes and subthemes;
2. Developing a coding system for each research question to integrate the emergent themes and subthemes with those inherent in the interview guide

and derived from select literature, to serve as a multi-level analytical coding framework to be deductively applied to the data;

3. Deductively applying the analytical framework to the data in a final round of coding, resulting in a dataset organized by themes and subthemes corresponding to the perspectives most relevant or prevalent to the research questions.

Iterative open coding was the first step, and the process was identical for both research questions. When performing open coding on the textual data, I labelled themes in documents, transcripts, and written responses without attempting to narrow the list or limit the codes, familiarizing myself with the data and inductively identifying emerging themes and patterns. Once I became familiar with the data, I proceeded through an iterative process of "cutting and sorting" (Ryan & Bernard, 2003), comparing codes and themes identified within each data type, creating larger categories based on connections, similarities, or differences between emergent themes, and regrouping or deleting themes as appropriate to winnow the list. Through this process, I generated an emergent coding framework with themes and subthemes that were most prevalent or relevant to the research question being asked.

To develop an analytical framework to be deductively applied, I combined the open-coded (emergent) themes with those I derived from the interview guide and selected relevant policy documents and scholarly literature. Through this combination, the open-coded themes aimed to capture the nuanced and contextual perspectives on recovery feasibility and its evaluation for the case of iBoF salmon, while the deductively applied themes aimed to relate these perspectives to the broader context of SARA and the wider scientific literature. I separately applied this process for each research question.

My first research question is concerned with perspectives on the feasibility of recovering iBoF salmon; therefore, I sought to link the results of my thematic analysis to the context of recovery feasibility as defined under SARA. I created a deductive analytical framework based on the emergent codes, the structure of the interview guide, and the definitions and guidelines for determining recovery feasibility published by DFO in 2010, as well as a more recent policy published by ECCC in 2021 (Table 2.4; Table 3.1). While DFO's 2010 guidelines would have been used to determine recovery

feasibility for iBoF salmon in the Recovery Strategy, ECCC's policy provides a more recent set of definitions for recovery feasibility that DFO has stated it would use to guide its approach to defining and evaluating feasibility in the future.

For my second research question, which concerns barriers and enablers to reassessing recovery feasibility, I performed a literature search and identified and reviewed seven papers that examine the implementation of processes such as monitoring, evaluation, and adaptive management in the context of conservation or wildlife management (Allen & Gunderson, 2011; Bottrill, Hockings, et al., 2011; Jacobson et al., 2006; Månsson et al., 2023; McIntosh, 2019; Soomai, 2017a; Stem et al., 2005). I then created an analytical framework based on common themes selected from the papers, the emergent codes, and those derived from the interview guide as relevant to this research question (Table 2.5; Table 4.1). Generally, the inductively derived (emergent) codes were organized around deductively derived parent codes, with emergent codes often representing subthemes within the deductively derived thematic categories.

The resulting analytical framework was then applied to all data. *To deductively apply the analytical framework,* I conducted a final round of focused coding, thereby organizing the data into the relevant themes and sub-themes for each research question. These organized datasets were summarized into spreadsheets, with key phrases and quotes compiled into summary tables associated with each research question. These tables provide the evidence to the results reported in this thesis (Appendices B-C).

2.4 Summary

I collected and analyzed recovery planning documents and conducted interviews with key stakeholders to explore the past and present perspectives on recovery feasibility and its determination under SARA in the case of iBoF salmon. By combining inductive and deductive approaches to thematic analysis, I uncovered key themes that expand on the current and future outlook of recovery for the species, and how the process of determining recovery feasibility has evolved for managers and stakeholders over time. In chapters 3 and 4, I present the results of these analyses organized around each of the two research questions.

Table 2.4: Example of thematic coding and analysis process for research question 1.
A subset of open codes identified in participants' responses to the relevant interview questions is presented. Combined codes* represent themes (**bold**), sub-themes (plain text), and sub-sub-themes (*italics*).

Interview questions	Open coding/emergent codes	Codes derived from documents	Combined codes* for deductive analysis
Has your own perception of the feasibility of recovery for iBoF salmon remained the same or has it changed since the original assessment? Why or why not? In your opinion, are the recovery goals for iBoF salmon still appropriate? Are they still realistic? Why or why not? Do you think the determination of recovery feasibility for iBoF salmon would be the same as in 2010, or different, under the new guidelines in ECCC's 2021 policy on survival and recovery? How so, or why not?	Concern about species' ability to reach recovery objectives; iBoF salmon condition not improving; Persistent limitation to recovery; Impacts of climate change; Marine habitats remain unknown; Decline of iBoF salmon affected freshwater habitat; Potential Allee effects; Population too small	Biological feasibility Total population abundance; Survival rates; Potential for self-sustainability; Improvement in these factors Availability of habitat; Reversible changes to ecosystem; Irreversible changes to ecosystem	**Biological feasibility** Lack of progress towards targets *Low abundance and distribution* *No self-sustainability* Allee effects Environmental shifts *Habitat loss* *Climate change*
	Addressing marine survival is more difficult today than in 2010; Researching threats more difficult than anticipated; Fewer personnel; Less money; Tension between genetic and population conservation; LGB focused on maintaining survival; LGB potentially contaminated with genes from farmed fish	Technical feasibility Ability to research threats; Ability to address threats; Capacity for research Availability of technology to improve species' condition; Ability of approaches to improve species' condition	**Technical feasibility** Researching & addressing threats *Difficulty of research* *Not enough research being done* Current management approaches *Conserving genetics vs population* *Problems with LGB*
	Less feasible due to budget cuts DFO's intention with iBoF salmon unclear; "Feasibility" is unclear; New ECCC policy clarifies "feasibility"	Political, social, economic factors are not considered in determining recovery feasibility; Role of these factors in recovery planning	**Other aspects of feasibility** Political/economic feasibility What is "feasibility"?

Table 2.5: Example of thematic coding and analysis process for research question 2.
A subset of open codes identified in participants' responses to the relevant interview questions is presented. Combined codes* represent themes (**bold**) and subthemes (plain text).

Interview questions	Open coding/emergent codes	Codes from scholarly papers	Combined codes* for deductive analysis
Have there been any barriers or challenges in reassessing recovery feasibility? If so, what are they? What sorts of information went into the original determination? Was the information sufficient and/or adequate? Were there other sources or types of information missing that you think would have been helpful or crucial? Why do you think it was not included or considered? Is that information available, or can it be made available? Are there currently any enabling conditions that support the re-evaluation[sic] of recovery feasibility at this time? What are they? Does the 2021 ECCC policy on survival and recovery affect the work of the Recovery Team in terms of determining recovery feasibility? How so, or why not?	Not much progress on understanding threats to iBoF salmon; First Nations/industry/anglers did not or would not contribute much information; Research is expensive; Resources are limited; Loss of information due to personnel turnover; Loss of personnel/volunteers over time; Not enough time in meetings for reassessment activities; Meetings are now "updates table"; Recovery Team members work in silos; iBoF salmon considered low priority by DFO; Deprioritization by DFO; Information barrier due to conflicting interests in DFO; Political reticence to reassess; Disagreement about "recovery"; Genetic preservation is not recovery; Is "feasibility" scientifically defensible? Abundance goals vs. survival rates; New ECCC policy is "paper-shuffling"	Lack of data to conduct reassessment; Barriers to data uptake	**Lack of information for reassessment** Lack of baseline or new data for iBoF salmon Challenges in accessing and utilizing non-DFO information
		Logistical barriers; Financial/capacity barriers	**Lack of resources for reassessment** Financial and technical challenges Personnel capacity and turnover
		Organizational barriers; Communication; Action procrastination; Organizational culture	**Organizational structure and culture** Lack of coordination among Recovery Team members Disconnects between scientists and managers Focus on updates, not innovation Leadership of the Recovery Team
		Governance barriers; Conflicts of interest; Power & decision-making	**Barriers at the governance level** Unclear role of Recovery Team Perceived conflicts of interest within DFO Reticence to reassess at the political level
		Conceptual barriers; Divergent interpretations; Unclear language;	**Conceptual barriers** How is "recovery" is defined for iBoF salmon What is "feasibility" and how to assess it
	Reassessing feasibility is important; Recovery Team is "hub" for salmon recovery activities; Opportunities for collaboration; Importance of TEK and LEK; Fundy Salmon Recovery program; Leveraging financial and personnel capacities; ECCC policy makes determining feasibility clearer; New policy could start discussion around feasibility	Value tied to monitoring	**Recovery Team members value reassessment**
		Building capacities	**The Recovery Team as a central organizing group**
		Facilitating learning processes	**Better integration of information from outside of DFO processes**
		Enhancing understanding of reassessment processes	**Clarifying recovery feasibility and its reassessment**

Chapter 3: Perspectives on the Feasibility of Recovery for iBoF Salmon

3.1 Introduction

This chapter is centered on the themes pertaining to the first research question of whether, how, and why perspectives on the recovery feasibility of iBoF salmon have changed since the publication of the 2010 Recovery Strategy. To answer this research question, I compared perspectives expressed in the Recovery Strategy and other documents circa 2010 with more recent documents (i.e., up to 2023); I also compared interviewees' recollections of their perceptions held around 2010 with those at the time of data collection for this study in 2023. Through this comparison, I identified any changes in perspectives and reasons for those changes. The Recovery Strategy contains the earliest perspective on recovery feasibility in the documents I analyzed, while the 2021 Progress Report contains the most recent. Because some individuals were members of the Recovery Team since before 2010 and others were not involved in iBoF salmon recovery until later (i.e., 2020), the semi-structured interview process asked interviewees to identify how they felt about the feasibility of recovering iBoF salmon around 2010, as well as how their perspectives may have changed over time to 2023. Perspectives on recovery feasibility expressed in the documents and by the interview participants, as well as the reasons why these perspectives did or did not change over time, were then organized and evaluated according to key elements of criteria for recovery feasibility (i.e., biological and technical) employed by organizations and processes under SARA.

3.1.1 Definitions for Recovery Feasibility and its Components

As described in Chapter 1, SARA explicitly requires the determination of recovery feasibility for species listed under Schedule 1 and identifies biological and technical feasibility as its components. However, SARA does not provide definitions for "recovery," "recovery feasibility," or biological or technical feasibility. Environment Canada (now Environment and Climate Change Canada (ECCC)), and Fisheries and Oceans (DFO) each developed guidelines for interpreting terms found in the text of SARA, including for recovery feasibility. The definitions I used as a frame of reference for recovery feasibility and its components (Table 3.1)

are from DFO's guidelines published in 2010 (hereafter 2010 SARA Guidelines), as well as the ECCC Policy on Recovery and Survival published in 2021. I chose the former document because DFO is responsible for administering the Act for aquatic species, and, according to DFO (2010a), its SARA Guidelines at the time "represent[ed] the best scientific and technical advice that can be provided on the interpretation of terms in the Species At Risk Act according to their ecological and biological meanings." The 2021 Policy on Recovery and Survival was developed by ECCC, which manages endangered terrestrial animals and plants within federally managed areas. As DFO participants state in their written response to the interview questions asked as part of my thesis research, "the development of aquatic-specific guidelines on operationalizing the new Policy are underway." I thus chose to also include the ECCC (2021) policy as it represents a more recent set of definitions for recovery and recovery feasibility under SARA that will guide DFO's approach to defining and evaluating recovery feasibility. Examining this policy also allowed me to compare the definitions and guidelines used by ECCC and DFO (see Table 3.1), and to explore further how these factors influence expressed perspectives.

While DFO's 2010 SARA Guidelines do not provide a direct definition of "recovery" for a marine species listed under the Act, the text does refer to a population achieving "the status of a viable, self-sustaining population that persists in the wild for multiple generations without human intervention" when discussing biological feasibility of recovery (DFO, 2010a). Conversely, the 2021 ECCC Policy on Recovery and Survival does explicitly define recovery: "A return to a state in which the risk of extinction or extirpation is within the normal range of variability for the species, as indicated in part by its population and distribution characteristics" (ECCC, 2021). ECCC's policy also establishes criteria for characterizing the threshold for recovery to be considered feasible for a listed species, and these criteria align closely with the definition of a recovered population in DFO's guidelines. Namely, for a species listed under SARA, the feasibility of recovering that species is evaluated against the likelihood that its survival can be maintained over the long term, that the species' condition can be improved over when it was listed, and that it can eventually sustain itself without direct human intervention. These three criteria remain central to the definition of "recovery" used by the federal government since at least 2010.

Table 3.1: Definitions for recovery feasibility and its components under SARA, including biological, technical, and other aspects.
From DFO's 2010 Guidelines for terms and concepts used in the Species At Risk Act, and ECCC's 2021 Species at risk policy on recovery and survival.

	DFO Guidelines, 2010	ECCC Policy, 2021
Recovery feasibility	"Recovery is considered technically and biologically feasible if all four of the following criteria are met: - Individuals of the wildlife species that are capable of reproduction are available now, or in the foreseeable future, to sustain the population or improve its abundance; - Sufficient suitable habitat is available to support the recovery of the species or could be made available through habitat management or restoration; - Primary threats to the species or its habitat (including threats outside Canada) can be avoided or mitigated; - Recovery techniques exist or can be developed to achieve recovery goal[sic]."	"When a species' condition can be improved to the extent that it meets or exceeds the recovery feasibility threshold, recovery will be considered to be feasible." "The competent [M]inister(s) will consider the recovery feasibility threshold as characterized by the following criteria: - Survival: survival characteristics can be met to the extent that the species is no longer at significant risk of extinction or extirpation as a result of human activity; and - Improvement: the condition of the species can be improved over when it was assessed as at risk; and - Not reliant on human intervention: when the above conditions are met, perpetuation of the recovered state can become not reliant on significant, direct, and ongoing intervention such as feeding, vaccinating, or breeding individuals, to maintain populations." "The purpose of determining the recovery feasibility of the species under section 40 of SARA is to establish whether it is biologically and technically feasible, after accounting for persistent limitations, to improve a species' condition for that improvement to reasonably constitute recovery."
Biological feasibility	"Biological feasibility is defined as a function of the intrinsic ability of a population/species to achieve the status of a viable, self-sustaining population that persists in the wild for multiple generations without human intervention." "In general, there are three requirements for biological feasibility of recovery: - Correction or removal of the root cause(s) of decline; - Sufficient habitat to support a viable population; and - Sufficient number of breeding individuals to overcome the initial elevated extinction risk."	"Biologically feasible means that the biological prerequisites (e.g., characteristics of habitat, population, or distribution) of recovery for the species in Canada are still present or can be reasonably expected to be recreated in time to support attainment of a recovered state."

	DFO Guidelines, 2010	ECCC Policy, 2021
Technical feasibility	"Technical feasibility can be considered the ability of management to successfully implement any actions required to achieve species recovery, regardless of cost." "Technical feasibility is dependent upon the ability of the organizations and jurisdictions responsible for recovery to respond to the needs of a species such that its recovery can be achieved. Questions to be considered to determine if it is technically possible to provide the conditions required for a recovery[sic] include: - Can the root cause(s) of decline be determined and eliminated; - Can habitat loss be reversed; if it cannot be linked to a single cause which can be mitigated, this may not be possible (e.g., global warming); - Have biotic changes occurred which cannot be reversed or which we are unlikely to reverse; and - Has an alternate stable population level been established which the population is unlikely to move beyond."	"Technically feasible means that the scientific/management techniques and technology required to attain the targeted condition for the species in Canada exist, or can be reasonably anticipated to be available in time to support attainment of a recovered state."
Other aspects	"The feasibility of recovery should … be based on the best available biological and technical information, and not socio-economic information."	"The determination of recovery feasibility under section 40 of SARA will be limited to considerations of whether the biological and technical necessities of attaining a recovered state exist, or are reasonable likely to exist in a time frame necessary to attain recovery. Political, socio-economic, and administrative considerations play no direct role in this determination." "A persistent limitation is a constraint on the ability to return a species to its natural condition. Persistent limitations include irreversible changes that result in the establishment of a new set of ecological or biological conditions that cannot be reasonably reversed or mitigated within a time-frame that will benefit the species … Examples of persistent limitations may include urbanization, major infrastructure, and the effects of climate change."

Both documents stress that only biological and technical feasibility should be considered when determining the feasibility of recovering a species at risk, with socioeconomic or political concerns coming into play later in the recovery planning process. While factors beyond solely biological or technical can and do affect the likelihood that a species will recover (Bean, 2009; Culbert & Blair, 1989), they are not to be considered in the determination of recovery feasibility. The documents analyzed in this study generally excluded these other factors; however, several interviewees did discuss them, and the implications are detailed in the appropriate section of this chapter.

3.1.2 Chapter Structure

The results of my thematic analysis of the documents, interview transcripts, and written responses are oriented around 1) biological, 2) technical, and 3) other components of recovery feasibility (section 3.2, 3.3, and 3.4, respectively), in alignment with my coding framework (Appendix 2). Within each section, I address whether and how reported perspectives concerning that specific component of feasibility have changed since 2010, and the reasons these changes may have occurred. Key quotes from the documents and interviews are presented throughout. I conclude the chapter by highlighting and briefly discussing key findings in the context of those from other studies.

3.2 Biological Feasibility of Recovery

The guidelines for interpreting and applying SARA terminology published by DFO in 2010 (Table 3.1) define biological feasibility as "a function of the intrinsic ability of a species/population to achieve the status of a viable, self-sustaining population that persists in the wild for multiple generations without human intervention." The document elaborates further, listing three requirements for recovery to be biologically feasible: the "correction and removal of the root cause(s) of decline; sufficient habitat to support a population; and sufficient number of breeding individuals to overcome the initial elevated extinction risk" (DFO, 2010a). In the 2021 ECCC Policy on Survival and Recovery, biologically feasible "means that the biological prerequisites (e.g., characteristics of habitat, population, or distribution) of recovery for the species in Canada are still present

or can be reasonably expected to be recreated in time to support attainment of a recovered state."

It is important to note that the definitions of biological feasibility given in both documents could also be understood to include components of technical feasibility. For example, while the 2010 Guidelines note that biological feasibility is "a function of the intrinsic ability" for an endangered species to move towards recovery, there is an implication of an active approach in the "correction and removal of the root cause(s) of decline." The 2021 Policy on Recovery and Survival includes the notion that "biological prerequisites ... can be reasonably expected to be recreated;" this recreation could occur thanks to ecological shifts or innate adaptation by the species in question but could also be brought about by management approaches such as habitat remediation, transplantation of individuals, or direct supplementation via breeding programs or hatcheries. Whether such approaches are considered to be available and likely to be effective would fall under the purview of technical feasibility (see section 3.3). Throughout the period from 2010 to 2021, the definition of biological feasibility centred on characteristics such as population abundance, habitat availability, and survival of individuals for a species listed under the Act, and thus my analysis in this section primarily focuses on these characteristics. The aspects of technical feasibility that link with biological feasibility will be discussed in detail in section 3.3, particularly sections 3.3.1.2 and 3.3.2, on addressing threats to recovery and the management approaches used in iBoF salmon recovery planning, respectively.

3.2.1 Biological Feasibility in the Recovery Strategy

In the Recovery Strategy for iBoF salmon, the evaluation of biological feasibility of recovery for the species centered on two major topics: the high rates of marine mortality that the population is experiencing, and the availability of habitat for the freshwater and marine phases of the salmon life cycle (DFO, 2010b). The Recovery Strategy states that in 2010, "the population [was] not viable without intervention … apparently because of very high rates of marine mortality." For iBoF salmon, intervention took the form of the Live Gene Banking (LGB) program, which collects individuals from the residual wild populations to rear them to maturity in captivity and eventually release

pedigreed progeny back into iBoF rivers. Some of these releases are recaptured before they go out to sea to repeat the rearing cycle, while the rest supplement the remnant populations. This process ensures that at least some fish can bypass the marine stage of their life cycle, where most of the mortality limiting recovery is thought to occur. DFO concludes in the Recovery Strategy that the LGB is "viable as a mechanism for contributing to the survival of the population." Supplementation efforts supported by the LGB program have also resulted in an increase in the abundance of juveniles in the wild (DFO, 2010b). However, the LGB is not sufficient to achieve recovery on its own unless marine survival improves for iBoF salmon. The factors that contribute to the increased rates of marine mortality experienced by iBoF salmon were "poorly understood" at the time and thus difficult or impossible to address.

The Recovery Strategy addresses both freshwater and marine habitat availability when discussing biological feasibility of recovery. The perspectives about freshwater habitat are optimistic, with DFO stating that "freshwater habitat remains largely unchanged since the collapse of the population in the late 1980s." Even with "ongoing threats of habitat degradation and loss," freshwater habitat is not considered a limiting factor for the recovery of iBoF salmon. DFO points to the successful stocking of LGB progeny into iBoF rivers as an indication that spawning habitats are able to support iBoF salmon production. The Recovery Strategy's assessment of marine habitat availability is more uncertain, as less information is available about it than for freshwater habitats. Because of the dearth of information about specific marine habitats used by iBoF salmon, DFO relied on water temperature as "currently the best indicator for marine habitat quality" for the species, with prey abundance as a secondary factor. Such techniques to infer Atlantic salmon habitat have been used to manage fisheries for other Atlantic salmon stocks in Canada (DFO, 2012). The results of one such analysis of water temperature ranges in the Bay of Fundy tentatively confirmed that "habitat within an acceptable temperature range for Atlantic salmon and its principal prey species appears to be widely available for much of the year." The assessment of biological feasibility in the Recovery Strategy did not discuss whether other factors such as structural barriers, turbidity, or salinity were considered. DFO concluded its assessment of biological feasibility for iBoF salmon as follows:

> Therefore, with the exception of low marine survival, which can be partially mitigated through the LGB program, life history characteristics and habitat attributes appear sufficient for population recovery to be biologically feasible (DFO, 2010b).

Since this cautiously positive assessment in 2010, however, the perspectives embedded in recovery planning documents and reported by the interviewees suggest a growing uncertainty about the biological feasibility of recovering iBoF salmon (Appendix C, Table C.1).

3.2.2 Changes in Perspectives on Biological Feasibility for iBoF Salmon

3.2.2.1 Lack of Progress Towards Recovery Targets

The lack of progress towards the targets stated in the Recovery Strategy was a frequent topic of discussion within the theme of biological feasibility of recovery for iBoF salmon, both in the recovery planning documents and in conversations with RT members. The Strategy lists both short-term and long-term targets for recovery. The short-term target, to be accomplished within five years of publishing the Recovery Strategy, aimed to "progress towards re-establishing self-sustaining populations to their conservation levels in … 10 river systems that contribute to the LGB program" (DFO, 2010b). Here, the "conservation level" is a reference to a specific number of salmon required in each river to optimize juvenile production in freshwater (Gibson & Claytor, 2013). The long-term target, which has no specific associated timetable, expands on the short-term target, setting abundance and distribution targets of 9,900 spawning adults in 19 river systems, including the 10 from the short-term target. These quantitative goals provide several concrete ways to measure progress toward recovery for the species, including an increase in the number of iBoF salmon returning to rivers in the Bay of Fundy, an increase in the number of rivers seeing iBoF salmon returns, the establishment of self-sustaining populations of any size, or a combination of these criteria.

From an estimated maximum of 40,000 adults in at least 32 rivers in the inner Bay of Fundy in the 1970s, the abundance of iBoF salmon shrank to as few as 250 individuals in 10 rivers or fewer by 1999, and at the time of the Recovery Strategy in 2010, "it [was] unlikely that abundance [had] subsequently increased" (DFO, 2004, 2010b). Despite this

significant decline, the above-mentioned abundance and distribution objectives were seen as reasonable and achievable in the Recovery Potential Assessment (RPA) for iBoF salmon published in 2009, and the Recovery Strategy states that "re-establishing self-sustaining populations in the above-noted 10 rivers would be considered the minimum required to conclude that success had been achieved in attaining recovery goal [sic]." Based on estimates of abundance in the policy documents I examined (Figure 2.1), more recent documents do not paint an optimistic picture of progress; for example, the 2020 Abundance Assessment states:

> Even with the uncertainty in the annual population estimates for [iBoF salmon], current estimates consistently remain below the 1999 estimate of … returning adults. The iBoF [designatable unit] population abundance has not improved and may have further declined since the late 1990s despite supplementation efforts. … Under current conditions, it is highly unlikely that adult returns to these rivers can be maintained without the support of the LGB program (DFO, 2020).

The failure to reach the short-term recovery target also cast doubt on the greater objectives of the iBoF salmon recovery program. The 2021 Progress Report directly acknowledged that "the overall recovery goal 'to re-establish wild, self-sustaining populations as required to conserve the genetic characteristics of the remaining anadromous iBoF salmon' was not achieved."

> Based on the iBoF Salmon's population status, threats to its survival and recovery, and analysis of progress to date towards achieving self-sustaining populations, it is uncertain whether the overall recovery goal and objectives for iBoF salmon remain relevant and achievable. Despite recovery efforts to date, there have been ongoing range-wide river-specific extirpations, and ongoing low abundances, even in LGB-supported rivers (DFO, 2021).

Amongst the 13 participants interviewed, 10 expressed greater pessimism about the biological feasibility of recovery, while the remaining three maintained that recovery was either just as feasible, or that biological feasibility remained unknown or uncertain. There were differing levels of pessimism among the majority: seven of the 10 in this category voiced the opinion that recovery was still feasible, though perhaps at lower abundance or distribution levels, while the remaining thought that it was now impossible

for iBoF salmon to return to self-sustaining levels. The consistently low number of returning adult iBoF salmon since the LGB program was implemented in 1997 was a source of concern for the interviewees both within and outside of governmental organizations, especially those who had been part of the Recovery Team since at least 2010. One interviewee, a member of DFO who participated in the Recovery Team for over a decade, noted the following when asked about the need to reassess feasibility of recovery for iBoF salmon:

> **DFO1:** The initial collections to support the Live Gene Banking program occurred in 1998. A formal program for the protection and maintenance of biodiversity started, really, in the early 2000s. We've done a three-generation [15-year] review of that, and we're now four years past that, maybe? There is no evidence of recovery within the population, or evidence of self-sustaining populations. I think intervention has played a major role in preventing extirpation, and some of the programs that are underway have had positive results … But I probably have more concern for the long-term persistence of that designatable unit now than I did in, say, 2007 or 2008, because we haven't seen any real progress in terms of life cycle closure and reduction in the mortality it's seeing.

Another DFO participant reported a similar change in perspective on biological feasibility, stating that "we did a survey in 2013 … that was meant to feed into our understanding of whether there were adults coming back and spawning in the Stewiacke River, for example… [and that survey] added a level of discouragement to me in terms of whether in fact biological feasibility was still there now" (**DFO4**).

One significant and specific concern about the biological feasibility of recovery for iBoF salmon was over the species' ability to re-establish self-sustaining populations. Self-sustainability is considered a key component of recovery under SARA. In the words of one participant, "recovery … means that you can stop what we're doing, walk away, and just ensure that things don't backslide in terms of value. And with that, you need self-sustaining populations that can persist in the long term" (**DFO1**). The ECCC Policy on Survival and Recovery explicitly indicates that a population must eventually move away from reliance on significant human intervention, including breeding programs, in order to be considered recovered (2021). Discussions surrounding the self-sustainability of iBoF

salmon, or lack thereof, were accompanied by some of the most emphatic language used to talk about biological feasibility both in the documents and interviews. In 2010, iBoF salmon was completely reliant on human intervention to persist in the wild, primarily in the form of Live Gene Banking (LGB), with the Recovery Strategy stating that "iBoF salmon will rapidly become extinct without the LGB program." A majority of interviewees noted the critical role that this gene banking and hatchery program played to prevent the total extirpation of the species, with one likening the situation of iBoF salmon to a "plug [that] was already out of the bathtub, and so they needed to act fast, and the LGB saved the fish from going extinct" (**NGO3**). Its role in ensuring the survival of the species was also highlighted: "the Live Gene Bank maintains the potential for recovery to happen, but without it, well, there's no hope" (**DFO3**).

This reliance on human intervention continues to the present day. Both the 2020 Abundance Assessment and the 2021 Progress Report explicitly mention the fact that, at the time of publishing each report, the remaining rivers containing iBoF salmon continued to depend on the LGB for their persistence. All 12 interviewees acknowledged, either directly or indirectly, that self-sustainability is "nowhere near being done or achievable at this time" (**NGO3**). NGO2 and PC1 went even further, expressing scepticism at the possibility of future iBoF salmon populations that didn't require some level of significant human involvement, with PC1 stating that this involvement might have to continue in perpetuity:

> **PC1:** So, the question, in other words: is there a future where there is a self-sustaining inner Bay of Fundy Atlantic population that is not requiring input? No. I don't think the ability is there.

The fact that iBoF salmon populations have not increased towards the abundance and distribution targets laid out in the Recovery Strategy, coupled with the growing concern expressed both in recovery planning documents and by Recovery Team members about the ability of iBoF salmon populations to sustain themselves in the future, reflects a negative turn in opinion on the biological feasibility of recovery for the species.

3.2.2.2 Ecological and Environmental Changes

Concern about environmental changes that have occurred in the marine and freshwater environments inhabited by iBoF salmon since 2010 were prevalent in both the recovery planning documents and interview responses. All interviewees expressed perspectives that were either directly or indirectly associated with this theme. DFO's initial line of thinking about the state of iBoF salmon was that its decline was due to a regime shift: a dramatic change in the bio-physical attributes of the Bay of Fundy that caused ocean conditions to become unfavorable to iBoF salmon survival (Lees et al., 2006). Importantly, it was thought that this regime shift would eventually revert to better conditions for the species. DFO1 noted that "we've had other large-scale oceanographic environmental signals in the past" in Canadian waters, including "flipping regime shifts [on the West Coast] that last five to 15 years," and, closer to the range of iBoF salmon, "a really cold event that covered most of the Scotian Shelf … in the early 1990s that lasted for about 10 years, and then it warmed up again." DFO4 echoed this sentiment when he described the evolution of thinking in the recovery program over time:

> **DFO4:** The feasibility of recovery was based on the fact that if you don't know what killed them, then maybe they might recover on their own … If it happened that quickly, then maybe whatever had caused it to happen would go away and they would recover. I remember that was the first thinking about feasibility of recovery. But they didn't recover on their own.

Perspectives about freshwater habitat were mixed among the documents and interviews, with some simultaneously expressing both positive and negative opinions on the subject. Optimistic appraisals of freshwater habitat for iBoF salmon tended to focus on the ability for that habitat to support spawning and rearing of Atlantic salmon, much like the Recovery Strategy stated in 2010. For example, the 2021 Progress Report maintains that "freshwater habitat is believed to be sufficient to maintain populations" and that habitat quality monitoring projects "have confirmed good water quality for Atlantic salmon production" in rivers where such projects had occurred. The perspective that freshwater habitats are able to support iBoF salmon production was shared by six interviewees (DFO1, DFO3, IN1, NGO3, NGO4, and PROV1), at least for some rivers in the inner Bay of Fundy. In particular, the fact that unfed fry released into iBoF rivers as

part of the LGB program could survive to become smolts was a major reason why DFO3 believed that the freshwater habitat was in fairly good shape. NGO4 highlighted how stewardship of iBoF rivers by both governmental and non-governmental organizations played a major role in maintaining and even improving freshwater habitat.

Conversely, four non-DFO interviewees (AC1, NGO2, NGO4, PC1) expressed the notion that the results gleaned from current monitoring programs may not be telling the full story about iBoF salmon freshwater habitats. According to the Progress Report, ecosystem monitoring projects were undertaken on five of the 10 iBoF rivers listed under the Recovery Strategy's short-term objective. Of these, only two (Stewiacke River, NS; Petitcodiac River, NB) were specifically monitored for iBoF salmon freshwater habitat quality. Two of the remaining three (Point Wolfe River; Upper Salmon River) were the subject of general ecosystem condition monitoring; and Big Salmon River was monitored for general water quality. This means that five key iBoF rivers are not directly monitored by DFO or Parks Canada and rely on monitoring from First Nations or NGOs. NGO1 specifically pointed out a mismatch between what DFO detected through its monitoring programs and what the NGO organization observed in rivers not monitored by DFO:

> **NGO1:** Where DFO or Parks [Canada] has put a lot of focus—Point Wolfe, Big Salmon, et cetera—from what I hear at the recovery table, they seem to be doing OK, at least no worse or maybe a little better than they were ten years ago. But I can tell you from the other critical habitat rivers, including the five that we work on, it's definitely gotten worse. And, so, I would say the feasibility of recovery has gone down quite a bit just from that balance.

One important point brought up by AC1 and PC1 concerning freshwater habitat quality was that current monitoring efforts tend to focus on abiotic factors such as oxygen, water clarity, and temperature, all of which indicate that good freshwater habitat for Atlantic salmon exists in the inner Bay of Fundy. However, AC1 argued that the removal of salmon from these rivers may have caused an ecosystem shift, fundamentally altering biotic characteristics such as primary production and smolt prey abundance in a way that now makes it difficult for salmon to re-establish itself.

Several interviewees (IN1, NGO4, PROV1, NGO2) were concerned about threats to freshwater habitats, including habitat destruction due to human development, damming

and loss of fish passage, the impacts of invasive species, or shifts in the trophic web of iBoF rivers and estuaries. Most of these perspectives held that the biological feasibility of recovery was reduced, but not outright eliminated, by these factors; however, NGO2 was markedly more negative, doubting that the salmon would ever return to iBoF rivers "because we've destroyed this habitat." Change in the marine environment was also an important topic in the recovery planning documents, and a substantial topic of discussion with five of the 12 interviewees. Discussion centered on two topics: the effects of climate change on the Bay of Fundy, and the potential impacts of aquaculture development on salmon marine habitat. The 2021 Progress Report states that DFO has not completed an analysis of marine habitat quality or quantity since the one included in the Recovery Strategy. That analysis relied only on seasonal changes in sea surface temperature to characterize the suitability of habitat for iBoF salmon, a common approach to characterizing salmon habitat suitability in general (see section 3.2.1). Climate change, and associated changes in the marine environment, was thus a prevalent topic among Recovery Team members. One-third of the interviewees directly expressed unease about climate change in terms of its potential impact on iBoF salmon recovery feasibility (DFO1, DFO4, IN1, NGO3). While the actual effect of climate change on marine habitat availability for iBoF salmon is not yet known, all four were concerned that it could make large portions of the Bay of Fundy uninhabitable in the marine phase of its life cycle, which would make recovery for the species less feasible. According to DFO1, the reduction in high-quality thermal regimes in the Bay of Fundy was "one of the things that's most concerning" to DFO currently, given that the Bay is "one of the fastest-warming areas on the planet."

While the Recovery Strategy identified aquaculture as a potential threat to iBoF salmon, it concentrated on impacts related to "interactions with farmed and hatchery salmon," including loss of fitness through mixing of iBoF and farmed salmon, the spreading of diseases such as infectious salmon anemia and sea lice, or the concentration of animals that prey on post-smolt Atlantic salmon near salmon farms (DFO, 2010b). The potential loss of salmon habitat to farms was mentioned in the Recovery Strategy. While several interviewees spoke on the subject, several disagreed about the impact that aquaculture developments had on marine habitat for iBoF salmon. NGO1, NGO3, and

NGO4 emphasized that farms would likely be placed in locations conducive to the growth of Atlantic salmon or that may have been used as overwintering habitat by iBoF salmon in the past. However, DFO1 and PROV1 pointed out that previous research on the subject, including telemetry studies on post-smolt iBoF salmon, did not show conclusive evidence of any overlap between iBoF salmon and farms in the Bay of Fundy. When discussing the topic of aquaculture and iBoF salmon, DFO3 acknowledged that these perspectives may not be completely at odds: while prior telemetry research was inconclusive, "it's not out of the question that we've lost a component [of iBoF salmon] with different behaviors," i.e., that historically used habitat is now occupied by salmon farms . Though it may be too soon to conclude that recovery is less biologically feasible than in 2010, there appears to be growing uncertainty among Recovery Team members about the availability of suitable marine and freshwater habitats to support iBoF salmon and a growing perception of the need for more research to reduce this uncertainty.

3.2.2.3 Allee Effects and Population Issues

As the decline in iBoF salmon numbers has persisted, consideration of the role *Allee effects* may be playing has grown in importance, especially among Recovery Team members. Allee effects are positive correlations between population size or density and mean individual fitness or *per capita* growth rate in a population or species (Courchamp et al., 2009). Essentially, high population sizes can improve the survival rates of species, while low population sizes can result in the opposite. Allee effects can include ecological mechanisms such as mate limitation or increased vulnerability to predation, as well as genetic effects such as bottlenecking or inbreeding depression. In the case of endangered species, Allee effects may be important to consider when the abundance of a population has been reduced to less than 10% of its historical average size, making the small size an impediment to recovery despite any action taken to reduce threats to that species (Hutchings, Butchart, et al., 2012).

Allee effects have been considered in recovery planning for iBoF salmon since at least 2010, partly due to the dramatic reduction of the salmon's abundance in a relatively short span of time—over 99% since the 1980s. Both ecological and genetic manifestations of the Allee effect were considered under the category of "depressed

population phenomena" in the list of threats to iBoF salmon in the Recovery Strategy. An example of the former was the potential inability for salmon to form schools in marine environments (though there was no evidence suggesting that this was or was not occurring for the species), and an example of the latter was the potential loss of genetic variability due to small population size during spawning in freshwater (DFO, 2010b).

Genetic Allee effects were of particular concern around 2010. One interviewee recalled that around that time, "everybody was thinking it was this genetic thing—sure, we save the last of the species, but it might all be for naught over 100 years where you're left with a population that is so dysfunctional that it can't survive by itself" (**NGO1**). Despite the initial grim condition of the species, more recent assessments of iBoF salmon genetic diversity reported in the recovery planning documents were cautiously optimistic about preventing the loss of genetic diversity in iBoF salmon populations. A 2018 peer review of the LGB's role in iBoF salmon recovery by DFO indicated that, for the Stewiacke River population (the only population for which this type of genetic analysis was possible at the time), there were "elevated rates of loss of variation in founder parent alleles and genome equivalents over time, and higher than anticipated rates of accumulation of inbreeding in subsequent generations." However, the report went on to indicate that the dire state of iBoF salmon at the time likely contributed to these negative changes in the population's genetics. DFO noted in the report that "levels of inbreeding may have been lower than observed today [if] founder collections [to start the LGB program for iBoF salmon were] initiated even two years earlier." When accounting for these factors, "rates of loss of molecular genetic variation between the founder and second-generation salmon were low, though some slight reductions were observed" (DFO, 2018). Several interviewees (DFO1, DFO4, DFO3, DFO2, NGO1, AC1) were similarly optimistic about efforts to prevent the loss of genetic diversity through the LGB program, with both DFO4 and NGO1 referencing the 2018 peer review's results to support the assertion that "we've been able to maintain almost all of that genetic diversity" (NGO1). This observation is an example of the significant ties of biological feasibility to technical feasibility, due to the population's dependence on captive breeding to maintain its survival. Despite the known challenges of using such technologies to conserve a species and maintain its genetic makeup, "something close to an inner Bay of

Fundy salmon" (**DFO3**) has been preserved on a genetic level through the use of the LGB program, potentially maintaining the possibility of recovery for the species.

While concerns about ecological Allee effects existed in 2010, their contribution to limiting recovery for iBoF salmon was either unknown or not considered to be significant. One respondent stated that "at that time [when the preliminary work was done in advance of the 2010 Recovery Strategy], we had no information to indicate that poor survivorship at sea would continue in perpetuity" (**DFO1**). Depensation, or the reduced production and survival of eggs and offspring in response to the decline in breeding individuals, has also been a topic of investigation in freshwater environments, but according to DFO3, "we haven't found evidence of that" occurring. Most other research on ecological Allee effects has been inconclusive thus far; but, with the ongoing low population and the lack of meaningful movement towards any sort of recovery for the species, many Recovery Team members, including DFO1, NGO1, and PC1, expressed greater uncertainty than in 2010 about whether iBoF salmon are in a genetic situation from which they cannot recover. The environment of the Bay of Fundy is one of the fastest changing in the world, and with the associated stressors, "the population numbers [may be] so low that any amount of harm is keeping the population from coming back" (**NGO1**).

Ironically, the very reason for the lack of concrete evidence for depensation or other ecological Allee effects may be the critically low number of salmon present in the Bay of Fundy rivers. Both PC1 and AC1 spoke about the critical ecological roles that salmon play in creating a high-functioning ecosystem in rivers, and the impact that their disappearance has likely had on the overall quality of the environment. In essence, rivers of the inner Bay of Fundy without salmon are quite different ecosystems from rivers with salmon; therefore, observing iBoF salmon in these new environments may not actually tell us whether or not depensation or other ecological Allee effects are occurring.

3.3 Technical Feasibility of Recovery

While the documents and interviewees highlighted many challenges associated with the biological feasibility for the recovery of iBoF salmon, several other major hurdles were also identified for technical feasibility. These shed light on whether, how,

and why the understanding of technical feasibility of recovering iBoF salmon has changed over time.

Technical feasibility refers to the development and implementation of technology or management techniques to aid in restoring biological characteristics, such as population size and availability of habitat, to a state where recovery of an endangered species can occur. The 2010 guidelines by DFO state that "technical feasibility is dependent upon the ability of the organizations and jurisdictions responsible for recovery to respond to the needs of a species such that its recovery is achieved" (DFO, 2010a). The guidelines list the following further considerations to help determine whether technical feasibility exists for recovering a species at risk: whether the root cause(s) of decline can be determined and eliminated; whether habitat loss can be reversed; whether biotic changes have occurred that are unlikely to be reversed; and whether a stable population level has been established which the species in question is unlikely to move beyond (DFO, 2010a). At first glance, the last two considerations appear to correspond more closely to biological than technical feasibility since they are related to the biological characteristics of a given species. Given their listing under technical feasibility in the document, these considerations could instead be referencing potential factors that could limit the success of currently available technical approaches for recovering a given species. It is unclear from the text in the guidelines which interpretation is correct.

In the ECCC Policy on Recovery and Survival, technical feasibility entails that, "the scientific/management techniques and technology required to attain the targeted condition for the species in Canada exist, or can be reasonably anticipated to be available in time to support attainment of a recovered state." ECCC references similar considerations to those present in DFO's guidelines, calling them *persistent limitations*, i.e., factors such as environmental changes and anthropogenic pressures that prevent a species from returning to its natural condition or otherwise constrain its recovery (ECCC, 2021). Persistent limitations are an additional factor for consideration when assessing both biological and technical feasibility for a species at risk. The technical aspect of persistent limitations is present in the wording in both DFO's and ECCC's documents, in that a constraint to recovery becomes a persistent limitation when technologies or

management approaches are unable to overcome such a constraint in an appropriate timeframe for the species to benefit from the reversal.

While there are a few differences between DFO's guidelines and the ECCC policy, the definition of technical feasibility used in both documents is largely the same between the two: it is the ability to develop and implement science, technologies, and management approaches to support recovery, and the ability of those technologies and approaches to promote recovery in an appropriate time frame for the species. At the recovery feasibility assessment stage, technical feasibility, similar to biological feasibility, is to be evaluated solely on its own merits: "cost to implement technically feasible measures is not a legitimate consideration," as cost considerations "become relevant at later stages in the recovery planning process" (DFO, 2010a). This point is an especially important distinction to make when discussing technical feasibility, as it is a product of research, development, and implementation of technology and other/management approaches to assist a species' recovery, all of which can be influenced by economic factors, and the social and political factors that interact with questions of costs and resources. For many individuals, it is impossible to disentangle economic considerations from technical feasibility. While these aspects may be touched on in this section, I will delve more deeply into economic factors affecting recovery feasibility in section 3.4.

3.3.1 Technical Feasibility in the Recovery Strategy

As is the case for biological feasibility, the first (and so far, only) official determination of technical feasibility for iBoF salmon is found in the Recovery Strategy. This determination focuses on two major topics: the LGB and its role in maintaining the survival of the species, and actions taken to discover and address threats to the species. According to the Recovery Strategy, "the LGB program has been a principal activity used to support iBoF Salmon [sic] survivorship," established in 1998 "with the goal of preserving the remnant populations and remaining genetic diversity of the species" (DFO, 2010b). In 2010, the LGB was maintained in three biodiversity facilities, one in New Brunswick and two in Nova Scotia. It successfully raised wild juvenile salmon to maturity in these facilities, conducted pedigree-based breeding in order to minimize the

loss of genetic variability or inbreeding in the resulting offspring, and released these pedigreed juveniles back into the wild to successfully become smolts, either to supplement the wild populations or to eventually return to the biodiversity facilities for rearing to maturity. According to DFO, there was enough existing technical expertise and infrastructure to support the LGB program through multiple capture, rearing, breeding, and release cycles (DFO, 2010b). At the time of the Recovery Strategy's publication, supplementation of smolts reared in the LGB into iBoF salmon rivers was noted to have "increased the abundance of juveniles in the wild and substantially reduc[ed] extinction risk" for the species (DFO, 2010b), though the subsequent effect on adult returns was unknown. Thus, the survival of iBoF salmon over the long term was considered technically feasible with the LGB program at the time. However, the Recovery Strategy cautions that "recovery will only be achieved if the causes of high marine mortality can be identified and remedied" (DFO, 2010b).

In several sections of the Recovery Strategy, DFO emphasizes the uncertainty surrounding the causes of iBoF salmon population decline and the threats acting on the species. It states, in section 1.7 addressing threats to iBoF salmon, "The factors that have caused the collapse of wild Atlantic salmon populations in the iBoF since the 1980s are not well understood"; in section 2.1 discussing recovery feasibility in general, "the causes of low marine survival are not well understood"; and, in section 2.3 discussing recovery objectives and approaches, "The causative factor(s) and the feasibility of overcoming those losses [to the iBoF salmon population at sea] are currently unknown." This uncertainty and lack of knowledge on threats and their mitigation are reflected in the technical feasibility determination. The section of the determination dedicated to researching and addressing the causes of high marine mortality is half as long as the section on the LGB program, and includes language that is tentative, vague, or lacking in detail (emphasis added):

> Success in population maintenance has allowed research *to begin to explore* sources of high marine mortality, and ultimately to evaluate what management measures are required to achieve recovery. *Potential causes of high marine mortality* are discussed elsewhere in this document and during the iBoF Salmon RPA [Recovery Potential Assessment]. The RPA also discussed *potential*

mitigation measures and alternatives to address specific threats which are described in the Science Advisory Report. *Some of the factors potentially contributing to low marine survival may be remediable, while others may not. Many management measures* will require collaboration between *multiple agencies and groups. Some measures* are already being implemented (DFO, 2010b).

Because of the significant uncertainty about the topic, the Recovery Strategy makes "identifying and remedying anthropogenic threats limiting survival and/or recovery to iBoF salmon" the focus of two explicit objectives in the Recovery Strategy, namely Objective 2, which focuses on threats in the marine environment, and Objective 3, which focuses on threats in the freshwater environment.

3.3.2 Changes in Perspectives on Technical Feasibility

3.3.2.1 Current Management Approaches Are Not Promoting Recovery

In the analysis of the recovery planning documents and of the responses of interviewees on the subject of technical feasibility for iBoF salmon, a recurrent theme emerged, namely that the existing management approaches for iBoF salmon are focused more on maintaining survival than promoting recovery.

The overarching goal of the Recovery Strategy for iBoF salmon is to "re-establish wild, self-sustaining populations as required to conserve the genetic characteristics of the remaining anadromous iBoF Atlantic salmon." This goal contains two parts with the implication that genetic conservation will be achieved through re-establishing populations. Both the five-year and long-term targets in the Recovery Strategy begin with text that reverses the order of these two components: "Conserve the genetic characteristics of the few remaining anadromous iBoF Atlantic salmon populations in order to progress towards re-establishing self-sustaining populations." This reversal introduces a level of ambiguity in the objectives: is the priority to re-establish wild populations as quickly as possible in order to maintain the iBoF genetic signature, or is the intention to preserve the genetic signature in order to re-establish populations of pedigreed iBoF salmon in the future? From interviews with Recovery Team members both within and outside of DFO, it appears that the latter approach was taken, mainly in

response to the rapid decline in the population over a very short period (less than 10 years, according to DFO4).

Since the massive decline in abundance and increase in marine mortality that iBoF salmon experienced between the 1970s and 1990s, the population has depended on the Live Gene Bank to maintain the species' survival and persistence in the wild. The LGB program's vital role is highlighted in recovery planning documents and by all interviewees. As noted in section 3.2.4 on potential Allee effects in the iBoF salmon population, the LGB has so far been successful in preserving both the unique genetics of iBoF salmon and genetic diversity in the remnant population (DFO, 2010b). However, the Recovery Strategy explicitly outlines that "the LGB program alone is not expected to achieve recovery of this population. Recovery will only be achieved if the causes of high marine mortality can be identified and remedied." Despite this latter limitation, several interviewees both within and outside of government claimed that the distinction has not been properly made between management approaches for maintenance and those for recovery (DFO1, DFO3, DFO2, AC1), and perhaps too much emphasis had been placed on the LGB and the genetic conservation of iBoF salmon in recovery planning (DFO1, DFO2, IN1, NGO3, NGO4, PROV1, AC1, PC1).

While the LGB program's primary objective is identified in the Recovery Strategy as being the preservation of the species' genetic characteristics and maintaining its survival in the wild, the Strategy also acknowledges the program as playing a role in eventually supporting recovery. Approaches 1 and 3 of Objective 1 of the Recovery Strategy—"Conserve iBoF Salmon genetic characteristics and re-establish self-sustaining populations to iBoF rivers"—are to "provide salmon with appropriate genetic characteristics for re-colonization of iBoF rivers designated for recovery" and to "use Live Gene Bank strategies" to achieve the objective (DFO, 2010b). However, the review of the LGB program published by DFO in 2018 provides the following consideration for the management of the program after the first 15 years of its operation (emphasis mine):

> If *a shift in focus of the iBoF Recovery program from maintenance of genetic variation to re-establishment of wild self-sustaining populations* were to be considered, the extent to which resources ought to be redirected should reflect both costs and benefits (DFO, 2018).

This statement suggests that the focus of the LGB program, and perhaps of recovery planning efforts as a whole, shifted between 2010 and 2018 to preserving iBoF salmon genetics, with less emphasis being placed on re-establishing self-sustaining populations. Part of the reason for the emphasis on genetic diversity and the LGB, according to DFO1, is because the unique genetic signature of iBoF salmon is "what the population is defined by," as opposed to simply the presence of salmon in inner Bay of Fundy rivers. Others also highlighted the unique status of iBoF salmon and the subsequent need to protect its genetic diversity, with the emphasis on LGB being appropriate for iBoF salmon due to its extremely low abundance. For example, NGO1 stated: "when you've only got returns of a few dozens [sic] on river systems, then you don't have too much hope other than to at least catch those, spawn them out, and maintain the genetic diversity." In discussing the evaluations of the LGB program that had occurred since 2010, DFO4 mentioned that "if you couldn't protect genetic diversity through the LGB, then [recovery] was not going to be feasible, because if you don't have a [genetically] diverse population then you're chasing your own tail." Thus, the early attention to both the LGB program and the conservation of genetic diversity for iBoF salmon in general was born from the combination of defining iBoF salmon through its unique genetic signature and the very real risk of losing that unique signature due to the species' precipitous decline. DFO3 claimed that using a hatchery approach for the Live Gene Bank, which occurred before the SARA listing, "was a practical decision: we know how to deal with freshwater, and we have hatcheries, so we can do it this way. That probably happened initially without thinking too much about the direction the Live Gene Bank would take; people just knew they were losing fish and they wanted to do something about it."

One of the drawbacks of the weight placed on the LGB program, however, is that the objectives corresponding to preserving the genetics and maintaining the survival of iBoF salmon have become muddled together with the overall recovery objectives for iBoF salmon, despite the previous statement by DFO that the LGB on its own is not enough to achieve recovery for iBoF salmon. This view was expressed by DFO3, DFO2, NGO3, NGO4, AC1, and PROV1. When speaking on iBoF salmon management and feasibility of recovery, DFO3 compared the LGB approach with other methods to move

towards recovery targets and expressed uncertainty about whether the distinction between the feasibility of the two had been made. Similarly, DFO2 referred to the relationship between conserving genetics and promoting recovery as "the question that never got asked":

> **DFO2:** I think it's true what the reports say, that if you want to conserve genetics, then you're doing the right stuff. But … there's conserving genetics, and then there's recovery, and those connections were never explicitly made.

Several respondents pointed to a potential danger of focusing on maintenance and survival, namely, a significantly larger portion of research and management efforts may be allocated to measures that do not, or cannot, move the species closer to recovery in the environment. NGO3 voiced the opinion that DFO put too much focus on the LGB program, which is a "band-aid solution at this point," and that the federal agency has subsequently ignored the threats that needed to be addressed. Another concern, communicated by PC1 and PROV1, was that this emphasis on genetic integrity could potentially result in "a genetic code in a captive environment somewhere" (**PC1**) becoming the benchmark of success for iBoF salmon management. Both interviewees expressed a negative opinion about this potential outcome, with PROV1 calling it "a disservice [to ourselves]" if maintaining the genetic integrity of iBoF salmon came at the cost of the ability to interact with the species in the wild.

The concerns with this potential focus on an approach that does not promote recovery are compounded by *conflicting perspectives on the continuing technical feasibility of the Live Gene Bank.* As stated earlier in this section and in section 3.2.4, the general consensus in recovery planning documents, as well as statements by interviewees in the federal government and those in research roles outside of the federal government, is that the objectives of the LGB continue to be technically feasible. However, several NGO interviewees brought up technical challenges with the LGB. NGO1 and NGO2 identified challenges based on the capacity of the facilities. For example, NGO1 stated that "the Coldbrook Biodiversity Facility is just way too small. It just doesn't have the equipment; it's just not up to the task of trying to recover salmon on the Nova Scotia side." NGO3 and NGO4 drew attention to a significant concern about the potential introgression over time of non-native genes from aquaculture escapees into the Live Gene

Bank. NGO3 shared with me that illegal European salmon stocks used in aquaculture have shown up in iBoF rivers. If this is the case, there is a very real risk that the LGB program has been threatened by the influx of non-native genes.

> **NGO3:** Information that came out within the last three to four years suggests that illegal European stocks have been used in the aquaculture industry, and that has shown up actually in iBoF rivers. There have also been indications, from talking to now-retired geneticists from DFO, that there's probably a large component of aquaculture escapees whose genetics may have been brought into the program. So, the LGB program itself, in my opinion, has been jeopardized over the years.

The 2018 review of the LGB program published by DFO does acknowledge that such introgression has occurred. It also notes that farm escapees or hybrid offspring were spawning in the inner Bay of Fundy between 1997 and 2012, and have spawned with endangered iBoF Atlantic salmon (DFO, 2018). In addition, the review states that iBoF/farm hybrids may have reduced survival in the early juvenile life stages compared to pure iBoF salmon. This situation presents a serious challenge to the technical feasibility of the LGB program. Its current objectives are geared towards preserving iBoF salmon genetics, yet it has been "contaminated with aquaculture stocks" (**NGO3**) that "may not be possible [to remove] using conventional methodologies" (DFO, 2018).

3.3.2.2 Research and Mitigation of Threats to iBoF Salmon

The technical feasibility of recovering iBoF salmon depends in part on improving the understanding of what threatens the species' recovery, and the ability to implement measures to reduce or eliminate these threats. Both governmental and non-governmental organizations interviewees agreed that at the time of the Recovery Strategy "the outstanding question was not a great understanding of the threats" (**DFO4**) and "a lack of empirical knowledge about the salmon itself" (**NGO2**), especially in the marine environment. That lack of understanding made recovery planning and feasibility determination much more difficult. Through the assessment of the status of iBoF salmon by COSEWIC in 2006, and the subsequent Recovery Potential Assessment in 2008, a list of potential threats was created and added to the Recovery Strategy (COSEWIC, 2006; DFO, 2008). These threats include aquaculture and interactions with farmed fish;

ecological shifts such as changes in salmon predators or prey; environmental shifts in both marine and freshwater environments; marine fisheries; freshwater contaminants and barriers to passage; and phenomena associated with depressed populations sizes (e.g., poor schooling capacity in the marine environment or Allee effects, see section 3.2.2.3). Several of these threats require knowledge of the habitats that salmon occupy in the marine phase of their life cycle, a component that is also stated to be poorly understood in the Recovery Strategy and is included in a table of "high priority research and monitoring recommendations" (DFO, 2010b).

The analysis of recovery planning documents and interview responses showed a notable lack of progress in understanding the threats to iBoF salmon since 2010. The 2021 Progress Report, which evaluated the degree to which the Recovery Strategy was implemented between 2010 and 2015, classified recovery activities into a set of performance indicators, some of which correspond to understanding and addressing threats to the species. A status was assigned to each performance indicator demonstrating whether the objectives were met, partially met, or not met between 2010 and 2015 (Table 3.2).

Several of the performance indicators for recovery activities related to researching and mitigating threats to iBoF were partially met between May 2010 and May 2015. Some of these recovery activities have resulted in more positive outcomes than others. For instance, research on marine habitat use by iBoF salmon "will inform the identification of estuarine and marine critical habitat for iBoF salmon in an amended recovery strategy," which will in turn give DFO better ability to protect this habitat. Another example is measures implemented to mitigate freshwater threats, e.g., in the Petitcodiac, Stewiacke, and FNP rivers and tributaries, directly resulted in improvements in habitat quality, fish passage, and connectivity. Research on threats themselves, however, appear to have had more limited success between 2010 and 2015. Non-genetic and non-habitat related threats "remain poorly understood," and the only new threat to iBoF salmon identified in the marine environment was predation by porbeagle shark (*Lamna nasus*) and bluefin tuna (*Thunnus thynnus*) on kelts—adult salmon that survive spawning and return to the sea to potentially spawn again in the future. Research on threats to kelts serves a long-term purpose for the management of iBoF salmon, as

Table 3.2: Performance indicators related to understanding and addressing threats to iBoF salmon. Numbered indicators, and additional information, was collected from the 2021 Progress Report. Comments and next steps are summarized from the text with key quotes.

Performance indicator	Status	Details
5) Extent that understanding of ocean distribution and habitat use by iBoF salmon has been increased	Partially met; underway	Studies have "bettered our understanding of ocean distribution and marine habitat use by iBoF salmon," with further steps needed to "finalize the identification of marine and estuarine critical habitat" and "complete the schedule of studies" on marine habitat use.
6) Contribution of research program towards identification of threats preventing or limiting recovery	Partially met; underway	A key result identified that large pelagic predators like porbeagle shark and bluefin tuna are linked to mortality of kelts—iBoF salmon that have already spawned then returned to the sea—but "more research is needed to further our understanding of other identified marine threats."
7) Success of mitigative measures for overcoming identified threats in marine and estuarine environment	Partially met; underway	Though several management activities have been implemented, "their success has not been evaluated and the level of effect of each threat … on the iBoF salmon's survival or recovery remain largely uncertain." Additionally, efforts to date have focused on circumventing the low marine survival," and the listed efforts (LGB, marine rearing projects) "do not directly address and remedy marine threats themselves."
10) Success of mitigative measures for overcoming identified threats in freshwater	Partially met; underway	Several restoration projects have been undertaken in freshwater that resulted in "improved fish passage and environmental conditions" and an "increase [in] habitat accessibility and … quality." Aquatic connectivity "was significantly improved to a 'Good' threshold" in several rivers as well.
13) Non-genetic and non-habitat related threats identified	Not met	Threats like depressed population phenomena, aquaculture interactions, ecological and environmental shifts, and bycatch in existing fisheries "remain poorly understood." Research identified predators of iBoF salmon that could be limiting recovery (performance indicator 6), though these predators mainly target kelts, which may not be a significant component of overall iBoF salmon populations at this time (DFO, 2020). Threats to outmigrating salmon remain largely unknown.
14) Non-genetic and non-habitat related threats reduced and mitigated	Not met	Because little progress has been made on identifying and understanding these threats (see performance indicator 13), "the specific actions needed to mitigate these threats are therefore also largely unknown, hence few direct management actions have been taken to reduce or mitigate these threats during the reporting period."

"repeat spawners are important for their recovery" (DFO, 2010b). However, less progress was made on understanding the marine threats to post-smolt salmon living in the ocean. According to the RPA, the Recovery Strategy, and several interviewees (DFO3, DFO1, DFO4), the bulk of the mortality to iBoF salmon occurs at this point in its life cycle. Any change in the technical feasibility for recovering iBoF salmon in light of this research progress was not directly mentioned in the Progress Report, although it did state that reviewing iBoF salmon recovery feasibility "may be warranted when guidance or criteria become available." DFO staff indicated in their written response in this study that the 2021 Policy on Recovery and Survival could serve as a starting point for developing this new guidance.

Responses from interviewees on whether the understanding of threats had improved since 2010 generally reflected the content of the 2021 Progress Report, especially where it concerned progress on understanding the dynamics of iBoF salmon in the marine environment (Appendix C, Table C.2). Some responses were cautiously optimistic about gains in understanding, as one NGO participant stated:

> **NGO1:** The big thing sort of hanging over everybody's head is that we just had no idea what's happening in the marine environment … there's a number of fisheries out there, some directed, like longlines and trolling, as well as bycatch of salmon. We know that there are sharks and other things that eat salmon. But these were all still very unknown in 2010 as to the extent. Since that time, there's been better reporting of SARA bycatch, better methods employed to direct catch and reduce bycatch, additional satellite tagging studies, and one study that showed just how much sharks or seals or whatever were eating [salmon]. And so, I think we're starting to unveil what's happening in the marine environment.

Other responses evoked more disappointment at the progress that has been made thus far. One respondent noted that "I thought at this point we would have a better grasp on those stressors. What's causing at-sea mortality, loss of habitat and juveniles? … I don't really know. I thought we'd have a better handle on what the issue was at this point, 10 years into recovery" (PROV1). Another interviewee echoed this perspective by stating that "after 20 years, [we] should be a little further down the road than we are. So, the Recovery Team can be criticized for not getting enough done fast enough" (PC1).

One prevalent subtheme in the recovery documents and participants' responses was the discovery of the difficulty of conducting research on iBoF salmon in the marine environment. This subtheme was primarily expressed in the recovery planning documents and by interviewees from governmental organizations, or whose roles on the Recovery Team or experience in iBoF salmon recovery planning were at least partially based on conducting or managing scientific research. The marine habitat research component is seen as particularly critical for iBoF salmon, as it could provide more information to help narrow the list of potential causes of decline in the marine environment, as well as identify critical marine habitats, whose protection would benefit iBoF salmon and its recovery. However, the 2021 Progress Report acknowledges that "undertaking the required research in the large and dynamic Bay of Fundy remains a challenge," and more specifically, that the "threat identification and mitigation research for iBoF salmon in the estuarine and marine environment is costly and logistically challenging in the large, dynamic, and turbid Bay of Fundy." This viewpoint was echoed by several interviewees from DFO and other governmental organizations.

> **DFO4:** For example, everyone believed that they were migrating out of the rivers, then not returning back. So, where are they dying when they've left the rivers? Are they dying 10 kilometers from the rivers, were they dying at the end of the Gulf of Maine, were they dying when they left the Gulf of Maine? And what was killing them when they did? So that's expensive to find out. How do you find that out? That takes a lot of marine research, some of which was successful, some of which was not.

The complexity of studying iBoF salmon in the marine environment was highlighted by several interviewees, including DFO1, DFO4, DFO3, PROV1, and IN1. Finding the causes of marine mortality "has turned out to be a particularly wicked and intractable problem" (DFO1), and even though "quite a bit of work [was done] to narrow down the window in the life cycle where we have issues … we still haven't identified that final cause" (DFO3). The two main perspectives expressed by interviewees categorized in this subtheme related either to the sheer difficulty of carrying out the necessary research, or the inconclusiveness of the results. DFO1 noted one example of the former: because of the very low abundance of iBoF salmon, as well as their migration patterns in

the Bay of Fundy, “they get lost in this huge 3D environment,” making finding what happens to individuals “very, very difficult to do with the technology that’s available now.” This response points to a potential decline in optimism about the technical feasibility, in that the technology needed to discover where in the Bay of Fundy iBoF salmon travel—and end up dying—is not as feasible as initially thought. DFO3 also specifically spoke of a “technical limitation” with the technology required to undertake this type of research, where “the size of the smolts, the size of the battery needed for the tag, and the need for a receiver array that can reasonably detect fish in the ocean” represented technical issues that have not yet been overcome in order to better understand where and when marine mortality occurs.

The inconclusiveness of some of the research results was highlighted by PROV1, DFO3, and NGO3. For instance, in response to a question about whether their personal perspective on recovery feasibility for iBoF salmon had changed since beginning participation in the Recovery Team, PROV1 noted that the slow progress on research was “no fault of anybody’s on the team! I mean, that’s the nature of science: sometimes you do experiments, and the results aren’t conclusive in a way that is meaningful, or … the same data can be interpreted by different parties in different ways and giving conflicting results.”

While most interviewees acknowledged that research on threats to iBoF salmon was difficult, several interviewees, including DFO2, NGO3, NGO4, and PROV1, claimed that not enough was being done to understand or address threats. This perspective contrasts with the one expressed in the previous paragraph, where interviewees attributed the lack of progress to inconclusive results from research that was either attempted or completed. This subtheme was closely linked with the theme of management approaches focused on survival rather than recovery (see section 3.3.2.1). For example, DFO2 compared the efforts put into the LGB with those to identify and remedy threats to the species, saying that the former “is doing its job, but making the environment a place where recovery could occur … that job’s probably not [been done].” He elaborated by recalling a key point from the 2008 RPA for iBoF salmon (emphasis added).

DFO2: You can conserve genetic material, but if the environment that you're putting [the salmon] in is full of the threats that caused them to decline in the first place, they're never going to recover. *You can't do one without the other.*

In some cases, different interviewees expressed contrasting perspectives on the same topic, such as identifying and protecting marine critical habitat. For example, NGO3 was under the impression that DFO devoted little or no effort towards identifying marine critical habitat for iBoF salmon, while NGO4 believed that the problem was not identification of critical habitat, but that DFO had not "turned any screws on it yet," meaning that it had not been officially designated or protected through the Act.

Aquaculture threats was another especially prevalent topic when interviewees discussed whether enough research was being done to address potential threats to iBoF salmon. There were notable disagreements among the interviewees about how much progress had been made to investigate and address the impacts of aquaculture development on the decline and continued endangerment of iBoF salmon. For example, both DFO1 and DFO3, who have been involved with the RT in a scientific research capacity, expressed the opinion that marine habitat use by humans, including aquaculture developments, was likely not impacting iBoF salmon to the point of preventing recovery, which they based on current and past telemetry research on outmigrating smolts. Conversely, several NGO respondents listed salmon aquaculture as one of several issues that "have not been addressed" by DFO, with NGO3 stating that "without a doubt—and not just with inner Bay of Fundy, but outer Bay of Fundy and Newfoundland stocks too—aquaculture has been listed as one of the key threats" through interbreeding with wild salmon. NGO4 pointed out that aquaculture developments in the Bay of Fundy, first established in the 1970s, were naturally placed in areas where salmon are most likely to thrive. DFO3 echoed this notion, despite acknowledging the lack of concrete evidence of overlap between smolt habitat use and aquaculture sites, and added a nuance to the topic that could explain what is happening:

DFO3: This is all very much speculation since there's no way to really test it, but I wonder if aquaculture development areas, particularly Passamaquoddy Bay, which has the better conditions for survival of salmon, did we lose that [habitat for iBoF salmon] when aquaculture was developed? Did we lose a component of

> populations that would have overwintered there? And when we do our studies now, we assume that we have similar salmon now to what they were in the past, but it's not out of the question that we've lost a component with different behaviors. And I don't know how you would explore that.

These perspectives raise questions about whether the current research is sufficient to conclude that aquaculture has no impact on the recovery for iBoF salmon. However, based on responses from NGO1 and NGO4, there appears to have been a reticence on the part of DFO to investigate the potential impacts of aquaculture sites on iBoF salmon—a reticence that could be partly influenced by previous research that found no link between aquaculture and iBoF salmon's poor recovery outcomes, and partly influenced by the economic and political landscape surrounding aquaculture development (see section 3.4).

Another major subtheme about threat identification and management for iBoF salmon that emerged was *whether the threats to iBoF salmon can actually be addressed at all.* This consideration ties into the persistent limitations described in the 2021 Policy on Survival and Recovery (see section 3.3.1), e.g., threats like habitat loss through urbanization, anthropogenic infrastructure, and climate change. It also relates to how research about threats to iBoF salmon may affect the determination of technical feasibility in the future, particularly if it was discovered that the primary limitation to iBoF salmon recovery is a threat that was not technically feasible to address. This concern was expressed by all interviewees in this study, primarily due to the fact that there has been "no evidence of recovery within the population" since at least 1998 (DFO1). Thus, threats that are insurmountable by technology or management approaches is a real possibility. Several respondents directly indicated a more negative opinion of recovery feasibility for iBoF salmon due to these concerns. Some felt recovery was less feasible "because of the changing ocean … due to climate change," but not yet impossible (NGO3), while others contended that recovery was no longer possible because the destruction of habitat had become too widespread to be addressed at all (NGO2).

Making progress on characterizing the threats to iBoF salmon was almost universally seen as an enabler to recovery, in keeping with the Recovery Strategy's statement that "recovery may be feasible if research can advance the understanding of marine survival." Many interviewees emphasized the link between understanding threats

and implementing recovery actions, in that the lack of knowledge on the nature, magnitude, and location of threats to iBoF salmon limits actions that can be taken by DFO or other stakeholders to promote its recovery (DFO3, NGO3). However, a lack of progress on understanding threats did not necessarily mean that recovery is less technically feasible than in 2010. DFO staff explicitly stated in their written response that "it would be premature to conclude that recovery is not feasible without further effort to understand limiting factors." Despite the difficulties in conducting research in the Bay of Fundy, and the technical limitations that were identified in smolt tagging studies, DFO1 maintained that recovery for iBoF salmon was "technically feasible, absolutely," and DFO3 asserted that the inconclusive research results were more an indicator that "we remain with an unknown feasibility," and that with the Live Gene Bank in operation, "we think we still have fish … that will be sufficient for rebuilding populations if survival changes." While the threats to iBoF salmon remain poorly understood, both the recovery planning documents and members of the Recovery Team are proceeding with the assumption that recovery for the species remains technically feasible, if perhaps less certain than in 2010.

3.4 Economic and Political Factors and Their Effect on Recovery Feasibility

Political and economic considerations by definition are not part of biological or technical feasibility of recovery for iBoF salmon. Here, it is important to emphasize the difference between the personal opinions and assessments of recovery feasibility expressed by the interviewees, and the perspectives that would inform a formal "determination of feasibility" for an endangered species under section 40 in the Species At Risk Act ("Determination of feasibility"). In both SARA and the definitions outlined in the 2010 Guidelines and the 2021 Policy on Recovery and Survival, only biological and technical factors are considered in the determination of recovery feasibility for a species at risk—economic, social, and political factors "play no direct role" (ECCC, 2021) at this stage of the recovery planning process. This approach is followed because the purpose of determining recovery feasibility is to establish a baseline of the chances a species has to attain a recovered state, both in terms of biological capacity and with the

application of technologies and management, prior to considering the costs and other factors.

The 2021 Policy on Recovery and Survival does mention that social, economic, and political factors become important considerations later in the recovery planning process, when affordability and political acceptability of research and management interventions come into play. These considerations fall under the purview of managers within departments, whose roles are to balance the needs of the species with the financial resources available, as well as to be responsive to ministerial consideration of economic and political factors. While members of a Recovery Team may have their own opinions about how economic, social, or political factors make recovery more or less feasible for an endangered species, these opinions would not contribute to the official determination of recovery feasibility produced through SARA processes. These perspectives are still important to explore, as non-biological and non-technological factors do play a role in whether a species can achieve recovery.

3.4.1 Political and Economic Feasibility of Recovering iBoF Salmon

When asked their opinion on the current feasibility of recovering iBoF salmon, most interviewees' responses centered on biological and technical feasibility, as per the guidelines from DFO and ECCC. However, many interviewees also discussed economic factors, largely in relation to the costs of recovery activities (DFO1, DFO4, DFO3, DFO2, NGO1, NGO2, NGO3, AC1). Similar to how research on iBoF salmon was described as being challenging (see section 3.3.2.2), management approaches for iBoF salmon were described as "expensive" and "costly work" by interviewees, with millions of dollars required for measures that may solely forestall the species' extinction.

A subset of interviewees (DFO1, DFO4, NGO3, NGO4) shared the perspective that, while biological and technical feasibility continue to exist for iBoF salmon, economic or political feasibility has worsened since 2010. DFO1 stated that biological and technical feasibility were both present "if you have the resources," suggesting that the lack of them was negatively affecting feasibility. Several others (DFO4, IN1, NGO2, NGO3, NGO4), focused on the decline in financial and political support for iBoF salmon recovery efforts. DFO4 believed that the question of feasibility "really comes down to

decisions to support things from a management perspective." Similarly, IN1 and NGO2 expressed the opinion that iBoF salmon is "not a topic that's on everyone's mind" at DFO. Both believed that iBoF salmon was low on DFO's list of priorities, and that the Department put more attention on current "high-[economic-]value" fisheries such as Atlantic lobster or tuna, as well as salmon aquaculture.

DFO4 shared a perspective about the relationship between biological, technical, and economic feasibility of recovery for iBoF salmon. With regard to the recovery feasibility of iBoF salmon, DFO4's optimism began to wane after the LGB program was "seriously curtailed" in 2012 despite a previously existing commitment to maintaining it until at least 2015. Despite the central role that the LGB plays in iBoF salmon recovery planning, over $1,000,000 was cut from the program, and one of the three biodiversity facilities that supported the LGB program was shuttered. While DFO4 believed that recovery remained biologically feasible, overall feasibility "was tied to being able to maintain a certain level of vigor in the program," and these cuts to the LGB represented a serious blow to the future feasibility of recovering iBoF salmon. The substantial cutbacks to hatcheries and the LGB program identified by DFO4 above were also mentioned by DFO2, DFO4, NGO2, and NGO3. According to the interviewees, the cutbacks were due to individuals at the policy level believing that the program was too expensive and that the investment in these measures was not paying dividends towards iBoF salmon recovery.

3.5 Discussion and Conclusion

This component of my research explored the perspectives on the feasibility of recovery for endangered inner Bay of Fundy Atlantic salmon, both embedded within recovery planning documents and expressed by a sample of members of the iBoF Salmon Recovery Team. I examined whether the perspectives changed over time, and if so, how and why they did. At first glance, the overall assessments of recovery feasibility for iBoF salmon embedded in the recovery planning documents appear to not have substantially changed from the initial determination published in the Recovery Strategy, i.e., that it was too soon to say for certain that recovery was not feasible, and that management efforts should proceed as though recovery is feasible for the species. That no change

occurred may be due, in part, to the fact that a new assessment of recovery feasibility has not been completed since 2010, and therefore the conclusion from the earlier assessment has been simply brought forward in the most recent publications. The interviewees differed, however, in their responses, with most indicating that they think that recovery is less biologically and technically feasible than it was in 2010 because of the lack of progress on recovery efforts and the continuing decline in populations over the intervening period despite the LGB program. Several attribute at least part of the blame to a decline in political and economic support, resulting in insufficient resources to undertake effective recovery actions.

3.5.1 Key Findings

In general, the perspectives on biological and technical feasibility of recovering iBoF salmon, embedded in the recovery planning documents and expressed by the interview participants, were more negative in 2023 than in 2010, though to varying degrees. Rarely did the interviewees state that recovery was no longer feasible at all, with only two interviewees, NGO2 and PC1, expressing this opinion. Instead, the majority of the documents and respondents claimed that either the time scale of recovery will be longer than anticipated, or that recovery may be attainable at a lower level of abundance or a narrower area of distribution than those described in the current targets.

While there are some differences among the interviewees about the degree to which biological feasibility for iBoF salmon has changed over time, the majority of the recovery planning documents, and the interviewees point to a moderate downturn in optimism on the topic. I found that the most common reasons for changes in perspectives included the perceived lack of progress towards abundance and distribution objectives set in the Recovery Strategy, concern about potential Allee effects and other population dynamics of iBoF salmon, and apprehension about significant environmental changes in the Bay of Fundy that could make recovery more difficult than was anticipated in 2010. All of the documents and interviews contained perspectives that clustered under at least two of these themes. Indeed, Allee effects and environmental changes were named as potential threats to iBoF salmon in the Recovery Strategy, and the level of concern about the impacts of such changes has grown among Recovery Team members since 2010.

The perspectives on the technical feasibility of recovery for iBoF salmon showed a high degree of variability in the data I analyzed. In the Recovery Strategy, the technical feasibility of recovering iBoF salmon depended on two major factors: the maintenance of the population via the Live Gene Bank, and the ability to identify and remedy threats to the species, especially in the marine environment. According to recovery planning documents and the majority of interviewees, the LGB has been largely successful in preventing the total extirpation of iBoF salmon from the Bay of Fundy and preserving enough genetic diversity in the remnant population to make future recovery possible. However, little progress has been made in understanding the factors preventing recovery, which in turn has made it difficult to know which technologies or management approaches would best support the species, or whether the threats would even be manageable with current technologies. Additionally, concern is growing among the interviewees about the ability of the LGB to fulfill the goal of preserving iBoF salmon genetic characteristics, as the number of hatchery facilities has declined and non-native genes from farmed salmon have found their way into salmon bred in the program. As research efforts have gone on since 2010, many respondents involved or familiar with these efforts indicated that the task of recovering iBoF salmon is much more difficult than anticipated, resulting in a more negative outlook on the technical feasibility of recovering the species than initially.

One aspect that became apparent as I explored the recovery planning documents and spoke with the interview participants was the lack of clarity in a number of aspects of iBoF salmon recovery planning since 2010. Points of ambiguity included the definitions of recovery goals used in the Recovery Strategy, and the definitions and criteria for evaluating biological and technical feasibility. As I noted in section 3.3.2.1, a mismatch exists between the overarching goal of the Recovery Strategy and the short- and long-term objectives, which may have contributed to a narrow focus on management approaches that maintain survival, but do not necessarily promote iBoF salmon recovery. As an example, several Recovery Team members expressed the view that the success of iBoF salmon management appears to be measured primarily by the implementation of the LGB program, which cannot achieve recovery on its own.

From my analysis of the definition of recovery feasibility in the planning documents, substantial overlap occurs between how biological and technical feasibility are defined and evaluated, especially in the terms used by DFO at the time of developing the Recovery Strategy (DFO, 2010a). Part of this intersection is likely intrinsic to how the question of feasibility is conceptualized in SARA. For example, if a determination of recovery feasibility finds that the environmental conditions in an endangered species' habitat cannot be restored using current technologies and management approaches, this finding could point either to biological feasibility when considering the environmental conditions, or to technical feasibility when considering habitat management in light of these conditions. The unclear definitions extend to the concept of "feasibility" itself. Several interview participants gave definitions of "feasibility" that did not match those used by DFO or ECCC. Typically, the interview participants' descriptions included economic and political factors in their personal assessment of recovery feasibility for iBoF salmon. One example was AC1's reference to the expenditure of money on a novel management approach as "completely feasible money well spent." The lack of clarity in the terms makes common understanding among recovery team members more difficult, impeding the (re-)assessment of recovery feasibility for the species (see chapter 4). This issue is also part of a general pattern identified in research on the Species At Risk Act, where discretionary and unclear language is highlighted as being partly responsible for the Act's ineffective implementation in the recovery planning stage (Bankes et al., 2014; Turcotte et al., 2021).

The documents I analyzed tended to contain perspectives that align closely with the definition of recovery feasibility contained in DFO's SARA guidelines and the ECCC policy on survival and recovery (DFO, 2010a; ECCC, 2021). This alignment corresponds to the fact that these documents are products of DFO processes and undergo extensive review to ensure that they agree with established policies and guidelines. DFO policy states that determining recovery feasibility is solely meant to assess a species' potential to reach a recovered state based on its intrinsic biological capacity as well as the ability for technology and management to support recovery. Conversely, several interviewees' responses often prompted the question of *whether recovery efforts should be undertaken* for iBoF salmon, a question that involves value-driven considerations such as socio-

cultural acceptability, economic concerns, and political will. While these value-driven considerations are excluded from the process for determining recovery feasibility under SARA, for many interviewees they were inextricably linked to the potential for recovery for the species. One common perspective among the respondents was that without financial or political support, recovery for iBoF salmon will be impossible due to its critically endangered state.

The inclusion of social, economic, and political considerations in SARA and other endangered species programs has been a topic of research for several years as they affect the success of conservation initiatives (Côté et al., 2021; Newediuk et al., 2021; Polasky, 2008). However, ensuring that these factors are taken into account by decision-makers, stakeholders and rightsholders participating in recovery planning is markedly different than making the considerations an explicit component of the determination of recovery feasibility for a species at risk. Several interviewees expressed points that capture this difference. They are aware of how these factors have impeded recovery for iBoF salmon—or how they believe such factors have done so—but they also maintain that socio-economic and political considerations cannot be used to conclude that recovery for a species is not biologically or technically feasible. This nuance relates to the concept of "conservation triage" that has gained significant traction in conservation biology in recent years (Beger et al., 2010; Gerber, 2016; Wiedenfeld et al., 2021). Participants, both within and outside of government organizations, articulated a link between recovery feasibility and conservation triage or other prioritization approaches. Being able to determine whether recovery is biologically and/or technically feasible can be an important approach to ensuring that the limited resources available for endangered species are assigned to those that will most benefit from intervention.

As a sort of counterpoint, salmon is an iconic species in Atlantic Canada, having been the focus of commercial and sport fishing for many decades, and harvested by First Nations in Eastern Canada for centuries or longer (Barsh, 2002; Daniels & Mather, 2017; Pinfold, 2011). In fact, Atlantic salmon is considered socially, culturally, and spiritually the single most important fish species to the Mi'kmaq, Wolastoqey, and Peskotomuhkati peoples, and the decline of iBoF salmon has impacted their cultural well-being (Maritime Aboriginal Peoples Council, 2014). The social, cultural, and erstwhile economic

importance of salmon in the inner Bay of Fundy plays a role in decision-making for the preservation of iBoF salmon. In part, this combination of factors helps to explain why the iBoF Salmon Recovery Team has persisted long after DFO moved away from the Recovery Team model; why so many resources are being expended for the species' preservation; and why, according to some interviewees, DFO cannot pull away from recovery efforts despite the expense and difficulty. The unique case of iBoF salmon illustrates the complex tension between "can it be done" and "should we do it" that lies at the heart of many conservation problems (Bankes et al., 2014; Wilson & Law, 2016).

3.5.2 Conclusion

Recovery of inner Bay of Fundy Atlantic salmon was considered feasible when the initial Recovery Strategy for the species was published in 2010, though there was a substantial degree of uncertainty about both biological and technical feasibility. While the most recent progress report on iBoF salmon recovery efforts maintains the same determination of feasibility as in 2010, Recovery Team members expressed a somewhat more negative view on the subject overall. Little progress has been made towards achieving either the abundance or distribution objectives laid out in the Recovery Strategy, raising concerns about whether persistent limitations to iBoF salmon recovery have emerged since 2010. Potential limitations identified in the documents and expressed by Recovery Team members included changes in freshwater and marine habitats, Allee effects brought on by the critically low abundance of the species, and the looming threat of climate change in the rapidly changing Bay of Fundy. While the Live Gene Bank has maintained the survival of the population since its implementation in the early 2000s, it is not enough to promote recovery on its own, and its role in preserving the unique genetics of iBoF salmon may be jeopardized by the introgression of non-native Atlantic salmon genetic material into the program. Additionally, many Recovery Team members asserted that the threats impeding the recovery of iBoF salmon remained poorly understood despite extensive research, making the technical feasibility of recovering the species more uncertain than in 2010. While all of the recovery planning documents and the majority of interviewees maintained that recovery remains feasible at some level for iBoF salmon in 2023, it continues to depend on the stewardship of DFO, Parks Canada, and

other organizations and groups involved in the Recovery Team, and uncertainty remains about the eventual fate of this unique population of Atlantic salmon.

Chapter 4: Barriers and Enablers to Assessing Recovery Feasibility

4.1 Introduction

The assessment of population status, sustainability, and recovery feasibility for iBoF salmon is one of the five explicit objectives outlined in the Recovery Strategy. One approach listed to achieve this objective is to "*periodically* (as prescribed in the recovery strategy and companion action plan(s), i.e. every five years) evaluate recovery strategy success, review progress towards attaining self-sustainable populations, and *assess the feasibility of recovery*" [emphasis added] (DFO, 2010b). This objective is in line with the provision in SARA requiring the competent Minister to report on the progress towards meeting the objectives of the Recovery Strategy every 5 years or until recovery is deemed no longer feasible (SARA, 2002 Section 46). While DFO reviewed the progress made in implementing the Recovery Strategy in the five years after its publication, that review explicitly states that recovery feasibility had not been reassessed in that time period—and no such reassessment has been made as of August 2024 (Figure 2.1; DFO, 2021). The absence of feasibility assessments raises the question of what has prevented a reassessment for iBoF salmon, and, conversely, what enabling factors exist for reassessment to occur.

The observation that SARA processes move too slowly in response to the needs of endangered species is not new. Several studies have explored outcomes from the processes and identified delays occurring at the time of listing an endangered species (Findlay et al., 2009; Kraus et al., 2021; Mooers et al., 2007), developing recovery plans (Brassard, 2014; Hutchings et al., 2016), identifying critical habitat (Bird & Hodges, 2017; Palm et al., 2020), and evaluating the success of management approaches (Bottrill, Walsh, et al., 2011). These sorts of deferments have also occurred in recovery planning for iBoF salmon. In addition to the postponement of reassessing recovery feasibility, the length of time between the drafting and final publication of both the Recovery Strategy and Action Plan for iBoF salmon far exceeded the timelines established in SARA section 43, subsections 1 and 2, which sets a maximum of 90 days between a proposed and final

version (SARA, 2002). The exact reasons why such delays occur are often unclear (Brassard, 2014).

Several studies acknowledge recovery feasibility determination is an explicit component of drafting a recovery strategy under SARA. Comparatively few directly analyze the topic itself, My literature search yielded one working paper and one master's thesis that examined the factors that influenced the results of feasibility assessments (Brassard, 2014; Khair et al., 2017). I found no papers or reports that directly or indirectly address the topic of completing a reassessment of feasibility for a species as part of ongoing management. The process of reassessing recovery feasibility shares many characteristics with monitoring and evaluation processes, and adaptive management. For example, reassessment processes provide the opportunity to integrate new knowledge, measure progress towards objectives, and re-evaluate the suitability of the objectives based on an updated understanding. Reassessing recovery feasibility under SARA serves this purpose as well, with a focus on the biological and technical aspects of recovering a given species.

4.1.1 Summary of Thematic Analysis Method

I used a combined inductive-deductive approach in my thematic analysis for this research question (Chapter 2, section 2.3.1). First, I performed iterative open coding on the transcripts and written responses, identifying a set of initial barriers and enablers as they emerged from my readings of the texts. Following this, I performed a literature search for studies examining the implementation of similar reassessment processes in conservation. I selected studies that centered on processes such as monitoring, evaluation, and adaptive management in the context of conservation or wildlife management (Allen & Gunderson, 2011; Bottrill, Hockings, et al., 2011; Jacobson et al., 2006; Månsson et al., 2023; McIntosh, 2019; Soomai, 2017a; Stem et al., 2005). I created an analytical framework based on common themes among selected papers and their relevance to the emergent coding framework in my study (Table 4.1). Finally, I applied the framework to all transcripts in a further round of coding, producing a thematic framework describing the barriers and enablers to recovery feasibility as expressed by Recovery Team members participating in my study (Table B.2).

Table 4.1. Thematic framework of barriers and enablers to reassessing feasibility

	Deductive category	Studies referencing category	Themes identified in inductive analysis
Barriers	Lack of data to conduct reassessment	Bottrill, Hockings, et al., 2011 Jacobson et al., 2009 Månsson et al., 2023 McIntosh, 2019	Lack of baseline or new data for iBoF salmon Challenges in accessing and utilizing non-DFO information
	Lack of resources	Allen & Gunderson, 2011 Bottrill, Hockings, et al., 2011Jacobson et al., 2009 Månsson et al., 2023 McIntosh, 2019	Financial and technical challenges Personnel capacity and turnover
	Organizational structure and culture of the Recovery Team	Månsson et al., 2023 McIntosh, 2019 Soomai, 2017	Lack of coordination among Recovery Team members Disconnects between scientists and managers Focus on updates, not innovation Leadership of the Recovery Team
	Challenges stemming from the regulatory authority	Jacobson et al., 2009 Månsson et al., 2023 McIntosh, 2019	Conflicting roles of DFO and the Recovery Team for feasibility assessment Perceived conflicts of interest within DFO Reticence to reassess at the political level
	Conceptual barriers	Jacobson et al., 2009	Challenges with how "recovery" is defined for iBoF salmon Uncertainty about how "recovery feasibility" is defined
Enablers	Value tied to monitoring	Bottrill, Hockings, et al., 2011 McIntosh, 2019	Recovery Team members value reassessment
	Building capacities	Bottrill, Hockings, et al., 2011 Jacobson et al., 2009 Månsson et al., 2023 McIntosh, 2019	The Recovery Team as a central organizing group
	Facilitating learning processes	Jacobson et al., 2009 Månsson et al., 2023 Soomai, 2017	Better integration of information from outside of DFO processes
	Enhancing understanding of reassessment processes	Månsson et al., 2023 Stem et al, 2005	Clarifying recovery feasibility and its reassessment

4.1.2 Chapter Structure

The results of my thematic analysis of the interview transcripts and written responses are classified as five barriers (section 4.2) and four enablers (section 4.3), in alignment with the categories in the framework described above (Table 4.1; Table B.2). The subheadings within each section correspond to the most prevalent barriers and enablers identified as themes in my analysis. Key quotations from the interviews and written responses are presented throughout. I conclude the chapter by highlighting and briefly discussing key findings in the context of other studies.

4.2 Barriers to Assessing Recovery Feasibility

Every participant addressed the issue of barriers to reassessing recovery feasibility at least to some extent, either directly or indirectly. Some barriers were identified by many different interviewees, while others were acknowledged by only a few, but were very strongly associated with reassessing feasibility. On balance, the most important barriers could be clustered into five categories: 1) lack of data to inform a reassessment; 2) lack of resources or capacity for research or reassessment; 3) challenges related to the organizational structure and culture of the Recovery Team; 4) challenges stemming from DFO as the regulatory authority; and 5) conceptual challenges with recovery planning for iBoF salmon, including the definition of "recovery feasibility." For each of these categories at least one type of barrier was identified. While I address each category separately, they are also interrelated, as will be described in the discussion.

4.2.1 Lack of Data to Conduct Reassessment

The dearth of information produced by research on iBoF salmon was brought up by the Recovery Team members as a factor affecting their perception of the feasibility of recovering the species (section 3.3.2.2). Because the determination of recovery feasibility relies on the "best available information" (DFO, 2010a; ECCC, 2021), it stands to reason that this deficiency could also be a barrier to reassessing feasibility for iBoF salmon. Indeed, all 12 interviewees expressed perspectives that clustered around two themes: a lack of information to support a reassessment of feasibility, and challenges in obtaining or utilizing information not produced by DFO.

4.2.1.1 Lack of Baseline Data or New Information for Reassessment

In its written response to this study, DFO staff identified "the lack of understanding of limiting factors and ability to mitigate threats in the marine environment" as one of the "main challenges in assessing iBoF Atlantic Salmon recovery feasibility." DFO1, DFO3, and DFO4 noted this to be true despite many years of research by DFO and other stakeholder groups involved with iBoF salmon conservation and management (section 3.3.2.2). While many interviewees had their own opinions about whether recovery was feasible for iBoF salmon, many also agreed that it was not possible to properly assess feasibility of recovery because "there are so many unknowns" (DFO3, NGO3, NGO4).

Not only is little new information coming out of recent research efforts, but according to NGO1, a substantial volume of historical information and data collected about iBoF salmon has been lost since at least the 1990s. This shortfall occurred either because people retired or moved to other positions; data were stored in notebooks or other formats that were misplaced or difficult to integrate into modern databases; or the people in charge of the data were not experienced in its management and transmission. NGO1 described the impact that this loss of data continuity had on reassessing recovery feasibility.

> **NGO1:** We know at one point you could walk across rivers on the back of the spawning salmon, right? That's part of the history. But it's becoming more and more, what was it, the Lord of the Rings? History becomes legend, legend becomes lore, and eventually becomes fantasy, or whatever. I think that's exactly what's happening to salmon where you don't have that connection to the past in the science; it's becoming more and more broken up. So, we know that 100 years ago there were tons and tons of salmon—and that's even in the Western science—but we know today there's virtually nothing for iBoF salmon, and we're missing decades of documentation. And so, it makes people less likely to believe that you could walk on the back of salmon, because you don't have that continuity in the science [documentation].

This loss of historical information about iBoF salmon, coupled with the inconclusive results from more recent research, means that there is little information and data to

inform a reassessment of feasibility and situate the species' recovery potential within the historical context.

4.2.1.2 Challenges in Accessing and Utilizing Non-DFO Information

The above section dealt primarily with information generated by DFO through its research or scientific processes: however, several interviewees, both within and outside of DFO, acknowledged that there were barriers to the uptake of non-DFO and non-scientific information to inform recovery feasibility. These types of information include scientific research from non-DFO sources, grey literature, and traditional and local ecological knowledge (TEK/LEK) from Indigenous groups and local stakeholders. Past analyses have shown that a high predominance of scientific information generated by DFO was used in iBoF salmon recovery planning, despite the Recovery Strategy acknowledging the "key input" from other stakeholder groups in the drafting process (Hart, 2018; VanderZwaag et al., 2011). Similarly, all interviewees who were familiar with the process of determining recovery feasibility for iBoF salmon—and even some who were not—pointed out that most of the information used in this process was scientific information generated primarily by DFO.

The interviewees did not agree on the reasons why non-DFO information was not prominent. In general, individuals who worked in governmental organizations tended to identify the following factors: limited knowledge exchange with external stakeholders, either by choice in the case of industry groups, or because they had no information to contribute in the case of TEK and LEK (DFO1, DFO2, DFO4); issues concerning the nature and quality of the information generated by external actors and uncertainty about how to integrate it into existing SARA processes (DFO1, DFO3, PC1); and, simple oversight of obscure or inaccessible information such as that found in grey literature (AC1, DFO2, DFO4). Conversely, Recovery Team members who were not from federal government departments tended to view the lack of uptake of non-DFO information as being due to the department not understanding the value of such information for reassessing feasibility (NGO1, NGO2, NGO3, PROV1), or due to political or economic pressure to exclude certain types of information (NGO3).

The use of TEK and LEK in iBoF salmon recovery planning is an example where conflicting opinions about information occurred. All interviewees acknowledged that TEK and LEK were under-utilized in the Recovery Potential Assessment that informed the determination of feasibility, but the reasons for this under-utilization varied. DFO4 believed that "there was [not] a lot of local knowledge that came into play in the inner Bay of Fundy process and thinking," at least in the initial stages. DFO1 and PC1 highlighted the fact that "[DFO and Parks Canada] only interpret things scientifically" and that this makes it difficult to integrate TEK and LEK into iBoF salmon recovery planning. Others, such as NGO1, NGO2, and PROV1, claimed that TEK and LEK were "not really, to this day, accepted or equated with science" by DFO, and doubted that managers and policymakers understood the value of such information for managing either fisheries or endangered species. Whether intentional or incidental, the limited uptake of TEK and LEK presents a barrier to information that could promote a better understanding of iBoF salmon and thus inform a reassessment of feasibility.

4.2.2 Lack of Resources to Perform Research and Reassessment

When discussing barriers to reassessing recovery feasibility, eight of 12 interviewees brought up aspects related to capacity issues, such as financial resources, technology, personnel, and expertise to perform research and reassessment (AC1, DFO1, DFO2, DFO4, IN1, NGO1, NGO3, NGO4, PROV1).

4.2.2.1 Financial and Technological Resources

Nearly all interviewees directly or indirectly acknowledged that research on and management of iBoF salmon is challenging and expensive. Limited financial resources often came into play when the interviewees discussed research and management efforts needed to understand and address threats to iBoF salmon (AC1, DFO1, DFO2, DFO4, IN1, NGO4, PC1, PROV1). These limitations are barriers to reassessing recovery feasibility because they hinder the ability to generate information that would contribute to a reassessment, as discussed in section 4.2.1.

Many interviewees expressed that the barriers to undertaking the research and management work needed for the species to recover were related to "the overall level of resources that are available" (DFO1) or "costs and logistical challenges" (AC1). The

Recovery Strategy highlighted many unknowns and uncertainties regarding iBoF salmon population dynamics, habitat use, and other factors that would influence which actions would best support recovery, and as such there are a substantial number of research priorities for the species. DFO2 and DFO4 noted that the sheer number of research priorities for iBoF salmon was difficult to address with the financial resources available to the Recovery Team.

> **DFO4:** Look, I'll tell you, some of those meetings, we come in, people have a list of priorities with a huge number of items, and the total budget … would be way outside of the realm of possibility. So, they had to make a decision to prioritize, and you have all these voices at the table argue which way the priority should go. Now science would lead oftentimes, but management had to prevail in the end, because there's only so much money to go around.

The multifaceted features of the marine environment was a particularly prominent topic of discussion regarding the cost of conducting research: for example, DFO1 stated that "we just don't have the technology and the resources" to directly investigate changes in marine habitat availability for iBoF salmon. DFO3, DFO4, and IN1 also brought up the technological difficulties and expense involved in conducting research in the marine environment, specifically in relation to tracking studies that rely on telemetry equipment. Part of the reason for these difficulties is that iBoF salmon's small population size imposes substantial limitations on any approaches to research or manage the species. DFO3 contrasted iBoF salmon with the Atlantic salmon population of the Southern Uplands in Nova Scotia, saying that "[because] marine survival isn't as limiting [with Southern Uplands salmon] … we've identified life stages that are limiting, environments that are limiting, and the potential to do something with that … and we just aren't at that stage with iBoF salmon."

4.2.2.2 Personnel Capacity

Challenges identified in personnel capacity for research largely focused on the sheer size of the area historically inhabited by iBoF salmon and the comparatively small—and decreasing—number of people and organizations available to monitor and assess it. Interviewees from both governmental (PROV1) and nongovernmental (AC1

NGO1, NGO4) organizations involved in iBoF salmon recovery efforts have noticed a decline in this capacity since at least the early 2000s. Examples include the shortage of DFO personnel, including scientists and managers, available to monitor the more than 30 streams of the inner Bay of Fundy; and the slow decline of non-governmental "Friends of the River" volunteer groups, many of which appear to exist in name only according to NGO1. This mismatch in scale and capacity is not unique to iBoF salmon. PROV1 noted that, within the larger inland fisheries division of the provincial organization, the section of the team that is directly involved with resource management and monitoring for these fisheries consists of five people—"two biologists, two technicians, and one sportfish development officer"—covering the entire province.

Personnel turnover within DFO and the Recovery Team was also mentioned. NGO4 described the experience of attending one of the last meetings for iBoF salmon, noting that there were many "new folks, and young people, very, very committed to the job. But they're here today, and they're gone somewhere else tomorrow." The limited capacity to undertake long-term research on iBoF salmon, especially in terms of personnel turnover, has also played a role in the "loss of institutional memory," as AC1 put it. When experienced staff leave, not only is their expertise lost, but any existing relationships cultivated by their presence and that could have facilitated information sharing between DFO and external stakeholders is also lost. Additionally, as experienced people retire and new people are hired, the remaining members of the Recovery Team must engage in an ongoing process of retraining and familiarizing members with the current state of the knowledge and practice for iBoF salmon management. This situation slows the generation of new information for reassessment as the Recovery Team revisits questions previously addressed. It also illustrates how the Recovery Team's organizational structure and culture are not conducive to reassessing recovery feasibility.

4.2.3 Barriers Arising from Organizational Structures and Culture

Many barriers identified by interviewees related to the organizational functioning of the Recovery Team, including the relationships and connections among its members, the structure of meetings, and its leadership. Several interviewees from DFO and Parks Canada stated that DFO has moved away from the Recovery Team model for endangered

species management, and yet the Recovery Team for iBoF salmon has persisted due to the value it brings for managing the species (DFO1, IN1, PC1). Nonetheless, there appear to be substantial challenges related to the way it operates, which have hindered the team's ability to reassess recovery feasibility for the species. Barriers identified by Recovery Team members include difficulties in coordination and communication between Recovery Team members, the lack of organizational infrastructure to support reassessment activities, and ineffective leadership of the Recovery Team.

4.2.3.1 Coordination and Communication Between Recovery Team Members

The iBoF Salmon Recovery Team membership varies over time, but typically includes stakeholders from two federal government departments (i.e., DFO and Parks Canada), two provincial governments (i.e., NS and NB), several non-governmental organizations (i.e. Atlantic Salmon Federation, Nova Scotia Salmon Association, Maritime Aboriginal Peoples Council), First Nations communities (i.e., Annapolis Valley, Fort Folly, Glooscap, Indian Brook, and Millbrook First Nations), industry (i.e., aquaculture, forestry, and hydroelectric), recreational anglers, and academia. Coordinating such a large and diverse group of people with ranging levels and types of expertise, as well as differing, often divergent, values or concerns about iBoF salmon, has been a challenging task at times. Coordination and communication between members of the Recovery Team were brought up as a difficulty in reassessing recovery feasibility by AC1, DFO1, DFO2, DFO4, NGO1, PROV1, and PC1.

It is important to note that most of the Recovery Team members I interviewed spoke positively about the functioning of the Recovery Team. Inclusivity was noted as an advantage by IN1, NGO1, NGO2, and PC1, enabling the Recovery Team meetings to function as a hub of salmon experts and to foster opportunities for collaboration between these various stakeholders. In DFO1's opinion, despite the Team's size and the diversity of stakeholders within it, the main challenges with getting things done for iBoF salmon recovery is "not because of disagreement or dispute among participants," but rather a function of the level of resources available to do the work (see section 4.2.2). However, some interviewees did not agree that the Recovery Team was functioning as smoothly as others perceived it to be. AC1, DFO2, and DFO4 acknowledged that while the different

groups that make up the Recovery Team came together for meetings, they often worked on their own projects outside of those and had difficulty coordinating their efforts across the Bay of Fundy. Here, I use the term "siloing" or "organizational silos" to describe a tendency within a larger organization or multi-stakeholder initiative for its components to operate in relative isolation to one another, especially when it hinders knowledge exchange and coordination of efforts between these components (Bento et al., 2020). Siloing has been identified as a barrier to the implementation of assessment processes, including adaptive management, in other conservation initiatives (Jacobson et al., 2006; Månsson et al., 2023).

In the case of iBoF salmon recovery planning, some of the disconnection was due to distrust by, or disengagement by, particular groups in the Recovery Team. DFO1, DFO2, and DFO4 each described situations where non-governmental research groups, recreational anglers, and/or aquaculture experts were reticent to share information with DFO because of mistrust of how the department might use that information. One example occurred in obtaining information about aquaculture escapees when the initial RPA was being drafted. DFO2 described how "opaqueness" and distrust from both anglers and representatives of the aquaculture industry made it difficult or impossible to collect information that would have been included in the RPA. PROV1 and NGO2, on the other hand, felt that DFO was not engaging meaningfully with groups such as recreational anglers or First Nations rights holders to collect information that could inform a reassessment of feasibility. While PROV1 was uncertain about the reason for the lack of engagement with fishers, the uncertainty related to "how much some of the senior policy-based folks actually understand angling, recreational fishing, and how important those are to understanding a fishery." Similarly, NGO2 described that First Nations individuals felt that "the voice of a few people didn't really count to the science of the non-native DFO side:" that is, that DFO did not consider the voice of First Nations individuals. Mistrust between different groups usually means restricted information exchange, which encourages these groups to operate independently instead of leveraging connections with other members of the Recovery Team.

Disconnection within the Recovery Team also occurs due to the complexity of iBoF salmon management in general, including the number of different jurisdictions

involved. AC1 pointed out that the population spans two provinces, is managed by DFO and Parks Canada, migrates between freshwater and marine environments, and is the subject of recovery efforts by dozens of groups across nearly as many rivers, each with their own budgets and priorities. With so many different jurisdictions at play, "how do we bring all these different efforts, different groups together, even though we're all still working under the same RPA and for the same common goal?" (AC1). Here, siloing occurs when groups focus primarily on maximizing vertical coordination within their own jurisdictional boundaries, at the expense of horizontal coordination with other groups (Scott & Gong, 2021). NGO1 gave an example with the management of inland waters.

> **NGO1:** Inland waters have been an area that the federal government and provincial governments have fought over since Confederation, so any talk of doing restoration work, or trying to identify critical habitat, or trying to, heaven forbid, protect critical habitat—particularly at a watershed scale—any of those kinds of discussions are hugely complicated.

Siloing has hindered knowledge sharing among Recovery Team members, especially in terms of applying innovative recovery approaches that could change the technical feasibility of recovering iBoF salmon. The Fundy Salmon Recovery (FSR) program, managed by Parks Canada since 2015, is one such innovative approach. This stock supplementation program captures smolts from the wild and raises them to adulthood in specialized marine pens, then releases these adults into Fundy Park rivers to mix with wild returning adults (Maysonet & Murphy, 2021). This method differs from the supplementation provided by the LGB program, which releases juveniles and adults that were raised primarily in a hatchery environment. IN1, NGO1, NGO3, and NGO4 expressed optimism about this new approach and the potential to apply it to other areas in the inner Bay of Fundy. However, only one non-governmental organization, the Fort Folly Habitat Restoration Program (FFHRP), has successfully sought a permit to conduct similar supplementation activities in the Petitcodiac River. According to PC1, "DFO Science is setting the pace, setting the direction, saying what's good or bad" in terms of recovery activities for iBoF salmon, and thus the department appears to "gatekeep" which activities are allowed. Part of the reason for this control is to avoid unintended

consequences caused by poor implementation by organizations that lack either expertise or full understanding of new approaches. This lack of knowledge is itself a product of siloing, as the details of the FSR program may not be clearly communicated by Parks Canada to NGOs who want to apply it to the rivers in their mandate. However, as PC1 stated, "when permits to do things are denied, things can't happen." Furthermore, this tight grip on recovery activities creates different "regulatory landscapes" for the member organizations of the Recovery Team. Because Parks Canada is one of the departments responsible for managing recovery planning efforts, it has more freedom to experiment or try new approaches within its own jurisdiction in Fundy National Park. Conversely, PC1 described how the FFHRP had to "jump through multiple different hoops" to establish their supplementation program. The differing regulatory landscapes are the product of siloing between DFO or PC and non-governmental organizations, which in turn promotes further siloing by discouraging NGOs from collaborating with either the federal government or other organizations.

4.2.3.2 Disconnects Between Scientists and Managers

Many interviewees noted a disconnect between scientists working on iBoF salmon and managers with broader portfolios of which iBoF salmon were a part (DFO2, DFO3, DFO4, NGO1, NGO3, NGO4, PC1). One of the ways this disconnect manifested was tension between the research needs for iBoF salmon and the financial resources available to the Recovery Team as a whole. Scientists felt that managers were not doing enough to support the research needs of iBoF salmon, while managers felt that scientists were not being "realistic" about either the resource limitations or the likelihood of long-term support for recovery efforts. While scientists and managers each understood their roles in iBoF salmon conservation, DFO4 described how the disconnect between the groups could lead to "worlds collid[ing], because [managers] are saying, 'It's completely unrealistic, we can't investigate that threat,' and then [scientists] go, 'You're not going to investigate the threat? How serious are you about recovery?'" When researchers and managers do not understand each other's needs, or have different priorities, the ability to set mutual priorities for conducting research and using the findings in decision-making processes is hindered.

Another dynamic between scientists and managers observed by DFO4, NGO3, and NGO4 was the tendency for managers to engage in "action procrastination" (Allen & Gunderson, 2011), or a reticence to act based on new scientific information. Action procrastination is often accompanied by calls for more research, either because the available information is deemed not relevant enough to the current system (i.e., research conducted in a different location than the one being managed), or to delay action for political or economic reasons. One of the ways this factor acted as a barrier to reassessing feasibility of recovery for iBoF salmon was by restricting the flow of research information to decision-makers. NGO3 provided an example where information he personally believed was relevant to recovery planning was excluded by DFO because DFO thought it did not fulfill certain inclusion criteria:

> **NGO3:** I actually did my Master's [research] on interactions of wild and aquaculture salmon for outer Bay of Fundy, which is, just as the crow flies, not very far from the inner Bay …. Then DFO said, "No, you can't include that information because it's different. You have to redo a study for inner Bay [of Fundy] to see if those threats are viable or not." So that was left out from DFO. I use the example of "smoking causes cancer in New Brunswick, but you need to do a study in Vancouver to see if it causes cancer in Vancouver."

DFO4, NGO3, and NGO4 all acknowledged that action procrastination in recovery planning may have been politically motivated as well. DFO4 linked the factor to the "tremendous antithesis to science taking a lead or having a strong influence on anything" that existed in the political realm in Canada in the years after the Recovery Strategy was published. Similarly, both NGO3 and NGO4 believed that pressure from recreational anglers or the aquaculture industry often led managers to engage in action procrastination, due to concerns about "trampling too many toes." This scenario points to conflicts between reassessing feasibility and other activities managed by DFO such as recreational angling or aquaculture, as will be discussed in section 4.2.4.2.

4.2.3.3 Show-and-Tell Without Innovation

Several interviewees observed that the current structure of the Recovery Team meetings did not give enough time to complete the work necessary to support the

reassessment of feasibility. DFO2, NGO3, NGO4, and PROV1 claimed that current meetings are primarily focused on DFO or other stakeholders providing updates about existing management efforts—or "show-and-tell," as both NGO3 and NGO4 put it—at the expense of considering future strategies and planning for next steps. NGO4 described how the number and quality of meetings declined over time, leading this participant to become somewhat disillusioned with the Recovery Team:

> **NGO4:** For a number of years, we had two meetings each year: two days in the fall, two in the spring. And we had what I called the "show and tell," or what happened, what we did, and what were the results; but then the next day, we had what I called "what are we going to do" or "what are the problems," "what can we do," type of thing. That was the meeting I loved, the meeting gravy: we looked at the results and then the next steps. And that disappeared off the map. We used to have two meetings, and then they have jammed it all into one session. I guess that's one reason I said to hell with it: somebody is not interested enough to have two meetings anymore.

DFO2 noted that even at the time of the drafting of the Recovery Strategy, "we spent very little time on strategies and mitigation, which is meant to be a large part of the recovery potential assessment" that eventually informs recovery feasibility. Because of the number of stakeholders involved in the Recovery Team meetings and the complexity of the information that was considered by the team, there was not enough time to explore different recovery scenarios and conduct a fulsome review of feasibility. DFO2, who has retired from the Recovery Team, was not certain whether that practice had changed in the years since, suggesting that the lack of emphasis on reassessment activities had persisted at least until the time of his retirement. Responses from DFO1 and PROV1 indicated that these organizational challenges have continued to the present. DFO1, whose involvement in the Recovery Team continued beyond 2015, stated that the deadlines written into the Species At Risk Act and iBoF salmon Recovery Strategy "don't provide us with opportunities for enabling [the] types of meetings" where reassessing feasibility would be the focus. PROV1, who had only been on the Recovery Team long enough to participate in two meetings before our interview, noted that the meetings were also primarily focused on information sharing from DFO and other Recovery Team Members, specifically about

current research initiatives as well as the Live Gene Bank. Little emphasis was apparently given to searching for new information or outlining the next steps of recovery planning. These comments are similar to observations by Lindenmayer et al. (2013) of conservation programs where "the decline and extinction of species is accurately recorded without any effective attempts at mitigation." The decline in the organizational infrastructure of the Recovery Team—fewer meetings and focusing on sharing rather than seeking information—contributes to the problems with siloing between stakeholder groups, where the structure of the Recovery Team does not foster or enhance collaborations that could help improve both the financial and personnel capacity for research or other actions for recovery (AC1), including reassessment of recovery feasibility.

4.2.3.4 Changing Leadership and Priorities of the Recovery Team

While the responses from DFO1 and DFO2 indicate that one reason for this lack of focus on reassessment was the difficulty of coordinating the large group of diverse stakeholders and rights holders, other Recovery Team members such as AC1, DFO4 and NGO4 suggested another reason was a change in emphasis within the Recovery Team brought about by changes in its leadership. Organizational leadership plays an important role in the success or failure of conservation programs, and poor or nonexistent leadership is noted as a significant barrier to monitoring, evaluation, and other aspects of adaptive management in such programs around the world (Flye et al., 2021; Kleiman et al., 2000; Månsson et al., 2023; Smith et al., 2003).

Decisive past action by key leadership figures in iBoF salmon recovery planning was noted by the majority of interviewees as fostering early and important successes in iBoF salmon conservation. For example, PC1 acknowledged "managers from DFO, or Parks Canada, or from stakeholder groups … took action on their own, before all of the recovery planning documents were in place, and had they not, we would have no fish to work with." Several Recovery Team members, however, expressed the opinion that since at least 2010 the leadership of the Recovery Team has not been pushing for reassessing feasibility or doing much beyond checking in on the research and restoration programs currently in place. NGO4 drew a direct link between changing leadership of the recovery team and a subsequent decline in organizational support:

> **NGO4:** For a while here, we had a head scientist who was really gung-ho, who wanted to get a lot of things done. And he retired, and the person that took over, I don't think had his heart and soul in it… and he didn't think we needed two meetings every year.

DFO4 noted this pattern as well, likening the role of some of the more recent chairs of the team to "figureheads" who expected scientists to lead from below and did not push to have research results guide decision-making for future management actions for iBoF salmon. DFO4 theorized that this more passive leadership style may have coincided with DFO's growing disengagement with SARA in general (section 4.2.4), stating the opinion that the department may have appointed a chair to the Recovery Team that would allow "a little bit of progress [to be] made, but at least it's not gonna make too many waves." Indeed, the shift to a more passive leadership style from chairs of the Recovery Team has caused several of its members to wonder whether DFO remains interested in supporting iBoF salmon recovery efforts.

4.2.4 Declining Support at the Governance Level for iBoF Salmon

Barriers to reassessing recovery feasibility are also linked to the Department of Fisheries and Oceans as the regulatory authority for iBoF salmon management. While several members of the Recovery Team represent divisions of DFO, such as Science, Fisheries & Aquaculture Management, and the Species At Risk Office, the barriers addressed in this section relate to DFO's role in administering recovery planning for aquatic species listed in Schedule 1 of SARA, including iBoF salmon. More specifically, a key perception of either a lack of interest in or opposition to reassessing the feasibility of recovery on the part of DFO is highlighted. Several interviewees (DFO1, DFO2, IN1, NGO1, NGO2, and NGO3) pointed to factors related to DFO's governance of iBoF salmon that hindered the ability of the Recovery Team to undertake a reassessment of feasibility.

4.2.4.1 The Unclear Role of the Recovery Team in Reassessing Feasibility

The process by which the initial determination of feasibility is made for a species listed under SARA is fairly clear: the text of the Act states that it is the competent Minister's responsibility to make the determination as part of the drafting of a recovery

strategy for a listed species (SARA, 2002). The Minister delegates this responsibility to DFO's Species At Risk division and the Recovery Teams associated with each species. The Recovery Strategy for iBoF salmon highlights the active consultation of over 70 individuals who were on the initial Recovery Team (DFO, 2010b; Government of Canada, 2016). The delineation of responsibilities between the federal departments and other members of the Recovery Team is also described in the Recovery Strategy. DFO and Parks Canada led the development of the strategy, including determining recovery feasibility, and the Recovery Team "played a key role in providing input" from experts, governmental representatives, and stakeholder group members (DFO, 2010b). Once the initial assessment is complete and included in the Recovery Strategy, the process by which subsequent reassessments occur is less clear. Even though regularly reassessing recovery feasibility of iBoF salmon is an explicit objective of the Recovery Strategy, there appears to be disagreement and confusion about who is responsible for starting a reassessment. DFO1 stated that the Recovery Team would be able to put the question of reassessing recovery feasibility on the table "if there was a solid consensus among all the parties involved." However, PC1 reported that "that type of question would only be asked by the overall jurisdiction of responsibility, the Department of Fisheries and Oceans."

Throughout my interviews with the Recovery Team members, I heard competing views about whether the Recovery Team had an effective role to play in the process of reassessing the feasibility of recovery for iBoF salmon. DFO stated in its written response that "any necessary updates to the iBoF Atlantic Salmon recovery strategy stemming from a re-evaluation of recovery feasibility … will be accomplished by DFO in consultation with Indigenous groups, provinces, and stakeholders including the Recovery Team." NGO1 highlighted the fact that the Recovery Team "still had a number of people who were pushing for [it] to be that central organizing authority, almost, or at least to be able to provide good advice and make it real." In contrast, statements by several interviewees and in parts of the written response of DFO staff suggest that reassessing feasibility is ultimately the sole responsibility of DFO. For example, when responding to how ECCC's new policy on recovery and survival would affect the work of the Recovery Team in determining recovery feasibility, DFO staff wrote in the response—reiterated in a separate comment provided upon receipt of the written response—that "it isn't the

Recovery Team's responsibility to determine recovery feasibility or set recovery goals." This position was noted despite acknowledging that the Recovery Team does play a role in shaping that determination by providing advice for DFO's consideration. The view that the Recovery Team's role has been minimized over time was alluded to by DFO1 and PC1 as they described that DFO was "moving away from [the Recovery Team] model" in general, with the iBoF Recovery Team being one of the last in Atlantic Canada. NGO1 and NGO4 directly acknowledged the declining influence of the Recovery Team. NGO1 stated that the function of the Recovery Team had shifted from collaboration between DFO and external stakeholders and rights holders, to a team primarily driven by DFO.

> **NGO1:** When [SARA] was passed in 2002, DFO finally came and said, "We have our enabling act now, we can really be a coordinator, a leader, we can chair the Recovery Team." There was a lot of excitement about that … because it has this official capacity, and we would be able to push [the Recovery Team] forward as an organizing body. …Eventually, the government began to realize just how onerous SARA would be … And so there was this pulling back at the national level to say, "If we are the chair of the Recovery Team, then we control the Recovery Team; if we develop the Recovery Strategy, then it is our Recovery Strategy; if there is critical habitat to be designated, we will be the ones to designate it," and to cut a lot of people out.

In this case, it was clear to both NGO participants that the Recovery Team was not considered a key agent for promoting iBoF salmon recovery activities, especially those that might come into conflict with economic or political interests (section 4.2.4.2). DFO's shift away from Recovery Teams in general, and its increased power in directing the activities of the iBoF salmon Recovery Team specifically, suggest that the federal department would have the final say on when to start the process of reassessing recovery feasibility.

4.2.4.2 Conflicts of Interest Within DFO May Preclude Reassessment of Feasibility

Several interviewees expressed the view that the recovery of iBoF salmon is not prioritized by DFO. In nearly all recovery planning documents produced for iBoF salmon, DFO recognized the species' ecological, cultural, and past economic importance;

however, all of the interviewees from non-governmental organizations noted that iBoF salmon is simply not as high on the list of priorities for the department as other resources it manages, which results in a lack of interest in reassessing the feasibility of its recovery. This view is due in part to the perceived conflict of interest with DFO being responsible for recovery planning for iBoF salmon while also managing industrial activity, like commercial fisheries, recreational fisheries, and aquaculture, that may directly or indirectly affect recovery efforts.

The conflict between conserving iBoF salmon and promoting aquaculture was discussed by several interviewees (DFO2, NGO1, NGO3, NGO4, PROV1). While interviewees who were members of the federal and provincial governments (DFO1, DFO3, PROV1) stated that there wasn't much "conclusive evidence" that aquaculture was impacting iBoF salmon, NGO4 explicitly stated the belief that DFO "can't protect wild Atlantic salmon and be the beneficiary of aquaculture: they're both in opposition to one another." NGO3 explicitly drew a link between "pressure from the [aquaculture] industry at the management level" and a subsequent decision to exclude a subset of information from the Recovery Strategy about interactions between wild and farmed salmon (section 4.2.3.2).

One of the starkest examples of how this perceived conflict shaped the functioning of the Recovery Team was of an incident in the early 2010s recounted by NGO1 and NGO4, where non-DFO Recovery Team members pushed for discussion on the potential threat to iBoF salmon from aquaculture developments in the Bay of Fundy. According to both interviewees, the then-chair of the Recovery Team did not allow the discussion to move forward, because "this is the Minister's group… the chair is a public servant and is there to protect the Minister" (NGO1). This incident nearly caused the Recovery Team to dissolve and had long-lasting effects on the efficacy of the Recovery Team. NGO1 stated that "we still have not come back from that date a decade ago." While NGO4 agreed the incident was "terrible," he also believed that DFO's attitude towards discussing aquaculture and its potential impacts on iBoF salmon had improved. However, the fact that DFO has attempted to "be quiet" about the potential introgression of genes from farmed Atlantic salmon into the LGB, according to both NGO3 and NGO4, casts some doubt about whether potential threats to iBoF salmon will be

researched or addressed if they conflict with economic activities that DFO wishes to promote. The "conflicting mandates" of the department may thus remain a barrier to reassessing recovery feasibility for iBoF salmon (VanderZwaag et al., 2011).

4.2.4.3 Reticence to Reassess Due to Lack of Progress

Some interviewees brought up a potential reluctance on the part of DFO to reassess feasibility due to a potential backlash from stakeholders and rights holders involved in Atlantic salmon conservation. This challenge has been noted in many conservation programs, rooted at least in part in the reticence of regulatory and management authorities to highlight or examine potential failures or lack of success (Kleiman et al., 2000; Månsson et al., 2023). As noted earlier (Chapter 3, section 3.2.2.1) and as stated in the 2021 Progress Report, despite some progress in implementing actions for iBoF salmon recovery, the population has not improved and may have further declined since the publication of the Recovery Strategy (DFO, 2021). This lack of progress may be one reason why DFO has not undertaken a reassessment of recovery feasibility. According to NGO3, "it's what hasn't been done is why DFO's dragged its heels in terms of doing re-evaluation, because they know the failure, in terms of actually having accomplished what they're supposed to set out to do." A reassessment of feasibility could generate significant controversy if it concluded that recovery is no longer feasible for the species.

> **DFO1:** Certainly, I could see there might be concern, either within the regulatory part of DFO, like Aquatic Ecosystems, or the political wing, like the Minister's office or Parliament. Do you really want to ask these tough questions? Are you ready for those kinds of discussions? …. If the result of a scientific review of recovery feasibility showed that it was unlikely, given environmental conditions in the near and medium term, then you've opened a big can of worms, right? And I wonder sometimes if there is reluctance to address these questions because of the heat and light that could be generated from holding that discussion.

Six of the 12 interviewees, mainly from NGOs and industry, held that DFO's reluctance to reassess stems from its general disengagement with SARA over time. NGO1 made a link between the reluctance to reassess recovery feasibility and "a larger

issue [in the federal government] that really … doesn't want to put the effort into SARA except for the most clear-cut cases." This was similar to the "pulling back" he described about how DFO's relationship to the Recovery Team changed over time (section 4.2.4.1). Similarly, NGO3 expressed doubts about DFO's intentions with iBoF salmon: he speculated that the reason the department had not reassessed recovery feasibility "could be that DFO was ... waiting for the last straw to say, 'Look, it's not recoverable, so we're just putting our hands up in the air and walking away.'" This perceived deprioritization by DFO affects the financial resources or number of personnel the department is willing to devote to iBoF salmon recovery in general (section 4.2.2.1). In fact, as mentioned in Chapter 3, section 3.4.1, changing priorities in the federal government have already led DFO to substantially reduce the budget for the LGB program and close one of the three biodiversity facilities that are essential for the program's function. DFO may thus be reluctant to reassess recovery feasibility for iBoF salmon because of potential backlash from organizations, stakeholders, and rights holders that believe DFO is not doing enough for the species.

4.2.5 Conceptual Barriers

Some of the barriers to reassessment expressed by the interviewees arose from differences in how individuals understood the concepts that inform the process of determining recovery feasibility. Barriers in this category clustered around two topics: how "recovery" is defined for iBoF salmon, and the differing definitions of "feasibility" used by members of the Recovery Team. Both terms are fundamental to the process of determining recovery feasibility. Diverging perspectives on the meaning of these terms leads to disagreements about what the recovery objectives for the iBoF salmon population should be, and how to evaluate the biological and technical ability to reach these objectives.

4.2.5.1 What Is "Recovery" for iBoF Salmon?

According to six participants (AC1, DFO1, DFO2, IN1, PC1, PROV1), what constitutes "recovery" for iBoF salmon has been debated since the species was listed in 2003. One aspect of this debate is about how "inner Bay of Fundy salmon" is defined. Recovery planning documents, and interviewees from DFO, specifically point to the

unique genetic signature of the population. As explored in Chapter 3, recovery efforts place a substantial emphasis on preserving the iBoF salmon genetic signature, and the original determination of recovery feasibility was shaped in part by the methods employed by DFO to do so. Some interviewees disagreed with this approach: IN1 believed that too much emphasis had been placed on the genetic uniqueness of iBoF salmon, while PC1 and PROV1 were wary of the potential of having the genetic code preserved in the LGB, but no actual fish in the Bay of Fundy. DFO1 stated that there was a "legitimate debate to hold" on this subject:

> **DFO1:** If you're doing whole genome work, you can identify breakdown into subfamilies within rivers, but where is the important line to be drawn? What is it that the public of Canada wants to conserve through its legislation? Do they want to conserve the genetic diversity of the species, or do they want to see individuals abundant in the ecosystem? … I think, like most things it's somewhere in the middle, and I don't think you can go right out to the tails and the extremes of that debate.

Whether quantitative targets based solely on abundance and distribution are even appropriate at all was another thread in the conversation. DFO4 recalled that at the time that the Recovery Potential Assessment was being drafted, "there was a tremendous amount of reluctance [on the part of researchers] to say anything firm in terms of what [recovery] meant" because they felt that the definitions being offered by DFO for "recovery" were not necessarily scientifically defensible. DFO3, questioned whether "recovery is not feasible" was a scientifically valid statement given the fact that species can and do adapt to changing conditions. Debates about what "recovery" means for iBoF salmon appear to be ongoing among Recovery Team members, with PC1 calling the targets in the Recovery Strategy "fairly arbitrary," and DFO4 stating that the goal was not firmly defined. PC1 in particular pointed out that the current objectives do not account for any dynamics regarding captive-raised fish versus wild fish (e.g.differences in fitness related to the effects of domestication in hatchery-raised salmon, see Milot et al., 2013; Stich et al., 2015), and stated that "10,000 fish in a population where the fish are predominantly produced in captivity… I don't know about [the value of] that." DFO3 gave a different perspective on the problem with the current recovery targets, where

setting a numeric abundance target means losing the complexities of population dynamics that could make recovery approaches more flexible.

> **DFO3:** The problem, and I think it links back to the [Species At Risk] Act, is that we write recovery targets in terms of numbers of fish, but really viability is about the rates. The things that determine the number of fish are the carrying capacity and the vital rates such as fecundity, egg-to-smolt survival, or survival in the marine environment. Now you can have viable populations in a couple of ways: high freshwater survival but low marine survival, higher marine survival but lower freshwater productivity… So, defining recovery in terms of the number doesn't quite cut it …. So, write the recovery target in terms of survival, and if you can get to this survival, then you would expect to see population increase, and you can test whether you're there or not based on that response. But it would be a way to move forward quite a bit more quickly than saying "we have to get to this particular number."

AC1 highlighted the reason why the ongoing debate about what recovery means for iBoF salmon is a barrier to reassessing recovery feasibility: "until we agree on what [recovery] looks like or what that is… feasibility will always be up in the air and may never be truly achieved." If the current state of iBoF salmon after more than 20 years of recovery efforts is prompting DFO to re-evaluate the meaning of "recovery" for iBoF salmon, then the feasibility of achieving recovery must also be re-evaluated.

4.2.5.2 What is "Feasibility"?

In a written submission to this study, DFO staff explicitly identified "the absence of finalized guidance and/or criteria to assessing recovery feasibility" as a reason why a reassessment has not been completed. The fact that DFO describes this as a barrier, despite the existing guidance on the subject in the department's 2010 SARA Guidelines document, suggests that uncertainty about the definition and evaluation of recovery feasibility has grown and/or persisted since the publication of the Recovery Strategy. If Recovery Team members are operating from differing frames of reference when considering the feasibility of recovery, that diversity of opinions can act as a hindrance to

reassessment by generating unproductive debates around which definition is correct or intended.

Five participants (AC1, DFO1, DFO2, DFO3, DFO4) directly acknowledged how "the definition and evaluation of feasibility under the Act has evolved" since its enactment (DFO1), first being concerned primarily with biological factors such as presence of breeding individuals and habitat availability, then adding considerations about the need of human intervention for survival. Some of the evolution in thinking about feasibility was related to similar uncertainties around the definition of "recovery" for the species (section 4.2.5.1). AC1 called feasibility "an interesting word" because it depends so much on how recovery is defined for a given species, a perspective echoed by DFO2 and DFO3.

While a determination of recovery feasibility for a listed species explicitly excludes consideration of social, political, and economic factors, some interviewees (DFO1, DFO4) expressed the opinion that feasibility of recovery doesn't solely depend on biological or technical factors.

> **DFO4:** If the government says, "OK, we're going to continue with [recovery efforts], but we're gonna cut your budget by about 60%," then [recovery] would no longer be feasible, because technically it's no longer feasible. You see what I mean?

This statement touches on the fact that feasibility is commonly conceptualized as the quality of something being both possible and likely to occur (Oxford English Dictionary, 2024a). In excluding social, political, and economic factors from consideration, DFO and ECCC's guidelines are primarily concerned with whether recovery is biologically and technically possible for a given species, and not whether it is likely to occur given the socio-political landscape of the day. Considering political and economic factors in the way DFO4 did goes against these guidelines, but it does highlight some of the issues with how the determination of recovery feasibility interacts with challenges such as political opposition, conflicts of interest, and ministerial discretion (section 4.2.4). For DFO4, if no resources are available for iBoF salmon due to a political decision to reduce the budget for recovery efforts, then recovery is no longer feasible, even if biological and technical feasibility are present. DFO1 offered a complementary perspective on the topic

but made the difference between the "science perspective" of *whether recovery is possible* for the species, and the "public policy decision" of *whether or not to proceed* with recovery efforts.

> **DFO1:** I think one of the things I've always struggled with around recovery feasibility is, we very rarely end up in a situation where it's really cut and dry, like it's obvious we're in a no feasibility situation … There's a lot of gray area [with iBoF salmon] and … a decision on whether or not to proceed in terms of producing a Recovery Strategy or saying "well, it doesn't seem like there's much we can do here" … that's a decision that needs to be made by Canadians according to the consensus view of the day, right? It's a cultural decision, if you will, rather than a biological one in the end.

Other interviewees also used "feasibility" in ways that spoke to whether or not to continue recovery efforts, rather than to indicate whether recovery was possible. One example of this was brought up by PC1 when talking about the factors that influence whether to proceed with a novel management approach that promotes the presence of iBoF salmon in a freshwater ecosystem but may not immediately or obviously promote recovery. Under the guidelines used by DFO or ECCC, a management approach that does not directly lead to recovery would be deemed to not support technical feasibility, but in PC1's opinion it would contribute to technical feasibility because it would be "completely feasible money well spent," as the approach contributes to a healthier ecosystem that could eventually support self-sustaining salmon populations. On balance, there is a lack of agreement or common understanding among participants about what recovery feasibility means and whether social and economic considerations should come into play in its determination.

4.3 Enablers to Reassessing Recovery Feasibility

An enabler to reassessing recovery feasibility is any factor expressed in the interviews or written responses that either addressed one or more of the barriers identified in this study, or that promoted the reassessment of recovery feasibility in general for iBoF salmon. Many of the enablers described by the participants were directly or closely related to a barrier. Key enablers identified include 1) the value of reassessing feasibility;

2) the potential of the Recovery Team as a central organizing group for iBoF salmon; 3) better integration of information generated outside of DFO into decision processes; and 4) the development of new guidelines for assessing recovery feasibility.

4.3.1 The Value of Reassessing Recovery Feasibility

All interviewees I spoke with for this study felt that reassessing recovery feasibility was important for iBoF salmon. For many, such as DFO4, IN1, NGO1, and NGO3, recovery feasibility should be reassessed as a sort of "report card … to assess what's been done in the program, what's worked and what hasn't worked, and where they are with the initial objectives" (NGO3). While the 2021 Progress Report published by DFO accomplished this by looking at the implementation of the Recovery Strategy between 2010 and 2015, it was published six years after the period on which it reported. Compared to a fulsome assessment of the implementation of the Recovery Strategy, a reassessment of recovery feasibility could be done more quickly and "without a huge amount of expense" (DFO4), while still providing information on progress towards targets and implementation of programs. A reassessment of feasibility would also be a way to examine whether the targets remain relevant for iBoF salmon, clarify the changes in thinking about management approaches for the species since 2010, and provide a chance to apply what the Recovery Team has learned from its experience since the last feasibility assessment. This perspective was shared by DFO2, DFO3, NGO2, NGO3, and PROV1. DFO1 believed that "if there was a solid consensus among all the parties involved in the Recovery Team that it's time to evaluate feasibility on the next iteration of the Recovery Strategy, that question would be on the table during that evaluation." The importance that Recovery Team members place in reassessing recovery feasibility is thus in itself an enabler to actually conducting a reassessment, though it may not be enough without confirming the Recovery Team members' consensus and further promoting the team's role in iBoF salmon recovery planning.

4.3.2 Promoting the Recovery Team's Role as a Central Organizing Group

The Recovery Team involves many stakeholders and rights holders from various interest groups, representing perhaps the largest meeting table for Atlantic salmon in Eastern Canada. Despite the dysfunctions noted earlier in this chapter regarding its

structure and governance, nearly all respondents recognized the opportunity for the team to be a central hub to coordinate action for iBoF salmon. Several respondents within and outside of DFO noted the positive role that the Recovery Team has already played. The responses from 11 of the 12 interviewees show that the Recovery Team also presents opportunities for addressing barriers to reassessing feasibility, particularly those related to resource capacity, organizational culture, and governance.

Because the Recovery Team brings together governmental and non-governmental stakeholders and rights holders, it presents an opportunity to address financial and personnel capacity barriers by allowing the leveraging of resources. The latter could, for example, allow for more research to generate information to inform a reassessment of recovery feasibility by tapping into financial opportunities available to stakeholders and rights holders in the Recovery Team. NGO4 described such a situation wherein an Indigenous initiative leveraged funding for research on iBoF salmon.

> **NGO4:** One positive thing that happened was that the Indigenous population got interested in [iBoF salmon], and for some reason or other money was found. I take my hat off to them, but I do find that very interesting: a scientist for DFO couldn't get the work, couldn't get the money, but somebody else could. And if it wasn't for the Indigenous population working on the Petitcodiac, I think the thing would have fallen through. They are a very committed group of people, and, like, that key piece, they're doing a lot of work.

The involvement of the governments of New Brunswick and Nova Scotia in the Recovery Team could also provide opportunities to leverage resources in terms of personnel capacity. NGO1 pointed to the efforts of the state of Maine to conserve Atlantic salmon, where "a government that comes in, commits to recovery, and puts a bunch of money to it [winds up] bringing everybody else" into recovery efforts, and suggested a similar approach in Canada by letting Nova Scotia and New Brunswick "step up with some organizational or leadership capacity to get those boots in the water." He did acknowledge that factors such as the debt load of both provinces, as well as potential jurisdictional conflicts between the provinces and the federal government, were substantial challenges to implementing this approach.

One of the Recovery Team's potential roles in enabling recovery feasibility reassessment lies in the political pressure that an engaged and coordinated team could advocate for a reassessment. Every interviewee that I spoke with highlighted the fact that the people who are involved in iBoF salmon recovery planning are engaged participants. They used terms like "interest," "excitement," "commitment," and "passion" to describe both newer and older participants to the Recovery Team. While much of the engagement was spoken of in terms of enabling external stakeholders to conduct their own research or execute their own restoration activities, several participants highlighted how such engagement already had persuaded the federal government to formally list and protect iBoF salmon when DFO may have been reticent to do so. Both DFO1 and NGO3 acknowledged that "it's non-DFO that has really taken the lead" in iBoF salmon recovery. NGO1 underlined the support these groups provided for conserving the species.

> **NGO1:** I mean, you know, kudos to the Atlantic Salmon Federation, the Atlantic Salmon Conservation Foundation, the Nova Scotia Salmon Association, and all the rest of them. They really made it a political issue that the government just couldn't back out of.

If the Recovery Team managed to address barriers of communication and coordination that exist among its members (section 4.2.3), it could have the power to directly advocate for activities that are DFO's responsibility, like reassessing recovery feasibility. DFO1 believed that, even now, "engaged stakeholders and rights holders who are invested … would be surprised at the amount of influence they have in decision-making—not so much in the department or the bureaucracy, but within the political side of things." This enabler could serve as a check to DFO's reticence to reassess recovery feasibility for iBoF salmon (section 4.2.4.3) by creating political support for DFO to consider in its decision-making.

4.3.3 Better Integration of Information Produced External to DFO

With respect to enabling the uptake and use of information generated outside DFO scientific processes in assessing recovery feasibility, several interviewees (DFO1, DFO2, NGO4) noted that it was easier to access this information now than when the Recovery Strategy was initially being drafted. They each also noted that since that time,

academic groups, recreational anglers, and the aquaculture industry have felt more comfortable participating in iBoF salmon recovery activities and sharing their information and data with the Team as a result of "ongoing collaborations that have been fostered by the Recovery Team" (DFO1). DFO2 also emphasized the importance of fostering collaborations with external stakeholders and rights holders to combat feelings of mistrust or alienation that prevent the uptake of relevant and valuable information for recovery planning.

> **DFO2:** I remember when we first started having fishers come to our assessment meetings, and a lot of them would say, "Why am I here? I don't understand any of this." .... In one meeting where we couldn't get our model in, a fisher who had been involved for three of four years raised his hand and suggested what might be going on: we took it, worked away that night with his idea, and it worked. To me, that's the classic example: you build a foundation of trust and communication with people, so when you come up with these kind of roadblocks like we have on feasibility or assessment data, people feel comfortable speaking. It's an intimidating environment... so you need to form that basis of trust. To me, that's the whole solution to a lot of these problems that you see come up.

Strengthening the inclusion of external-to-DFO information was viewed as a direct enabler for assessing recovery feasibility (DFO1, AC1, PROV1). TEK can provide a longer-term perspective than is currently available in DFO's scientific knowledge and directly help inform recovery goals by providing fuller contextual information about what a population looked like in the past (DFO1). A fuller understanding can then help set a frame of reference for recovery targets against which both biological and technical feasibility can be assessed. LEK, such as from anglers who recreationally fish in iBoF rivers, can provide information on changes happening in the ecosystem much more quickly than is typically obtained through western-scientific research approaches (PROV1), improving the Recovery Team's ability to gauge any changes to the biological feasibility of recovery for the species.

Improving the uptake of external information can also build and strengthen collaborations between Recovery Team members, providing opportunities for developing new management approaches and improving the technical feasibility of recovery. The

Fundy Salmon Recovery (FSR) program is an example, which is a product of collaboration between the federal government, the province of New Brunswick, Fort Folly First Nation, the University of New Brunswick, and the aquaculture industry. The initial impetus for this project was findings by Clarke et al. (2016) that early exposure to the wild improved the size-at-age and offspring viability of Atlantic salmon raised in captivity. Parks Canada then collaborated with Cooke Aquaculture and the Atlantic Canada Fish Farmers Association (ACFFA), who shared their knowledge of the technical aspects of raising salmon in conditions that maximized wild exposure. The FSR program was successfully implemented by Parks Canada in Fundy National Park, and by Fort Folly First Nation in the Petitcodiac River. As highlighted in section 4.2.3.1, many interviewees expressed excitement about the program, with PC1 noting promising results in terms of adult returns to Fundy National Park. The development and implementation of the FSR program is a clear illustration of how better pathways for non-DFO information into recovery planning efforts create opportunities for new management approaches, which then feeds into supporting a reassessment of the technical feasibility of recovery for iBoF salmon.

4.3.4 Clarifying Recovery Feasibility and its Assessment

To assess recovery feasibility, it is important to be clear about what that term means, as well as implement a comprehensive and transparent process through which such an assessment can be completed. To that end, the publication of a new Policy on Survival and Recovery by ECCC created an opportunity for DFO to review its own guidelines on the topic and better tailor the process for endangered aquatic species. DFO staff acknowledged this opportunity in their written response, stating it "would enable a more focused approach for interpreting concepts of recovery, recovery feasibility, and survival, thereby promoting a more robust operationalization of information in the context of determining whether recovery is feasible for a species at risk, including iBoF Atlantic Salmon, and setting appropriate population and distribution objectives." Unsurprisingly, most DFO stakeholders agreed with this idea. DFO1, DFO2, and DFO4 all noted that the policy provides a more focused definition of recovery, survival, and feasibility that could guide the reassessment of iBoF salmon's recovery feasibility. While

most interviewees who were familiar with recovery feasibility and its assessment agreed that the process needs greater clarity, IN1 and NGO1 were more critical in their assessment of whether DFO's implementation of the ECCC policy would accomplish this goal, particularly because DFO and ECCC policies change often.

> **NGO1:** I've got in my office probably four or five feet of binders of DFO and Environment Canada policy on species at risk. Half of it is stuff in draft or stuff that was produced and then eight or 10 years later, all of a sudden, here's another policy talking about the same thing, but called something different. Well, is that old policy gone now? I don't know. And so, it's kind of at this point, for me anyways, that I don't put a whole lot of stock in the policies because they change so much.

One benefit of introducing a new policy was highlighted by DFO1 and DFO2 as it could start "focused discussion" around feasibility and its evaluation. Given that the reassessment of feasibility for iBoF salmon, initially slated for five years after the publication of the Recovery Strategy, is now overdue by nearly a decade, the explicit acknowledgement of the new policy by DFO as well as the department's plan to operationalize it is a welcome perspective.

4.4 Discussion and Conclusion

This component of my research explored the perspectives of Recovery Team members about the factors that prevented a reassessment of iBoF salmon's recovery feasibility from being implemented after 2010, as well as factors that could enable such a reassessment. Barriers to reassessment expressed by Recovery Team members included a lack of actionable information to conduct a reassessment of feasibility, a lack of capacity or resources to undertake a reassessment, challenges related to organizational structure and culture within the Recovery Team, declining interest from the regulatory authority to reassess feasibility, and conceptual problems relating to how "recovery feasibility" is defined under SARA. While responses from interviewees often focused on specific challenges based on their experience with the Recovery Team, all acknowledged that many interrelated factors hinder the reassessment of recovery feasibility.

Similarly, the enablers identified by interviewees were often directly related to the challenges they had experienced. Where DFO's intentions towards iBoF salmon and reassessing recovery feasibility were perceived as unclear, Recovery Team members all supported reassessing feasibility as part of good management of iBoF salmon. They also identified the Recovery Team itself as an enabler despite its shortcomings, both in terms of leveraging resources among its members and acting as a unified front representing the interests of endangered iBoF salmon. Where there is a dearth of information produced by DFO research, interviewees pointed to strengthening the inclusion of non-DFO information to gain a historical perspective of iBoF salmon and rapidly detect changes in the marine and freshwater environments. Finally, the development of new guidelines for determining recovery feasibility, based on ECCC's Policy on Survival and Recovery, would ensure that reassessment of recovery feasibility is not slowed by unclear or discretionary language.

4.4.1 Key Findings

Many of the barriers identified by the Recovery Team members were resource limitations related to finances or personnel to either generate information or conduct a reassessment of feasibility. Financial and personnel limitations were especially common in the interview responses, both in terms of completing the actual reassessment as well as conducting research necessary to obtain more information for the reassessment. Resource limitations, particularly those relating to finances or personnel capacity, are acknowledged in several studies as barriers to reassessment and adaptive management processes in conservation, especially for conservation problems that are biologically, technically, and/or politically complex (Allen & Gunderson, 2011; Jacobson et al., 2006; Månsson et al., 2023; McIntosh, 2019). It is not surprising that the same limitations also arise for iBoF salmon recovery planning, given its own complexity. The population's historical distribution spans the provinces of Nova Scotia and New Brunswick, migrating between freshwater and saltwater environments. Inner Bay of Fundy salmon are at such a low level of abundance that the population depends on intensive breeding and stocking through the LGB program to simply forestall its extinction (DFO, 2010b, 2021). This program is managed by two federal government departments, and dozens of stakeholder

and rights holder groups are involved in recovery activities for the species. Each of these factors adds a layer of difficulty to recovery planning efforts for iBoF salmon, including any attempts to assess progress towards recovery and update understanding of recovery feasibility.

An obvious enabler for reassessing recovery feasibility would be to devote more time, money, and personnel to research and evaluation efforts for the species. The level of attention and funding given to a particular conservation problem often depends on social, political, or cultural factors (Adamo et al., 2022; Krebs, 2024; Wiedenfeld et al., 2021). In the case of iBoF salmon, the social and cultural value of Atlantic salmon in the Maritimes drove much of the initial push for iBoF salmon recovery efforts, but the diminishing number of volunteer groups working on rivers, as well as perceived disengagement on the part of DFO, have resulted in budget cuts and loss of professional and technical capacity for recovery efforts. Several enablers named by interviewees specifically addressed the role that the Recovery Team could take to address these social and political factors in order to improve access to financial and capacity resources for research on iBoF salmon, which would in turn help support a reassessment of recovery feasibility.

According to the SARA, DFO, and ECCC guidelines, a determination of recovery feasibility for an endangered species should utilize "the best available information" on the subject (DFO, 2010a; ECCC, 2021; SARA, 2002). However, individuals and organizations often disagree on what types of information count as the "best available" for management decisions, based on their own judgments about the credibility, relevance, and legitimacy of information available to them (MacDonald et al., 2016b). There is substantial evidence that practical management actions in conservation are often informed primarily by tradition, personal experience, or expert opinions from sources that managers trust (Pullin et al., 2004; Soomai, 2017b). DFO has historically placed great emphasis on utilizing scientific information for managing fisheries and endangered species. The department has shown a particular preference for scientific information that DFO itself generated, as that information is generated through established processes and is tailored to specific questions asked by managers; thus, DFO considers that information

particularly credible, relevant, and legitimate for use in its decision-making (Hart, 2018; Soomai, 2017a).

In the present study, the interviewees indicated that scientific information generated by DFO was the primary type of information used to determine recovery feasibility; however, the interviewees also acknowledged that the body of scientific knowledge generated by DFO research was incomplete and had not expanded substantially since 2010. The inclusion of scientific information external to DFO was seen as an enabler to reassessing recovery feasibility as it could fill existing knowledge gaps about iBoF salmon and threats to its recovery, as well as support further collaboration with external groups to support monitoring and evaluation efforts. However, many Recovery Team members pointed out that there were challenges involved in incorporating external scientific information due to concerns from DFO about that information's credibility, relevance, or legitimacy. Improving the collaboration between the federal government and academic or non-governmental organizations could not only improve DFO's ability to incorporate external-to-DFO scientific information, but also potentially improve the feasibility of recovering iBoF salmon. The FSR program is one such example of a collaboration that started from the uptake of scientific information generated by the University of New Brunswick, and eventually led to the implementation of a new technical approach to support recovery for iBoF salmon (Maysonet & Murphy, 2021).

Other forms of information external to DFO that could support the reassessment of recovery feasibility for iBoF salmon include TEK and LEK. Both TEK and LEK have been acknowledged as having key roles to play in better informing management decisions and strengthening the stewardship of aquatic resources (Dawe, 2010; Hill et al., 2019). However, responses from some interviewees suggested that these forms of knowledge, particularly TEK, needed to be "made to fit" the scientific frameworks being used by DFO. Statements like these frame the process of utilizing Indigenous knowledge in a way that aims to assimilate it into the body of western scientific knowledge, a problematic notion that can further alienate stakeholders and rights-holders involved in conservation and management of natural resources (Battiste, 2005; Reid et al., 2021). The Maritime Aboriginal Peoples Council (MAPC) previously raised concerns about the potential for

misappropriation of Indigenous knowledge by federal agencies collecting information for the iBoF salmon COSEWIC status report (Maritime Aboriginal Peoples Council, 2014). These concerns led to disengagement from the consultation process by several Indigenous organizations and resulted in no Indigenous knowledge being provided for the status report.

One approach that DFO could utilize to better include TEK and LEK into management decisions is the Two-Eyed Seeing framework that explicitly emphasizes harnessing the strengths of both Indigenous and western worldviews and ways of knowing for the benefit of all (Bartlett et al., 2012; Denny & Fanning, 2016). A "collaborative co-existence" approach for Atlantic salmon governance in Nova Scotia centered on co-management and Two-Eyed Seeing has already been proposed in a previous study, which points to the potential value such an approach could have for iBoF salmon management as well (Denny & Fanning, 2016).

All members of the Recovery Team I interviewed believed that reassessing the feasibility of recovering iBoF salmon was important. The interviewees in management roles or who were part of industry groups tended to view the role of reassessment as a way to account for the funds, time, and effort directed towards the recovery of iBoF salmon. Those in research roles, or who were members of NGOs, saw reassessment as a way to check on progress towards recovery targets and an opportunity to apply a form of adaptive management to recovery efforts. Starting a reassessment recovery feasibility for iBoF salmon would be much more difficult if both DFO and the Recovery Team were uninterested. However, the desire to undertake a reassessment of recovery feasibility did not actually lead the Recovery Team to complete one, nor has it been enough to secure the information and resources required to undertake one. Part of the reason for this state is due to the current organizational culture of the Recovery Team, which appears to place a greater emphasis on monitoring and reporting on current approaches and efforts than examining whether a change in approach is needed for iBoF salmon. Several interviewees used the metaphor of a vehicle "spinning its wheels" when describing the current operation of the Recovery Team. Addressing these organizational shortcomings may be informed by looking to the beginnings of the iBoF salmon recovery program, which many interviewees characterized as guided by decisive leadership from key

individuals, a high degree of collaboration among stakeholders, and a more reciprocal relationship between the regulatory authority of DFO and the Recovery Team.

Social, economic, and political factors were not considered in the actual determination of the recovery feasibility for iBoF salmon. However, they appear to have played a substantial role in hindering the reassessment of feasibility for the species by affecting the Recovery Team's ability to generate or collect information and directly interfering with the team's ability to pursue reassessment. Similar to the results of other studies about SARA listed species, political factors or ministerial discretion were found to have hindered recovery planning for iBoF salmon (Hutchings, Côté, et al., 2012; Hutchings et al., 2016; Mooers et al., 2010; Turcotte et al., 2021). The enablers found to address issues of governance identified in those studies were broadly related to addressing the unclear or discretionary language used in SARA and associated policy documents. Such enablers include restructuring the recovery planning process so "unbiased scientific effort develops strategies or plans followed by clear government responses" (Hutchings et al., 2016), establishing statutory deadlines for recovery planning documents, or removing discretionary language in the text of SARA (Turcotte et al., 2021). In the present study, clarification of the definitions and the process used in determining recovery feasibility falls within this category of enablers. This clarification process is already underway according to the written submission by DFO staff in this study. However, clearer policy is only the first step towards resolving deeper issues identified in this study related to DFO's relationship with the iBoF salmon Recovery Team and SARA as a whole. The federal department must renew its commitment to iBoF salmon, even in the face of the complexity of its management and the potential conflicts between recovering the species and promoting industrial activities (Hutchings, Côté, et al., 2012).

4.4.2 Conclusion

Reassessment of recovery feasibility for iBoF salmon was initially planned to occur every five years after the publication of the Recovery Strategy, consistent with SARA provisions (SARA, 2002 Section 46). However, no such reassessment has taken place, even as of August 2024. Recovery Team members interviewed for this study

identified a variety of barriers to reassessing recovery feasibility. Two major categories are logistical in nature: little to no new information that could inform a reassessment of feasibility, and a lack of financial resources and personnel to conduct research to support reassessment. The organizational culture of the Recovery Team was another important barrier. Siloing between managers, scientists, and non-DFO stakeholders has limited knowledge exchange that would support reassessment, and current meetings appear to emphasize reviewing current projects at the expense of planning for the future of iBoF salmon management. This situation is compounded by a perceived reticence by DFO to reassess recovery feasibility, either because of potentially conflicting mandates between endangered species management and economic activities such as aquaculture development, or because of a more general disengagement from SARA by DFO.

Despite these challenges, members of the Team continue to support iBoF salmon recovery efforts, including the reassessment of recovery feasibility. As one of the largest multi-stakeholder groups involved in the management and conservation of Atlantic salmon, the Recovery Team is uniquely positioned to address these barriers. Member organizations can coordinate with one another to leverage resources, promote research and monitoring activities for iBoF salmon, and aid in the uptake of information that could be used in reassessing feasibility. The publication of the Policy on Survival and Recovery (ECCC, 2021), as well as the use of the policy by DFO as a model for developing its own guidance for endangered aquatic species, are examples of each department's efforts to establish clearer definitions for "recovery" and "feasibility" and clarify the process of determining recovery feasibility for species listed under the Act. While doubts remain about whether the current targets and objectives of the iBoF salmon recovery program are still attainable or appropriate, the aforementioned factors may enable a reassessment of feasibility that would help guide recovery efforts for this critically endangered species.

Chapter 5: Discussion and Conclusion

5.1 Overview of Findings

This study explored the determination of recovery feasibility for inner Bay of Fundy Atlantic salmon through an exploratory approach focusing on the perspectives found in documents produced by the recovery planning process as well as perspectives elicited from members of the iBoF salmon Recovery Team. Through this approach, this research expanded the existing analysis of iBoF salmon recovery efforts thus far, as well as the broader discussion on the efficacy of the Species At Risk Act. Other studies have examined the factors that have shaped the results of determinations of recovery feasibility under the Act in general (Brassard, 2014; Khair et al., 2017). However, little work has examined either how recovery feasibility was determined for a single species, or the factors that influence whether recovery feasibility is reassessed for a listed species. The present study was centered on two research questions: whether and how recovery planning documents and Recovery Team members' perspectives on recovery feasibility of iBoF salmon have changed since the 2010 Recovery Strategy (Chapter 3), and what barriers and enablers Recovery Team members experienced or thought were most relevant to reassessing recovery feasibility for iBoF salmon (Chapter 4).

In response to the first question, I found that the perspectives embedded in recovery planning documents and expressed by Recovery Team members in their interviews about the feasibility of recovering iBoF salmon tended to be more negative in 2023 than in 2010. Explicit statements about recovery feasibility in the recovery planning documents did not change between 2010 and 2023. However, the documents published between 2018 and 2021 acknowledged the lack of progress towards recovery targets and the continued uncertainty about threats to iBoF salmon, which indirectly conveyed a more negative view of recovery feasibility. The interviewee responses were more variable, both in terms of direct statements about recovery feasibility for iBoF salmon and the reasons their perspectives had changed since 2010. A majority of the interviewees expressed their belief that recovery was less feasible in 2023—though not completely unfeasible—for iBoF salmon than in 2010, and none felt that recovery was now more feasible for the species. The reasons for their change in perspective included doubt about

the species' ability to reach the abundance, distribution, and self-sustainability targets set out in the Recovery Strategy; concerns about ecological changes such as habitat loss and Allee effects in the population; lack of meaningful progress towards understanding and mitigating threats to the species; concern that current technical approaches are geared towards maintaining survival instead of promoting recovery; and political and economic factors preventing the implementation of recovery efforts for iBoF salmon. While discussions within the Recovery Team are growing about whether it is possible to achieve the targets set out in the Recovery Strategy, the most recent documents demonstrate a cautionary approach by maintaining the determination that recovery remains feasible for iBoF salmon.

For the second research question, I found five categories of barriers to reassessing recovery feasibility and four categories of enablers experienced by Recovery Team members since 2010. Barriers included a lack of new information that would help to inform an updated assessment of recovery feasibility; a lack of resources to carry out research and conduct a reassessment of feasibility; challenges related to the organizational structure and culture of the Recovery Team; challenges stemming from DFO as the regulatory authority for iBoF salmon; and conceptual barriers related to how the Recovery Team interpreted the definition of "feasibility of recovery." Enablers to reassessment included the substantial value placed by Recovery Team members on reassessing feasibility; the Recovery Team's ability to build resource capacities and apply political pressure for reassessment; opportunities to better integrate information from non-DFO sources into decision processes; and initiatives to enhance understanding of recovery feasibility and its assessment. Many of the barriers and enablers were interrelated, and while the interviewees often focused on one or two challenges based on their own experience, none attributed the lack of reassessment to a single cause.

5.2 Key Findings

5.2.1 Recovery Feasibility Remains Uncertain at Many Levels

Uncertainty was a substantial through-line among the perspectives explored in the present study and manifested in a variety of ways. Perspectives embedded in recovery planning documents and expressed by the interviewees often invoked substantive

uncertainty about iBoF salmon's status, the threats that it faces, the ways its habitats and environment would change in the future, and the solutions that would best support its recovery. From my analysis of the perspectives concerning the current feasibility of recovering iBoF salmon, as well as the perceived barriers that prevented a reassessment of feasibility from taking place, uncertainty about the nature of the problems the species faces is perhaps the most prominent among recovery planning documents and interviewees. Part of the reason is that the process of determining recovery feasibility relies primarily on scientific information relating to biological and technical factors. The opinions expressed in responses to the questions I posed in the present study would thus more readily highlight any uncertainties that exist in the problem dimensions (status, present and future threats, and management approaches). The fact that so little progress appears to have been made towards understanding iBoF salmon's situation is a major challenge impeding recovering iBoF salmon in general and understanding the feasibility of recovery for the species in particular.

Another object of uncertainty that emerged from the analysis was strategic, relating to choices made by actors in the governance process (Dewulf & Biesbroek, 2018). I observed this perspective primarily in how interviewees characterized the interactions between different organizations in the Recovery Team. In particular, representatives from non-DFO organizations often expressed uncertainty about DFO's intentions for iBoF salmon recovery planning since 2010. Some interviewees related their uncertainty about DFO to an opinion of broader disengagement by the federal government from SARA, a perspective reported in other studies and voiced by other individuals involved in research on SARA (Mooers et al., 2017; Turcotte et al., 2021). While the determination of recovery feasibility under SARA does not in itself relate to political, economic, or social factors that could hinder efforts to recover a species at risk, these factors do play an important role in understanding how recovery planning succeeds or fails for a species at risk and were highlighted by several participants in this study as impacting the likelihood of recovery.

Institutional uncertainty—relating to "the rules of the game" that apply in decision-making (Dewulf & Biesbroek, 2018)—was also prevalent in the results. This form of uncertainty manifested itself in terms of how the Recovery Team and DFO each

interpreted their roles in iBoF salmon recovery planning, as well as uncertainty about the functioning of the process for determining feasibility. For example, different interviewees had markedly dissimilar opinions about the role of the Recovery Team in starting the process of reassessing feasibility. Some believed that the Recovery Team had a substantial and direct role to play in initiating the process, while others categorically placed the responsibility with the regulatory authority. Another example was the conflict that occurred in the mid-2010s between some Recovery Team members and the then-chair of the team about considering proposed aquaculture developments and their potential impact on iBoF salmon recovery. Here, the uncertainty was latent, i.e., each side had their own interpretation of their role in iBoF salmon recovery planning, and the uncertainty manifested itself in the ensuing conflict. DFO appeared to employ a "go-alone" strategy to deal with this institutional uncertainty, invoking its role as the regulatory authority to enforce its own interpretation of the rules that were to be followed. The interviewees described the fallout from this conflict as a clear example of how institutional uncertainty can damage conservation efforts by alienating stakeholders.

The substantial and multifaceted uncertainty in the iBoF salmon recovery program must be addressed in order to improve the program's functioning and support recovery for this critically endangered population.

5.2.2 Dynamics of the Recovery Feasibility Science-Policy Interface

From my analysis of policy documents as well as interviews with Recovery Team members, I identified a number of challenges in the recovery feasibility determination process for iBoF salmon related to issues at the science-policy interface. One example of this was the perception from some interviewees that DFO sets priorities based on information generated from its own research and monitoring processes in its decision making, at the expense of other potentially useful sources of information. Other studies have noted the department's emphasis on using information that it generates itself for fisheries management and in the process of listing iBoF salmon as a species at risk (Hart, 2018; Soomai, 2017a; VanderZwaag et al., 2011).

Based on the perspectives and experiences of the Recovery Team members I interviewed, the priority given to DFO-generated information in iBoF salmon recovery

planning is likely due to similar attitudinal or cultural factors observed in other fisheries management processes in the department, though the interviewees disagreed on which factors were most important. A subset believed that managers were not utilizing particular types of information due to their own biases about the quality or appropriateness of that information, or because of pressure from other stakeholders, such as the aquaculture industry, to disregard certain types of information. Other interviewees pointed out that the information needed to support iBoF salmon recovery efforts far outweighed the resources available to conduct the research to obtain it. They also spoke of the struggle to balance the various information needs and research priorities held within the Recovery Team as a result. As the number of actors and parties involved in a given conservation initiative increases, so does the complexity of the interactions between them, and the sense of accountability that decision-makers may feel about which information to use (Jacobson et al., 2006). This situation can push managers and decision-makers to prioritize information production pathways that they are already familiar with, inadvertently discouraging the uptake of unfamiliar or "risky" information (Cook et al., 2010; Flye et al., 2021). In the case of iBoF salmon, it appears that both active prioritization of information from known processes, and inadvertent discouragement of outside information, have occurred.

Another substantial barrier to information use in iBoF salmon recovery planning was due to organizational inefficiencies, with many interviewees stating that there was either not enough time for or emphasis on doing work that would contribute to reassessing recovery feasibility. Highlighting the Recovery Team's role as a potential "boundary organization" (MacDonald et al., 2016b) could help address these inefficiencies, and in turn enable a reassessment of recovery feasibility. Boundary organizations work at a science-policy interface by facilitating interactions between producers and users of information which can improve the actors' perceptions of the credibility, salience, and legitimacy of various forms of information involved at that interface (MacDonald et al., 2016b). While several interviewees indicated that the Recovery Team had fallen short of its potential to foster larger collaborations among its members, they also expressed the view that the Recovery Team could be empowered to play a stronger facilitation role due to its long-standing history and the existing

relationships that have been developed within it, consistent with the role of a boundary organization.

5.2.3"Recovery" and "Feasibility" as Panchrestons

In my conversations with Recovery Team members, I heard several differing interpretations of "recovery" and "feasibility" in the context of iBoF salmon. The definitions of both terms were established by DFO in its 2009 guidelines to SARA terms (DFO, 2010a), and by ECCC in its 2021 policy on survival and recovery (ECCC, 2021), yet several interviewees spoke of these terms in ways that differed from these definitions. For example, whereas many DFO interviewees defined "recovery" for iBoF salmon as achieving a state where the population could sustain itself without intensive human intervention through the LGB program, other interviewees questioned whether recovery had to include self-sustainability at all. In this case, the diverging opinions appear to come from the intersection between the ideal end goal for iBoF salmon as defined by DFO, the level of improvement in abundance and distribution that Recovery Team members perceive is possible under the current circumstances, and the value that Recovery Team members place on salmon being present in the ecosystem. If self-sustainability is impossible to achieve for iBoF salmon, but its presence in the ecosystem can be maintained through intensive intervention, that may count as "recovery" for some individuals.

The concepts of "recovery" or "recovered state" have been noted to be poorly defined in academic literature and legislation (Westwood et al., 2014), though most definitions do highlight the difference between "conservation," which involves human intervention of some kind, and "recovery," which implies that a species is no longer at risk of extinction without this intervention (Neel et al., 2012). Many recent studies suggest that focusing on simple viability and eliminating extinction risk is insufficient to achieve recovery, and that the species' function in the ecosystem should also be taken into account when setting recovery objectives (Akçakaya et al., 2020; Westwood et al., 2014; Wolf et al., 2015). Diverging perspectives on what constitutes recovery makes it more difficult for Recovery Teams to coordinate research or management efforts, as

different definitions often result in different objectives for recovery planning efforts, and different determinations of whether recovery is feasible or not.

Diverging interpretations often arose around the definition of "feasibility," as well. When interviewing participants, I defined and used "feasible" in terms of whether recovery was possible for iBoF salmon given the biological state of the species (abundance, habitat availability, productivity, etc.) as well as the technologies and management approaches at our disposal. This definition follows from the text of SARA and policies published by DFO and ECCC, which stress that only biological and technical factors, not economic or political, should be accounted for when determining recovery feasibility (Table 3.1). However, many Recovery Team members did consider the economic, social, cultural, and political landscape surrounding iBoF salmon, DFO, and SARA in general in their opinions on the likelihood of achieving recovery for the species. The DFO and ECCC guidelines, as well as SARA itself, intend for questions of political and economic feasibility to be addressed in later steps of recovery planning. If feasibility is reassessed for iBoF salmon in the future, Recovery Team members would need to ensure that they follow the guidelines established by DFO and consider only biological and technical factors in their overall assessment.

The multiple definitions used by the interviewees for "recovery" and "feasibility" could be considered a "panchreston problem." A panchreston is defined as "an explanation or theory which can be made to fit all cases, being used in such a variety of ways as to become meaningless" (Oxford English Dictionary, 2024b). Both terms exhibit characteristics of a panchreston, as they are used in inconsistent or overly broad ways both within and outside of SARA. Panchreston problems hamper efforts to understand and address conservation issues due to unclear terminology or competing definitions and can contribute to unproductive debates among groups and individuals working on these issues (Lindenmayer & Fischer, 2007). In the context of the present study, the inconsistent definitions of key terms such as "recovery" and "feasibility" used by Recovery Team members may directly affect the ability to undertake a reassessment of feasibility, since there is a level of confusion about these fundamental terms. It may also contribute to alienating governmental and non-governmental stakeholders and rights-holders who are perceived to be using "incorrect" definitions, in a similar vein to the

alienation that occurs due to the use of technical language or jargon, as identified by Suzuette Soomai (2017a).

5.2.4 Complexity: iBoF Salmon as a "Wicked" Conservation Problem

Based on the perspectives uncovered in this study about the feasibility of recovering iBoF salmon as well as the barriers to reassessing recovery feasibility, the conservation and recovery of this critically endangered species exhibits many hallmarks of a wicked problem. "Wicked problems" are characterized by complexity and interdependency in their components, uncertainty of risks and unintended consequences, divergence in values and decision-making power of multiple stakeholders, mismatches in spatial and temporal scales of ecological and administrative processes, and the need for different disciplinary approaches to find solutions (DeFries & Nagendra, 2017). The complexity of iBoF salmon recovery comes from the species' migratory life history, the multiple jurisdictions that its habitats occupy, and the involvement of dozens of stakeholders and rights holders in its management. Uncertainty is rife within the characterization of the iBoF salmon problem, particularly regarding the threats it faces in the marine environment. Several barriers to reassessing the feasibility of recovering iBoF salmon arise from diverging values and unequal decision-making power among Recovery Team members, and even within DFO as the management authority for the species. Several interviewees noted that iBoF salmon recovery requires more time and effort invested than the current administration appears to be willing to consider and allocate, demonstrating a mismatch between ecological and administrative objectives and processes. The diversity of perspectives in the findings, especially with the factors that interviewees viewed as most responsible for preventing the reassessment of recovery feasibility, showcases how solutions for wicked problems are subject to multiple interpretations.

Many interviewees who were familiar with the process of determining recovery feasibility in SARA drew a link between that process and adaptive management in general. Adaptive management in conservation is variously defined in the scientific literature, but most definitions emphasize that it goes beyond the simple presence of adaptability or experimentation in management approaches (Allen & Gunderson, 2011;

Kingsford et al., 2017). Adaptive management is a looped, stepwise process of learning and adaptation that uses structured decision-making to reach management goals, and it includes governance, planning, implementation of decisions, and monitoring and evaluation of subsequent outcomes (Kingsford et al., 2017; Månsson et al., 2023). Regularly reassessing recovery feasibility can be a component of a broader adaptive management approach by providing opportunities to evaluate the performance of current recovery approaches and consider alternatives.

In the case of iBoF salmon, the lack of progress towards the abundance and distribution targets in the Recovery Strategy, despite 20 years of management efforts, may indicate that current approaches are not working at all to promote recovery. By conducting a fulsome reassessment of recovery feasibility, the iBoF recovery program could evaluate the successes and failures of the current methods being used and explore other technologies and approaches for managing and eventually recovering the species. Another component of the iBoF salmon recovery efforts, the LGB program, was initially and explicitly set up as an adaptive process, primarily in terms of fine-tuning technical aspects of the program such as the selection of breeding adults and locations of juvenile and adult releases for supplementation. Unfortunately, the fact that some components of the LGB program were designed to be adaptive does not mean that adaptive management was applied to recovery planning for iBoF salmon. Organizational inefficiencies and apparent reticence from DFO to fully commit to supporting the recovery program hinder movement towards more adaptive approaches for managing iBoF salmon, including regular assessments of recovery feasibility.

This situation reflects the conclusions offered by Allen and Gunderson (2011) regarding the difficulty of implementing adaptive management to wicked conservation problems. While adaptive management is often touted as a solution for making progress on wicked conservation problems, it requires time, and openness from managers, to consider and/or experiment with multiple alternatives. This makes it ill-suited for conservation problems constrained by entrenched management, engineering, economic, and social systems. The ensemble of barriers expressed by Recovery Team members, as well as the intrinsic qualities of the iBoF salmon conservation problem, effectively demonstrate how such constraints prevent adaptive management from taking place in a

wicked conservation problem, even when some of its components are designed with adaptiveness in mind. However, the fact that the process of determining recovery feasibility is explicitly stated in the text of SARA as a requirement for completing a Recovery Strategy, and the existence of multiple policies providing definitions and guidelines for the process shows that there is an institutional basis for adopting adaptive approaches in recovery planning. In that sense, the very presence of recovery feasibility as a concept in SARA is itself an enabler to approaches that better support recovery for species at risk.

5.3 Current Limitations and Future Applications

5.3.1 Study Limitations

This research is centered on the case of inner Bay of Fundy Atlantic salmon, and specifically on recovery feasibility and its evaluation for the species, in part for practical reasons surrounding time limitations and research design. The perspectives uncovered from documents and expressed by the interviewees are constrained by the study population, comprised of the conservation experts and key knowledge holders on the iBoF salmon Recovery Team. Because of these specific delimitations of the study, its results are not necessarily broadly generalizable to other cases or processes undertaken under SARA. Regardless, I have observed commonalities between the perspectives uncovered in this study and findings from research on other aspects of SARA such as listing and broader recovery planning processes, as outlined in the discussion above, which lends confidence to this study's results.

The purposive sampling approach I used for this study was intended to recruit participants from the Recovery Team with knowledge about recovery feasibility assessment under SARA, or who had a part in drafting or providing feedback to the initial determination of feasibility published in the Recovery Strategy. While these criteria were appropriate for the purpose of this thesis, it is also possible that they limited the participation of members of the Recovery Team with unique insights or perspectives on the subject. Additionally, while the proportion of different organizations in my sample were similar to those in the Recovery Team, industry groups and provincial government organizations were represented by one individual each. There was also no representation

of certain key stakeholder groups, including any members of an aquaculture organization. Data saturation was reached for DFO and NGOs but may have been lacking for the underrepresented groups. These limitations are important to note when interpreting the results of this study.

The present study was adapted from its original research design to utilize a remote interview format in response to restrictions on travel and gatherings imposed by the federal and provincial governments of Canada during the COVID-19 pandemic (Cornejo et al., 2023; Keen et al., 2022) between 2020 and 2022, which had a variety of impacts. On one hand, the remote format of the interviews gave both the interviewees and me some flexibility in how they were conducted. Participants could choose to be contacted by telephone or video conferencing software based on their level of comfort with each form of communication, as well as participate in a single, longer interview or two shorter interviews. The flexibility and accessibility that participants and I experienced was similar to other researchers' experience with qualitative data collection methods adapted for the realities of the COVID-19 pandemic (Keen et al., 2022). However, remote interviews may also have affected the data collection and results by introducing implicit and unconscious biases (Falter et al., 2022). A remote interview over video conferencing software, for instance, allowed for both a participant and me to see one another in conversation and respond to visual cues as our conversation progressed, whereas a telephone interview lacked any form of visual context, which could lead to misinterpretation of questions or answers from me or an interviewee.

At the start of this study, only semi-structured interviews were included as a data collection method from participants. Partway through the recruitment process, I modified the research design to include written responses from organizations as a data collection method. This change was made in response to a request by potential interviewees from DFO and was approved by Dalhousie University's Research Ethics Board. There are limitations associated with the introduction of a novel data collection method during the study. For instance, because the written questionnaire was based on the interview guide, the questions may not have been optimally designed to elicit perspectives on recovery feasibility in a written format. The context in which these written responses were crafted is also different from those elicited during an interview; this factor is discussed in

Chapter 2 but is important to keep in mind when considering results that rely on comparing perspectives produced by these two different methods.

One important limitation to discuss about any study that relies on qualitative research methods is the approach of the person conducting the research. My own academic and research background is primarily based in quantitative methodologies, and I was inexperienced with designing and conducting qualitative research in general. While I sought to be reflexive in my approaches and eliminate my personal biases from the thematic analysis, the results provided herein are products of my own interpretation of the perspectives I discovered in recovery planning documents and heard from interviewees.

5.3.2 Future Research

The present study was designed to be exploratory. Thus, several potential avenues for future research may build upon the findings. These include engaging with a wider diversity of perspectives, whether by recruiting a larger sample of Recovery Team members or engaging with individuals or groups outside of the Recovery Team, such as local Indigenous and non-Indigenous communities, anglers, aquaculture professionals, conservationists, and others involved in Atlantic salmon management in Atlantic Canada. Future research could also focus on one or a subset of related themes explored in the present study, perhaps exploring the relationships between DFO and Recovery Teams for other species at risk.

Many SARA processes, including the determination of recovery feasibility, rely on the uptake, sharing, and dissemination of information among stakeholder groups involved in recovery planning. The present study identified several points in the determination of recovery feasibility where information flow was enabled or restricted. More research is needed to develop a more detailed understanding of the factors that contribute to the movement and pathways of information (or lack thereof) in recovery planning processes for iBoF salmon in particular, or other aquatic species listed under SARA, as well as explore ways to address barriers to information flow (MacDonald et al., 2016a; Malmer et al., 2020; T. Moon et al., 2020; Olson & Pinto Da Silva, 2019).

As stated in the 2021 Progress Report, DFO is in the process of drafting an updated Recovery Strategy for iBoF salmon. An updated Recovery Strategy is likely to

include a reassessment of recovery feasibility. Future research could explore the factors that contribute to this anticipated reassessment and the perspectives of individuals who participate in it and compare their perspectives to those expressed in the present study. The department is also operationalizing the guidelines for determining recovery feasibility provided in ECCC's new Policy for Survival and Recovery. Future research could examine how DFO's operationalization is consistent with or differs from ECCC's definitions and guidelines, and how the updated guidelines support (or hinder) recovery efforts for species listed under SARA, including iBoF salmon.

A larger study could expand upon the results highlighted here by focusing on a different species listed under SARA or comparing findings from examining multiple listed species, with the aim of identifying more-broadly generalizable findings than was possible in this study. Future research could also seek to recruit a larger sample size relevant to iBoF salmon recovery planning by focusing on a diverse array of perspectives, to help address the possible lack of saturation reached for certain target populations in this study, as indicated above. In particular, addressing the underrepresentation of key perspectives in the present study will be important in future research to better characterize the factors that affect determinations of recovery feasibility, and recovery planning for iBoF salmon or other aquatic species.

5.4 Conclusion

In terms of key conclusions, I found that the Recovery Team and other individuals involved in recovery planning efforts for iBoF salmon maintained the opinion that it was too soon to say that recovery is not feasible for the species. Nevertheless, there is growing concern among Recovery Team members and in recovery planning documents about the lack of progress towards recovery targets, accounting for changes in the environment of the inner Bay of Fundy and its watersheds, and potential Allee effects in the population since 2010. The difficulty and cost of researching and managing iBoF salmon in the marine environment has become more prominent to scientists, managers, stakeholders, and rights holders over time, and Recovery Team members are actively engaged in discussions about whether current management approaches such as Live Gene Banking and supplementation are conducive to achieving the objectives of the iBoF

recovery program. These factors contribute to greater pessimism about the biological and technical feasibility of recovering iBoF salmon in 2023 compared to 2010.

The Recovery Team members I interviewed maintain that a wide variety of factors played a role in the fact that no reassessment of recovery feasibility has been implemented since the publication of the Recovery Strategy in 2010. Some of these factors were logistical in nature, such as a lack of new information that would contribute to a reassessment or limited financial resources or personnel to produce such information or conduct a reassessment. Others were organizational or institutional, stemming from the relationships between Recovery Team members, a lack of strong leadership to support reassessing recovery feasibility, or disengagement from iBoF salmon recovery planning in general due to economic or political reasons by DFO in its capacity as a regulatory authority. Regardless of the reason, little emphasis appears to have been placed on performing a reassessment of feasibility in the current organizational structure and culture of iBoF salmon recovery planning. Despite this situation, Recovery Team members demonstrated a strong interest and value in regularly reassessing recovery feasibility and viewed the Recovery Team as a key vehicle for enabling reassessment.

Substantial conceptual barriers related to the definitions of "recovery" and "feasibility," and about how the process of determining feasibility functions, were revealed in this study. Ambiguity and lack of clarity surrounding key terms in SARA is not new (Kraus et al., 2021; Mooers et al., 2017; Turcotte et al., 2021), and such ambiguity hinders processes for monitoring and evaluating progress on recovery efforts for the species, without which it becomes difficult to actually tell whether efforts are having the desired impact (Bottrill, Walsh, et al., 2011; Stem et al., 2005; Wolf et al., 2015). The development and future implementation of a new policy defining recovery, survival, and recovery feasibility under SARA presents an opportunity to combat the ambiguity that exists around these key terms, and eventually for regular monitoring and reassessment to be prioritized for iBoF salmon.

iBoF Atlantic salmon has been the subject of concerted conservation efforts since the 1990s. Its addition to Schedule 1 of SARA in 2003 seemed to indicate that serious effort would be devoted to protecting the species and eventually leading it back to recovery. Despite ongoing research and recovery efforts, selective implementation of the

measures within the Act granted iBoF salmon “trickles of protection” (VanderZwaag et al., 2011) The lack of a reassessment of recovery feasibility after 14 years is one such example of this selective implementation. Meanwhile, iBoF salmon remains critically endangered. Doubts are beginning to form about whether the species can ever reach a point where it no longer requires human intervention to continue to exist in Canada—or whether the Canadian government believes the species is worth putting the effort into recovery and sustainability. While there may be reticence to make an explicit statement about recovery feasibility for a species at risk, especially in the face of the extremely complex problem of iBoF salmon recovery, regular reassessment can provide opportunities to identify points of weakness in current recovery programs and work towards an adaptive approach to promote the return of Atlantic salmon to the inner Bay of Fundy.

References

Adamo, M., Sousa, R., Wipf, S., Correia, R. A., Lumia, A., Mucciarelli, M., & Mammola, S. (2022). Dimension and impact of biases in funding for species and habitat conservation. *Biological Conservation*, *272*, 109636. https://doi.org/10.1016/j.biocon.2022.109636

Akçakaya, H. R., Rodrigues, A. S. L., Keith, D. A., Milner-Gulland, E. J., Sanderson, E. W., Hedges, S., Mallon, D. P., Grace, M. K., Long, B., Meijaard, E., & Stephenson, P. J. (2020). Assessing ecological function in the context of species recovery. *Conservation Biology*, *34*(3), 561–571. https://doi.org/10.1111/cobi.13425

Allen, C. R., & Gunderson, L. H. (2011). Pathology and failure in the design and implementation of adaptive management. *Journal of Environmental Management*, *92*(5), 1379–1384. https://doi.org/10.1016/j.jenvman.2010.10.063

Amiro, P. G. (2003). *Population status of inner Bay of Fund Atlantic salmon (*Salmo salar*) to 1999.* Canadian Technical Reports Fisheries and Aquatic Sciences (44p + vi)

Archibald, D. W., McIver, R., & Rangeley, R. (2021). The implementation gap in Canadian fishery policy: Fisheries rebuilding and sustainability at risk. *Marine Policy*, *129*, 104490. https://doi.org/10.1016/j.marpol.2021.104490

Aylesworth, L., Foster, S. J., & Vincent, A. C. J. (2020). Realities of offering advice to governments on CITES. *Conservation Biology*, *34*(3), 644–653. https://doi.org/10.1111/cobi.13451

Bankes, N., Mascher, S., & Olszynski, M. (2014). Can environmental laws fulfill their promise? Stories from Canada. *Sustainability*, *6*(9), Article 9. https://doi.org/10.3390/su6096024

Barr, L. M., & Possingham, H. P. (2013). Are outcomes matching policy commitments in Australian marine conservation planning? *Marine Policy*, *42*, 39–48. https://doi.org/10.1016/j.marpol.2013.01.012

Barsh, R. L. (2002). Netukulimk past and present: Mi'kmaw ethics and the Atlantic fishery. *Journal of Canadian Studies*, *37*(1), 15. https://doi.org/10.3138/jcs.37.1.15

Bartlett, C., Marshall, M., & Marshall, A. (2012). Two-Eyed Seeing and other lessons learned within a co-learning journey of bringing together indigenous and mainstream knowledges and ways of knowing. *Journal of Environmental Studies and Sciences*, *2*(4), 331–340. https://doi.org/10.1007/s13412-012-0086-8

Battiste, M. (2005). Indigenous knowledge: Foundations for First Nations. *WINHEC: International Journal of Indigenous Education Scholarship*, *1*, Article 1. https://journals.uvic.ca/index.php/winhec/article/view/19251

Bean, M. J. (2009). The Endangered Species Act: Science, policy, and politics. *Annals of the New York Academy of Sciences*, *1162*, 369–391. https://doi.org/10.1111/j.1749-6632.2009.04150.x

Beger, M., Grantham, H. S., Pressey, R. L., Wilson, K. A., Peterson, E. L., Dorfman, D., Mumby, P. J., Lourival, R., Brumbaugh, D. R., & Possingham, H. P. (2010). Conservation planning for connectivity across marine, freshwater, and terrestrial realms. *Biological Conservation*, *143*(3), 565–575. https://doi.org/10.1016/j.biocon.2009.11.006

Bellanger, M., Speir, C., Blanchard, F., Brooks, K., Butler, J. R. A., Crosson, S., Fonner, R., Gourguet, S., Holland, D. S., Kuikka, S., Le Gallic, B., Lent, R., Libecap, G. D., Lipton, D. W., Nayak, P. K., Reid, D., Scemama, P., Stephenson, R., Thébaud, O., & Young, J. C. (2020). Addressing marine and coastal governance conflicts at the interface of multiple sectors and jurisdictions. *Frontiers in Marine Science*, *7*, 743. https://doi.org/10.3389/fmars.2020.544440

Bento, F., Tagliabue, M., & Lorenzo, F. (2020). Organizational silos: A scoping review informed by a behavioral perspective on systems and networks. *Societies*, *10*(3), Article 3. https://doi.org/10.3390/soc10030056

Bird, S. C., & Hodges, K. E. (2017). Critical habitat designation for Canadian listed species: Slow, biased, and incomplete. *Environmental Science & Policy*, *71*, 1–8. https://doi.org/10.1016/j.envsci.2017.01.007

Bordeleau, X., Hatcher, B. G., Denny, S. K., Fast, M. D., Whoriskey, F. G., Patterson, D. A., & Crossin, G. T. (2018). Consequences of captive breeding: Fitness implications for wild-origin, hatchery-spawned Atlantic salmon kelts upon their return to the wild. *Biological Conservation*, *225*, 144–153. https://doi.org/10.1016/j.biocon.2018.06.033

Bottrill, M. C., Hockings, M., & Possingham, H. P. (2011). In pursuit of knowledge: Addressing barriers to effective conservation evaluation. *Ecology and Society*, *16*(2), art14. https://doi.org/10.5751/ES-04099-160214

Bottrill, M. C., Walsh, J. C., Watson, J. E. M., Joseph, L. N., Ortega-Argueta, A., & Possingham, H. P. (2011). Does recovery planning improve the status of threatened species? *Biological Conservation*, *144*(5), 1595–1601. https://doi.org/10.1016/j.biocon.2011.02.008

Bowen, G. A. (2009). Document analysis as a qualitative research method. *Qualitative Research Journal*, *9*(2), 27–40. https://doi.org/10.3316/QRJ0902027

Brassard, C. (2014). *Recovery planning under Canada's Species At Risk Act* [Master's thesis, Université d'Ottawa / University of Ottawa]. https://doi.org/10.20381/ruor-6511

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology*, *3*(2), 77–101. https://doi.org/10.1191/1478088706qp063oa

Buddendorf, W. B., Jackson, F. L., Malcolm, I. A., Millidine, K. J., Geris, J., Wilkinson, M. E., & Soulsby, C. (2019). Integration of juvenile habitat quality and river connectivity models to understand and prioritise the management of barriers for Atlantic salmon populations across spatial scales. *Science of the Total Environment*, *655*, 557–566. https://doi.org/10.1016/j.scitotenv.2018.11.263

Carolan, M. S. (2008). The politics in environmental science: The Endangered Species Act and the Preble's mouse controversy. *Environmental Politics*, *17*(3), 449–465. https://doi.org/10.1080/09644010802055683

Chapman, M., Satterfield, T., & Chan, K. M. A. (2020). How value conflicts infected the science of riparian restoration for endangered salmon habitat in America's Pacific Northwest: Lessons for the application of conservation science to policy. *Biological Conservation*, *244*, 108508. https://doi.org/10.1016/j.biocon.2020.108508

Chase, S. (2007). Closing the North American mixed-stock commercial fishery for wild Atlantic salmon. In *Salmon at the Edge* (pp. 84–92). Blackwell Science Ltd. https://doi.org/10.1002/9780470995495.ch8

Clark, T. W., Crete, R., & Cada, J. (1989). Designing and managing successful endangered species recovery programs. *Environmental Management*, *13*(2), 159–170. https://doi.org/10.1007/BF01868363

Clarke, C. N., Fraser, D. J., & Purchase, C. F. (2016). Lifelong and carry-over effects of early captive exposure in a recovery program for Atlantic salmon (*Salmo salar*). *Animal Conservation*, *19*(4), 350–359. https://doi.org/10.1111/acv.12251

Cook, C. N., Hockings, M., & Carter, R. W. (2010). Conservation in the dark? The information used to support management decisions. *Frontiers in Ecology and the Environment*, *8*(4), 181–188. https://doi.org/10.1890/090020

Cope, M. (2010). Coding qualitative data. In I. Hay (Ed.), *Qualitative research methodologies for human geographers* (3rd ed., pp. 281–294). Oxford University Press.

Cornejo, M., Bustamante, J., Del Río, M., De Toro, X., & Latorre, M. S. (2023). Researching with qualitative methodologies in the time of coronavirus: Clues and challenges. *International Journal of Qualitative Methods*, *22*, 16094069221150110. https://doi.org/10.1177/16094069221150110

Committee on the Status of Endangered Wildlife in Canada. (2006). *COSEWIC assessment and update status report on the atlantic salmon Salmo salar (inner Bay of Fundy populations) in Canada* (p. vii + 45 pp.). Committee on the Status of Endangered Wildlife in Canada. www.sararegistry.gc.ca/status/status_e.cfm

Côté, D., Van Leeuwen, T. E., Bath, A. J., Gonzales, Emily. K., & Côté, A. L. (2021). Social–ecological management results in sustained recovery of an imperiled salmon population. *Restoration Ecology*, *29*(5), e13401. https://doi.org/10.1111/rec.13401

Courchamp, F., Berec, L., & Gascoigne, J. (2009). *Allee effects in ecology and conservation* (1. paperback ed). Oxford University Press.

Creighton, M. J. A., & Bennett, J. R. (2019). Taxonomic biases persist from listing to management for Canadian species at risk. *Écoscience*, *26*(4), 315–321. https://doi.org/10.1080/11956860.2019.1613752

Critical Habitat of the Atlantic Salmon (Salmo Salar) Inner Bay of Fundy Population Order, SOR/2019-322 (2019). https://canadagazette.gc.ca/rp-pr/p2/2019/2019-09-18/html/sor-dors322-eng.html

Culbert, R., & Blair, R. (1989). Recovery planning and endangered species. *Endangered Species UPDATE*, *6*(10), 2–8.

Daniels, J., & Mather, C. (2017). Conservation and care: Material politics and Atlantic salmon on Newfoundland's Gander River. *Maritime Studies*, *16*(1), 1–17. https://doi.org/10.1186/s40152-017-0072-6

Dawe, J. L. (2010). *Marine fish, local ecological knowledge, and the species at risk act in Canada: Lessons from the case study of three species of wolffish* [Master's thesis, Memorial University of Newfoundland]. https://research.library.mun.ca/9253/

DeFries, R., & Nagendra, H. (2017). Ecosystem management as a wicked problem. *Science*, *356*(6335), 265–270. https://doi.org/10.1126/science.aal1950

Denny, S. K., & Fanning, L. M. (2016). A Mi'kmaw perspective on advancing salmon governance in Nova Scotia, Canada: Setting the stage for collaborative co-existence. *The International Indigenous Policy Journal*, *7*(3), Article 3. https://doi.org/10.18584/iipj.2016.7.3.4

Dewulf, A., & Biesbroek, R. (2018). Nine lives of uncertainty in decision-making: Strategies for dealing with uncertainty in environmental governance. *Policy and Society*, *37*(4), 441–458. https://doi.org/10.1080/14494035.2018.1504484

Department of Fisheries and Oceans [DFO]. (2004). *Allowable harm assessment for inner Bay of Fundy Atlantic salmon .: Fs76-1/2004-030E-PDF - Government of Canada Publications - Canada.ca* (No. 2004/030; Can. Sci. Advis. Sec. Stock Status Rep.). https://publications.gc.ca/site/eng/9.814333/publication.html

DFO. (2007). *Revised protocol for conducting recovery potential assessments* (No. 2007/039; Can. Sci. Advis. Sec. Sci. Advis. Rep.). Department of Fisheries and Oceans.

DFO. (2008). *Recovery potential assessment for inner Bay of Fundy Atlantic salmon* (DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. No. 2008/050; p. 34). Canadian Science Advisory Secretariat. https://waves-vagues.dfo-mpo.gc.ca/library-bibliotheque/335147.pdf

DFO. (2009). *Recovery strategy for the Atlantic salmon (Salmo salar), inner Bay of Fundy populations—Proposed*. https://publications.gc.ca/site/eng/9.566436/publication.html

DFO. (2010a). *Guidelines for terms and concepts used in the Species At Risk Act* (No. 2009/065; Can. Sci. Advis. Sec. Sci. Advis. Rep., p. 9). Department of Fisheries and Oceans.

DFO. (2010b). *Recovery strategy for the Atlantic salmon (Salmo salar), inner Bay of Fundy population* (Species At Risk Act Recovery Strategy Series, Issue April, p. xiii + 58 pp. + Appendices). Fisheries and Oceans Canada. https://www.canada.ca/en/environment-climate-change/services/species-risk-public-registry/recovery-strategies/atlantic-salmon-inner-bay-fundy-populations-final-2010.html

DFO. (2012). *Temperature threshold to define management strategies for Atlantic salmon (Salmo salar) fisheries under environmentally stressful conditions* (No. 2012/019; Can. Sci. Advis. Sec. Sci. Advis. Rep., p. 17). Department of Fisheries and Oceans. https://waves-vagues.dfo-mpo.gc.ca/library-bibliotheque/346488.pdf

DFO. (2018). Review of the science associated with the inner Bay of Fundy Atlantic salmon Live Gene Bank and supplementation programs. *Canadian Science Advisory Secretariat Science Advisory Report*, *2018/041*(August). https://waves-vagues.dfo-mpo.gc.ca/library-bibliotheque/40726241.pdf

DFO. (2019). *Action plan for the Atlantic salmon (Salmo salar), inner Bay of Fundy population in Canada* (Species At Risk Act Action Plan Series, p. vii + 59 pp). Fisheries and Oceans Canada. https://wildlife-species.canada.ca/species-risk-registry/virtual_sara/files/plans/Ap-SaumoniBoFSalmon-v00-2019Sept-Eng.pdf

DFO. (2020). *Inner Bay of Fundy (iBoF) Returning Adult Atlantic Salmon Population Abundance Estimate* (No. 2020/027; Can. Sci. Advis. Sec. Sci. Advis. Rep.). https://waves-vagues.dfo-mpo.gc.ca/library-bibliotheque/40902754.pdf

DFO. (2021). *Report on the progress of recovery strategy implementation for the Atlantic salmon (Salmo salar), inner Bay of Fundy population in Canada for the period 2010 to 2015.* https://epe.lac-bac.gc.ca/100/201/301/weekly_acquisitions_list-ef/2021/21-33/publications.gc.ca/collections/collection_2021/mpo-dfo/En3-4-67-1-2020-eng.pdf

Environment and Climate Change Canada [ECCC]. (2021). *Species at Risk policy on survival and recovery: Final version 2021*. https://www.canada.ca/en/environment-climate-change/services/species-risk-public-registry/policies-guidelines/survival-recovery-2020.html

Elo, S., & Kyngäs, H. (2008). The qualitative content analysis process. *Journal of Advanced Nursing*, *62*(1), 107–115. https://doi.org/10.1111/j.1365-2648.2007.04569.x

Falter, M., Arenas, A. A., Maples, G. W., Smith, C. T., Lamb, L. J., Anderson, M. G., Uzzell, E. M., Jacobs, L. E., Cason, X. L., Griffis, T. A. N., Polzin, M., & Wafa, N. Z. (2022). Making room for Zoom in focus group methods: Opportunities and challenges for novice researchers (during and beyond COVID-19). *Forum Qualitative Sozialforschung / Forum: Qualitative Social Research*, *23*(1), Article 1. https://doi.org/10.17169/fqs-23.1.3768

Ferreira, C. C., Hossie, T. J., Jenkins, D. A., Wehtje, M., Austin, C. E., Boudreau, M. R., Chan, K., Clement, A., Hrynyk, M., Longhi, J., MacFarlane, S., Majchrzak, Y. N., Otis, J. A., Peers, M. J. L., Rae, J., Seguin, J. L., Walker, S., Watt, C., & Murray, D. L. (2019). The recovery illusion: What is delaying the rescue of imperiled species? *BioScience*, *69*(12), 1028–1034. https://doi.org/10.1093/biosci/biz113

Findlay, C. S., Elgie, S., Giles, B., & Burr, L. (2009). Species listing under Canada's Species at Risk Act. *Conservation Biology*, *23*(6), 1609–1617. https://www.jstor.org/stable/40419200

Flye, M. E., Sponarski, C. C., Zydlewski, J. D., & McGreavy, B. (2021). Understanding collaborative governance from a communication network perspective: A case study of the Atlantic salmon recovery framework. *Environmental Science & Policy*, *115*, 79–90. https://doi.org/10.1016/j.envsci.2020.10.001

Gerber, L. R. (2016). Conservation triage or injurious neglect in endangered species recovery. *Proceedings of the National Academy of Sciences*, *113*(13), 3563–3566. https://doi.org/10.1073/pnas.1525085113

Gibson, A. J. F., Bowlby, H. D., Bryan, J. R., & Amiro, P. G. (2008). Population viability analysis of inner Bay of Fundy Atlantic salmon with and without Live Gene Banking. *Canadian Science Advisory Secretariat*, *Research D*(2008/057), 71 p.

Gibson, A. J. F., & Claytor, R. R. (2013). *What is 2.4? Placing Atlantic salmon conservation requirements in the context of the precautionary approach to fisheries management in the Maritimes region* (Research Document No. 2012/043; Can. Sci. Advis. Sec. Sci. Res. Doc., p. iv + 21 p). DFO.

Government of Canada, F. and O. C. (2016, December 19). *Recovery planning*. https://www.dfo-mpo.gc.ca/species-especes/sara-lep/recovery-retablissement-eng.html

Grantham, H. S., Wilson, K. A., Moilanen, A., Rebelo, T., & Possingham, H. P. (2009). Delaying conservation actions for improved knowledge: How long should we wait? *Ecology Letters*, *12*(4), 293–301. https://doi.org/10.1111/j.1461-0248.2009.01287.x

Gregory, R., Long, G., Colligan, M., Geiger, J. G., & Laser, M. (2012). When experts disagree (and better science won't help much): Using structured deliberations to support endangered species recovery planning. *Journal of Environmental Management*, *105*, 30–43. https://doi.org/10.1016/j.jenvman.2012.03.001

Haida Nation v. British Columbia (Minister of Forests), No. 29419 (2004 SCC 73 2004).

Hart, R. J. (2018). Salmon, science, and conservation: Organizational power and the listing and recovery planning of an endangered species. *Environmental Science and Policy*, *88*, 124–133. https://doi.org/10.1016/j.envsci.2018.06.020

Hill, C. J., Schuster, R., & Bennett, J. R. (2019). Indigenous involvement in the Canadian species at risk recovery process. *Environmental Science & Policy*, *94*, 220–226. https://doi.org/10.1016/j.envsci.2019.01.017

Hughes, C., Yarmey, N., Morehouse, A., & Nielsen, S. (2020). Problem perspectives and grizzly bears: A case study of Alberta's grizzly bear recovery policy. *Frontiers in Ecology and Evolution*, *8*, 38. https://doi.org/10.3389/fevo.2020.00038

Hutchings, J. A., Butchart, S. H. M., Collen, B., Schwartz, M. K., & Waples, R. S. (2012). Red flags: Correlates of impaired species recovery. *Trends in Ecology and Evolution. 27(10): 542-546.*, 542–546. https://doi.org/10.1016/j.tree.2012.06.005

Hutchings, J. A., Côté, I. M., Dodson, J. J., Fleming, I. A., Jennings, S., Mantua, N. J., Peterman, R. M., Riddell, B. E., Weaver, A. J., & VanderZwaag, D. L. (2012). Is Canada fulfilling its obligations to sustain marine biodiversity? A summary review, conclusions, and recommendations 1This manuscript is a companion paper to Hutchings et al. (doi:10.1139/a2012-011) and VanderZwaag et al. (doi:10.1139/a2012-013) also appearing in this issue. These three papers comprise an edited version of a February 2012 Royal Society of Canada Expert Panel Report. *Environmental Reviews*, *20*(4), 353–361. https://doi.org/10.1139/er-2012-0049

Hutchings, J. A., Stephens, T., & VanderZwaag, D. L. (2016). Marine species at risk protection in Australia and Canada: Paper promises, paltry progressions. *Ocean Development and International Law*, *47*(3), 233–254. https://doi.org/10.1080/00908320.2016.1194092

Irvine, J. R., Gross, M. R., Wood, C. C., Holtby, L. B., Schubert, N. D., & Amiro, P. G. (2005). Canada's Species at Risk Act: An opportunity to protect endangered salmon. *Fisheries*, *30*(12), 11–19. https://doi.org/10.1577/1548-8446(2005)30[11:CSARA]2.0.CO;2

Jackson, K., & Bazeley, P. (2019). *Qualitative data analysis with NVivo* (3rd ed.). Sage Publications.

Jacobson, S. K., Morris, J. K., Sanders, J. S., Wiley, E. N., Brooks, M., Bennetts, R. E., Percival, H. F., & Marynowski, S. (2006). Understanding barriers to implementation of an adaptive land management program. *Conservation Biology*, *20*(5), 1516–1527. https://doi.org/10.1111/j.1523-1739.2006.00476.x

Keen, S., Lomeli-Rodriguez, M., & Joffe, H. (2022). From challenge to opportunity: Virtual qualitative research during COVID-19 and beyond. *International Journal of Qualitative Methods*, *21*, 16094069221105075. https://doi.org/10.1177/16094069221105075

Khair, S., McIntosh, S., Stoyanovich, S., Greenwald, N., Suckling, K., & Findlay, C. S. (2017). Empirical correlates of SAR recovery. *Department of Biology and Institute of Environment Working Paper*.

Kingsford, R. T., Roux, D. J., McLoughlin, C. A., Conallin, J., & Norris, V. (2017). Strategic adaptive management (SAM) of intermittent rivers and ephemeral streams. In *Intermittent Rivers and Ephemeral Streams* (pp. 535–562). Elsevier. https://doi.org/10.1016/B978-0-12-803835-2.00021-8

Kleiman, D. G., Reading, R. P., Miller, B. J., Clark, T. W., Scott, J. M., Robinson, J., Wallace, R. L., Cabin, R. J., & Felleman, F. (2000). Improving the evaluation of conservation programs. *Conservation Biology*, *14*(2), 356–365. https://doi.org/10.1046/j.1523-1739.2000.98553.x

Koubrak, O., VanderZwaag, D. L., & Worm, B. (2021). Saving the North Atlantic right whale in a changing ocean: Gauging scientific and law and policy responses. *Ocean and Coastal Management*, *200*, 105109. https://doi.org/10.1016/j.ocecoaman.2020.105109

Kraus, D., Murphy, S., & Armitage, D. (2021). Ten bridges on the road to recovering Canada's endangered species. *FACETS*, *6*, 1088–1127. https://doi.org/10.1139/facets-2020-0084

Krebs, C. (2024, July 20). Problems in funding biological conservation research. *Ecological Rants*. https://www.zoology.ubc.ca/~krebs/ecological_rants/problems-in-funding-biological-conservation-research/

Lees, K., Pitois, S., Scott, C., Frid, C., & Mackinson, S. (2006). Characterizing regime shifts in the marine environment. *Fish and Fisheries*, *7*(2), 104–127. https://doi.org/10.1111/j.1467-2979.2006.00215.x

Lemieux, C. J., Groulx, M. W., Bocking, S., & Beechey, T. J. (2018). Evidence-based decision-making in Canada's protected areas organizations: Implications for management effectiveness. *FACETS*, *3*(1), 392–414. https://doi.org/10.1139/facets-2017-0107

Lindenmayer, D. B., & Fischer, J. (2007). Tackling the habitat fragmentation panchreston. *Trends in Ecology & Evolution*, *22*(3), 127–132. https://doi.org/10.1016/j.tree.2006.11.006

Lindenmayer, D. B., Piggott, M. P., & Wintle, B. A. (2013). Counting the books while the library burns: Why conservation monitoring programs need a plan for action. *Frontiers in Ecology and the Environment*, *11*(10), 549–555. https://doi.org/10.1890/120220

Lumivero. (2023). *NVivo* (Version 14) [Computer software]. www.lumivero.com

MacDonald, B. H., Soomai, S. S., De Santo, E. M., & Wells, P. G. (Eds.). (2016a). *Science, information, and policy interface for effective coastal and ocean management*. CRC Press, Division of Taylor & Francis. https://doi.org/10.1201/b21483

MacDonald, B. H., Soomai, S. S., De Santo, E. M., & Wells, P. G. (2016b). Understanding the science-policy interface in integrated coastal and ocean management. In B. H. MacDonald, S. S. Soomai, E. M. De Santo, & P. G. Wells (Eds.), *Science, information, and policy interface for effective coastal and ocean management* (pp. 19–43). CRC Press, Division of Taylor & Francis.

Malmer, P., Vanessa, M., Austin, B., & Tengö, M. (2020). Mobilisation of indigenous and local knowledge as a source of useable evidence for conservation partnerships. In W. J. Sutherland, P. N. M. Brotherton, Z. G. Davies, N. Ockendon, N. Pettorelli, & J. A. Vickery (Eds.), *Conservation Research, Policy and Practice* (1st ed., pp. 82–113). Cambridge University Press. https://doi.org/10.1017/9781108638210.006

Månsson, J., Eriksson, L., Hodgson, I., Elmberg, J., Bunnefeld, N., Hessel, R., Johansson, M., Liljebäck, N., Nilsson, L., Olsson, C., Pärt, T., Sandström, C., Tombre, I., & Redpath, S. M. (2023). Understanding and overcoming obstacles in adaptive management. *Trends in Ecology & Evolution*, *38*(1), 55–71. https://doi.org/10.1016/j.tree.2022.08.009

Maritime Aboriginal Peoples Council. (2014). *Case study on consultation, accommodation and cooperation with Aboriginal peoples undertaken by Environment Canada in regard to the boreal woodland caribou, and by Fisheries and Oceans Canada in regard to the inner Bay of Fundy Atlantic salmon and american eel; and identification of gaps and suggestions to increase the level of Aboriginal participation in the Species At Risk Act* (National Aboriginal Council on Species at Risk).

Martín-López, B., Montes, C., Ramírez, L., & Benayas, J. (2009). What drives policy decision-making related to species conservation? *Biological Conservation*, *142*(7), 1370–1380. https://doi.org/10.1016/j.biocon.2009.01.030

Maysonet, S. C., & Murphy, S. D. (2021). *Recovery of Atlantic salmon in Fundy National Park* (Ecological Restoration: Nature-Based Solutions for CLimate Mitigation and Engaging Canadians with Nature, p. 44). School of Environment, Resources, and Sustainability, University of Waterloo.

McIntosh, E. J. (2019). Barriers to the evaluation of systematic conservation plans: Insights from landmark Australian plans. *Biological Conservation*, *237*. https://ora.ox.ac.uk/objects/uuid:ceeab754-9ea3-4b23-8edf-c6ea2b4a30fb

Milot, E., Perrier, C., Papillon, L., Dodson, J. J., & Bernatchez, L. (2013). Reduced fitness of Atlantic salmon released in the wild after one generation of captive breeding. *Evolutionary Applications*, *6*(3), 472–485. https://doi.org/10.1111/eva.12028

Mooers, A. Ø., Doak, D. F., Findlay, S. C., Green, D. M., Grouios, C., Manne, L. L., Rashvand, A., Rudd, M. A., & Whitton, J. (2010). Science, policy, and species at risk in canada. *BioScience*, *60*(10), 843–849. https://doi.org/10.1525/bio.2010.60.10.11

Mooers, A. Ø., Hutchings, J. A., Kerr, J., Whitton, J., Findlay, S., & Otto, S. P. (2017, February 14). Recovering the Species at Risk Act. *Policy Options*. https://policyoptions.irpp.org/magazines/february-2017/recovering-the-species-at-risk-act/

Mooers, A. Ø., Prugh, L. R., Festa-Bianchet, M., & Hutchings, J. A. (2007). Biases in legal listing under Canadian endangered species legislation. *Conservation Biology*, *21*(3), 572–575. https://doi.org/10.1111/j.1523-1739.2007.00689.x

Moon, K., Brewer, T., Januchowski-Hartley, S., Adams, V., & Blackman, D. (2016). A guideline to improve qualitative social science publishing in ecology and conservation journals. *Ecology and Society*, *21*(3). https://doi.org/10.5751/ES-08663-210317

Moon, T., Scambos, T., Abdalati, W., Ahlstrøm, A. P., Bindschadler, R., Gambill, J., Heimbach, P., Hock, R., Langley, K., Miller, I., & Truffer, M. (2020). Ending a sea of confusion: Insights and opportunities in sea-level change communication. *Environment: Science and Policy for Sustainable Development*, *62*(5), 4–15. https://doi.org/10.1080/00139157.2020.1791627

Neel, M. C., Leidner, A. K., Haines, A., Goble, D. D., & Scott, J. M. (2012). By the numbers: How is recovery defined by the US Endangered Species Act? *BioScience*, *62*(7), 646–657. https://doi.org/10.1525/bio.2012.62.7.7

Newediuk, L., Ethier, J. P., Boyle, S. P., Aubin, J. A., Balluffi-Fry, J., Dedeban, E., Laforge, M. P., Prokopenko, C. M., Turner, J. W., Webber, Q. M. R., & Wal, E. V. (2021). Sociopolitical factors drive conservation planning timelines: A Canadian case study with global implications. *Biological Conservation*, *257*, 109091. https://doi.org/10.1016/j.biocon.2021.109091

Nutley, S. M., Walter, I., & Davies, H. T. O. (2007). *Using evidence: How research can inform public services* (1st ed.). Bristol University Press. https://doi.org/10.2307/j.ctt9qgwt1

Olson, J., & Pinto Da Silva, P. (2019). Knowledge production at the science–policy interface: Lessons from fisheries scientists. *Science and Public Policy*, scz045. https://doi.org/10.1093/scipol/scz045

Oxford English Dictionary. (2024a). Feasibility, n., sense 1. In *Oxford English Dictionary*. Oxford University Press.

Oxford English Dictionary. (2024b). *Panchreston, n., sense 2*. Oxford University Press; Oxford English Dictionary. https://doi.org/10.1093/OED/8152574096

Palm, E. C., Fluker, S., Nesbitt, H. K., Jacob, A. L., & Hebblewhite, M. (2020). The long road to protecting critical habitat for species at risk: The case of southern mountain woodland caribou. *Conservation Science and Practice*, *2*(7), e219. https://doi.org/10.1111/csp2.219

Pawluk, K. A., Fox, C. H., Service, C. N., Stredulinsky, E. H., & Bryan, H. M. (2019). Raising the bar: Recovery ambition for species at risk in Canada and the US. *PLoS ONE*, *14*(11). https://doi.org/10.1371/journal.pone.0224021

Pinfold, G. (2011). *Economic value of wild atlantic salmon* (p. 70). Atlantic Salmon Federation.

Polasky, S. (2008). Why conservation planning needs socioeconomic data. *Proceedings of the National Academy of Sciences*, *105*(18), 6505–6506. https://doi.org/10.1073/pnas.0802815105

Pullin, A. S., Knight, T. M., Stone, D. A., & Charman, K. (2004). Do conservation managers use scientific evidence to support their decision-making? *Biological Conservation*, *119*(2), 245–252. https://doi.org/10.1016/j.biocon.2003.11.007

Redford, K. H., Amato, G., Baillie, J., Beldomenico, P., Bennett, E. L., Clum, N., Cook, R., Fonseca, G., Hedges, S., Launay, F., Lieberman, S., Mace, G. M., Murayama, A., Putnam, A., Robinson, J. G., Rosenbaum, H., Sanderson, E. W., Stuart, S. N., Thomas, P., & Thorbjarnarson, J. (2011). What does it mean to successfully conserve a (vertebrate) species? *BioScience*, *61*(1), 39–48. https://doi.org/10.1525/bio.2011.61.1.9

Reid, A. J., Eckert, L. E., Lane, J.-F., Young, N., Hinch, S. G., Darimont, C. T., Cooke, S. J., Ban, N. C., & Marshall, A. (2021). "Two-Eyed Seeing": An Indigenous framework to transform fisheries research and management. *Fish and Fisheries*, *22*(2), 243–261. https://doi.org/10.1111/faf.12516

Ryan, G. W., & Bernard, H. R. (2003). Techniques to identify themes. *Field Methods*, *15*(1), 85–109. https://doi.org/10.1177/1525822X02239569

Sayre, N. F. (2004). Viewpoint: The need for qualitative research to understand ranch management. *Journal of Range Management*, *57*(6), 668–674. https://doi.org/10.2307/4004026

Scott, I., & Gong, T. (2021). Coordinating government silos: Challenges and opportunities. *Global Public Policy and Governance*, *1*(1), 20–38. https://doi.org/10.1007/s43508-021-00004-z

Shelton, P. A. (2007). The weakening role of science in the management of groundfish off the east coast of Canada. *ICES Journal of Marine Science*, *64*(4), 723–729. https://doi.org/10.1093/icesjms/fsm008

Smith, R. J., Muir, R. D. J., Walpole, M. J., Balmford, A., & Leader-Williams, N. (2003). Governance and the loss of biodiversity. *Nature*, *426*(6962), 67–70. https://doi.org/10.1038/nature02025

Soomai, S. S. (2017a). The science-policy interface in fisheries management: Insights about the influence of organizational structure and culture on information pathways. *Marine Policy*, *81*, 53–63. https://doi.org/10.1016/j.marpol.2017.03.016

Soomai, S. S. (2017b). Understanding the science-policy interface: Case studies on the role of information in fisheries management. *Environmental Science & Policy*, *72*, 65–75. https://doi.org/10.1016/j.envsci.2017.03.004

Species At Risk Act, S.C. 2002, c. 29 (2002). https://laws.justice.gc.ca/eng/acts/S-15.3/FullText.html

Stem, C., Margoluis, R., Salafsky, N., & Brown, M. (2005). Monitoring and evaluation in conservation: A review of trends and approaches. *Conservation Biology*, *19*(2), 295–309. https://www.jstor.org/stable/3591242

Stich, D. S., Bailey, M. M., Holbrook, C. M., Kinnison, M. T., & Zydlewski, J. D. (2015). Catchment-wide survival of wild- and hatchery-reared Atlantic salmon smolts in a changing system. *Canadian Journal of Fisheries and Aquatic Sciences*, *72*(9), 1352–1365. https://doi.org/10.1139/cjfas-2014-0573

Turcotte, A., Kermany, N., Foster, S., Proctor, C. A., Gilmour, S. M., Doria, M., Sebes, J., Whitton, J., Cooke, S. J., & Bennett, J. R. (2021). Fixing the Canadian Species at Risk Act: Identifying major issues and recommendations for increasing accountability and efficiency. *FACETS*, *6*, 1474–1494. https://doi.org/10.1139/facets-2020-0064

VanderZwaag, D. L. (2002). The precautionary principle and marine environmental protection: Slippery shores, rough seas, and rising normative tides. *Articles, Book Chapters, & Popular Press*, *33*, 165. https://digitalcommons.schulichlaw.dal.ca/scholarly_works/504

VanderZwaag, D. L., Cecilia Engler-Palma, M., & Hutchings, J. A. (2011). Canada's Species At Risk Act and Atlantic salmon: Cascade of promises, trickles of protection, sea of challenges. *Journal of Environmental Law and Practice*, *22*, 267–307. www.sararegistry.gc.ca/status/status_e.cfm

Westwood, A. R., Otto, S. P., Mooers, A., Darimont, C., Hodges, K. E., Johnson, C., Starzomski, B. M., Burton, C., Chan, K. M. A., Festa-Bianchet, M., Fluker, S., Gulati, S., Jacob, A. L., Kraus, D., Martin, T. G., Palen, W. J., Reynolds, J. D., & Whitton, J. (2019). Protecting biodiversity in British Columbia: Recommendations for developing species at risk legislation. *FACETS*, *4*(1), 136–160. https://doi.org/10.1139/facets-2018-0042

Westwood, A. R., Reuchlin-Hugenholtz, E., & Keith, D. M. (2014). Re-defining recovery: A generalized framework for assessing species recovery. *Biological Conservation*, *172*, 155–162. https://doi.org/10.1016/j.biocon.2014.02.031

Wiedenfeld, D. A., Alberts, A. C., Angulo, A., Bennett, E. L., Byers, O., Contreras-MacBeath, T., Drummond, G., da Fonseca, G. A. B., Gascon, C., Harrison, I., Heard, N., Hochkirch, A., Konstant, W., Langhammer, P. F., Langrand, O., Launay, F., Lebbin, D. J., Lieberman, S., Long, B., … Zhang, L. (2021). Conservation resource allocation, small population resiliency, and the fallacy of conservation triage. *Conservation Biology: The Journal of the Society for Conservation Biology*, *35*(5), 1388–1395. https://doi.org/10.1111/cobi.13696

Wilson, K. A., & Law, E. A. (2016). Ethics of conservation triage. *Frontiers in Ecology and Evolution*, *4*. https://doi.org/10.3389/fevo.2016.00112

Wistbacka, R., Orell, M., & Santangeli, A. (2018). The tragedy of the science-policy gap – Revised legislation fails to protect an endangered species in a managed boreal landscape. *Forest Ecology and Management*, *422*, 172–178. https://doi.org/10.1016/j.foreco.2018.04.017

Wolf, S., Hartl, B., Carroll, C., Neel, M. C., & Greenwald, D. N. (2015). Beyond PVA: Why recovery under the Endangered Species Sct is more than population viability. *BioScience*, *65*(2), 200–207. https://www.jstor.org/stable/90007047

Young, J. C., Rose, D. C., Mumby, H. S., Benitez-Capistros, F., Derrick, C. J., Finch, T., Garcia, C., Home, C., Marwaha, E., Morgans, C., Parkinson, S., Shah, J., Wilson, K. A., & Mukherjee, N. (2018). A methodological guide to using and reporting on interviews in conservation science research. *Methods in Ecology and Evolution*, *9*(1), 10–19. https://doi.org/10.1111/2041-210X.12828

Appendix A: Interview guide and questionnaire

Table A.1: Semi-structured interview guide.

1. To get started, would you tell me a bit about your participation in the iBoF Salmon Recovery Team? a. How long have you been on the team? In what capacity? b. What has your role been? What form(s) of engagement have you participated in on the team?
2. The feasibility of recovering iBoF salmon populations is an important question when considering recovery. It was first assessed in the Recovery Strategy in 2010 as "feasible". a. Did you participate in the 2010 feasibility assessment for iBoF salmon? b. [If not]: Are you familiar with the process of assessing feasibility of recovery? c. What are your opinions on the determination of feasibility in that original assessment? Do you think it was accurate at the time? Why/why not?
3. It appears, from my review of the documents, that the recovery feasibility for iBoF salmon has not been fully reassessed since the 2010 Recovery Strategy. Is this the case? a. [If not reassessed] In your opinion, should it be reassessed? Why/why not? [If reassessed] When was it reassessed? • Has this reassessment been published? Why/why not? • Do you agree with the outcome? Why/why not? • What prompted the reassessment? • What sorts of considerations went into it? b. Have there been any barriers or challenges in assessing recovery feasibility? [if yes]: What are they? c. Are there currently any enabling conditions that support the re-evaluation of recovery feasibility at this time? [If yes]: What are they?
4. Feasibility of recovery may or may not change over time. a. Has your own perception of the feasibility of recovery for iBoF salmon remained the same or has it changed since it was first assessed in the Recovery Strategy in 2010? b. [if changed] How so and why? c. [If the same] Why? d. [If no longer feasible] Do you think that an explicit statement that the recovery of iBoF salmon is or may not be feasible should be included in a revised recovery strategy? Why/why not?

5. The recovery feasibility assessment for iBoF salmon helped inform the recovery goals for the population in 2010.

a. In your opinion, are the recovery goals still appropriate/ realistic? (5-year goal: conserve genetic characteristics to re-establish self-sustaining populations in 10 rivers; long-term: 9,900 spawning adults in 19 river systems)

b. Why or why not?

6. Determining recovery feasibility and recovery goals is to be done using the best available information on the species' condition.

a. What sorts of information went into the assessment?

b. Do you think the information considered at the time was sufficient or adequate?

c. Were there other types or sources of information that you think would have been helpful or crucial and that were missing from the assessment?

[If yes] Such as?

d. Why do you think it was not included or considered?

e. How crucial do you think that information is, and why do you think so?

f. Is that information now available?

[If yes] How, where?

[If not] Is it potentially available or accessible (e.g., through data collection or analysis)?

g. Are there other types or sources of information you think should be considered now that was not on the radar screen at the time of the first assessment? Such as? Is it available or potentially available?

7. A new policy on survival and recovery under SARA was published in 2021 by Environment and Climate Change Canada. It explicitly defines survival and recovery under the Act and outlines new guidelines for determining recovery feasibility.

a. Are you familiar with this new policy?

Are you familiar with the new guidelines for determining recovery feasibility

b. [if no] (describe guidelines and probe for thoughts)

[if yes] Given these new guidelines, do you think feasibility assessment of iBoF salmon would be the same? Why/why not?

c. [either yes or no] In your opinion, does this new policy affect the work of the Recovery Team in terms of determining recovery feasibility and/or setting goals for recovery?

[if yes] How so?

[if no] Why not?

8. Is there anything else you'd like to mention or add on this topic?

Table A.2: Questionnaire for written responses to the study.

1. What do you see as the role of your organization in inner Bay of Fundy Atlantic salmon (iBoF salmon) recovery?
2. What was the role of your organization in the process of determining the feasibility of recovery of iBoF salmon for the 2010 Recovery Strategy?
3. Has your organization's perception of the feasibility of recovering iBoF salmon populations changed over time? If yes, how has it changed? If no, why does it remain the same?
4. The recovery goals for iBoF salmon, as stated in the 2010 Recovery Strategy, are as follows: 5-year/short term: conserve genetic characteristics to re-establish self-sustaining populations in 10 key inner Bay of Fundy rivers; Long-term: 9,900 spawning adults returning to 19 river systems. In your opinion, are these recovery goals still appropriate and/or realistic? Why or why not?
5. Determining recovery feasibility for iBoF salmon is done using the best available information on the species' condition. a. Was the information considered at the time sufficient and/or adequate to make a determination on recovery feasibility?
b. Were there sources of information that you think would have been helpful or crucial and that were missing from the initial feasibility assessment (e.g., local ecological knowledge, data from academic institutions or non-government organizations, etc.)? What kinds?
c. Why was this information not available or included at the time?
d. How can this information be made available or accessible?

6. One of the objectives of the Recovery Strategy is to periodically review the feasibility of recovering iBoF salmon. a. To your knowledge, has a new assessment of the feasibility of recovering iBoF salmon populations been completed since the 2010 Recovery Strategy? If yes, can you expand on the considerations that went into the assessment?
b. Should feasibility of recovery for iBoF salmon be reassessed at this time? Why or why not?
c. Have there been any barriers or challenges in assessing recovery feasibility, in the past or present? If yes, what are they? Why were these barriers?
d. Have there been any enabling conditions that support re-evaluating recovery feasibility? If yes, what are they? What changed to create these enabling conditions?
7. A new policy on survival and recovery under SARA was published in 2021 by Environment and Climate Change Canada, which outlines new guidelines for determining recovery feasibility. The policy can be viewed at the following page: https://www.canada.ca/en/environment-climate-change/services/species-risk-public-registry/policies-guidelines/survival-recovery-2020.html In your opinion, how does this new policy affect the work of the iBoF Salmon Recovery Team in terms of determining recovery feasibility and/or setting goals for recovery?

Appendix B: Coding frameworks

Each coding framework includes names and descriptions of themes and theme categories, the number of documents, transcripts, and written responses where each theme was found ("files"), and the number of unique codes associated with each theme identified ("references"). Bolded text corresponds to section headers in text; bolded text with grey highlighting.

Table B.1: Thematic framework for research question 1: whether, how, and why perspectives on feasibility change between 2010 and 2023.

Name	Description	Files	Refer-ences
Research question 1 – Perspectives on recovery feasibility of iBoF salmon		20	489
Biological feasibility	Biological feasibility is at play when discussing factors such as habitat availability, population size, or reproductive ability of a population	15	264
Lack of progress toward targets	Views on the progress towards biological recovery objectives such as abundance and distribution	15	109
Low abundance & shrinking distribution	Total returns; LGB versus wild individuals; critical habitat; number of rivers requiring support	12	53
No self-sustainability	Human intervention; the LGB program; recovery vs. survival	9	36
Environmental shifts	Discussion of factors such as ecological changes or intrinsic population effects that may not be reversible	14	40
Habitat loss	Anthropogenic habitat loss; potential impacts of aquaculture; abiotic vs. biotic habitat quality	11	26
Climate change	Rapid warming in Bay of Fundy; effects of climate change on marine environment	3	7
Allee effects	Effects of small population size on recovery; genetic or ecological Allee effects; depensation	8	28
Technical feasibility	Technical feasibility refers to the ability to implement management techniques and technology to support recovery for a species at risk	15	241
Researching & addressing threats	Views on the progress towards understanding and managing threats to iBoF salmon; key component of technical feasibility	15	125
Difficulty of researching marine threats	Cost and personnel requirements of research; challenges of working in the Bay of Fundy; inconclusive results	10	35
Not enough research being done	iBoF salmon research viewed as low priority for DFO; conflicts of interest precluding research efforts	14	82
Management app-roaches not promoting recovery	Discussions related to whether current efforts are actually designed for promoting recovery for the species	15	98

Conserving iBoF genetics vs population	iBoF salmon defined by genetic signature or presence in environment	11	34
LGB & hatchery approach	LGB emphasizes preserving genetics; LGB insufficient for recovery; introgression of farmed salmon genes in LGB pool	9	24
Other aspects of feasibility	Discussion of feasibility other than biological or technical aspects	12	72
Political/economic feasibility	Policy decisions; balancing conservation needs with economic realities; declining resources	10	40
What is "feasibility"?	The scientific validity of "feasibility;" uncertainty in definitions and time scales; other statements that make the idea of defining recovery feasibility questionable.	10	32

Table B.2: Thematic framework for research question 2: barriers and enablers to reassessing recovery feasibility experienced by Recovery Team members.

Name	Description	Files	Refer-ences
Research question 2 – Barriers and enablers to reassessing iBoF salmon recovery feasibility		13	133
Barriers to reassessment	Factors that prevented or hindered reassessment of feasibility	13	88
Lack of information to conduct reassessment	Challenges related to information that could be used to reassess recovery feasibility	10	22
Lack of baseline or new information on feasibility	Inconclusive results from research; difficulty of conducting research; loss of information over time; little progress on understanding threats	4	6
Challenges in obtaining non-DFO information	Emphasis on DFO-produced information; challenges with TEK and LEK; mistrust from industry or angling groups	6	10
Lack of resources	Limitations related to financial, or personnel resources required to obtain information and conduct an assessment of feasibility	7	24
Financial resources	Cost of doing research in Bay of Fundy; research needs vs. budget limitations; cuts to recovery planning for iBoF salmon	6	12
Personnel	Lack of DFO personnel for monitoring; staff turnover in Recovery Team; decline in number of NGOs working on rivers	4	10
Organizational structure and culture	Barriers related to how the Recovery Team functions, including relationships between members, number and quality of meetings, and leadership	10	41
Coordination and communication in the Recovery Team	Coordinating many different stakeholders and rights holders; siloing between organizations; lack of knowledge exchange	5	19
Disconnects between scientists and managers	Balancing research needs and available budget; conflicting management priorities; perceived restrictions on uptake of information by managers	5	7
Show-and-tell without innovation	Recovery Team meetings focused on reviewing existing work; no time outside of meetings for evaluation; fewer meetings	7	10

Leadership challenges	Changes in leadership; conflicts between Recovery Team and its chair; past vs present leadership	4	6
Declining support at the governance level	Experiences or perceptions of lower engagement, interest, or investment by DFO in iBoF salmon recovery efforts	10	29
Unclear role of the Recovery Team in reassessing feasibility	Who is in charge of starting a reassessment; diminishing power of Recovery Team over time; DFO asserting more control over recovery planning; emphasis on advisory role of Recovery Team	5	8
Conflicts of interest	Conflicting management priorities in DFO; aquaculture; recreational or commercial fisheries; iBoF salmon as "low priority"	6	10
Reticence to reassess	Lack of progress seen as "embarrassing;" disengagement by DFO from SARA in general; doubts about DFO's intentions with iBoF salmon	4	9
Conceptual barriers	Challenges related to different understandings from stakeholders about fundamental concepts e.g., recovery under SARA, definition of feasibility	10	38
What is "recovery?"	Differing recovery goals; genetic vs ecological conservation; number target vs. survival/ecological function	5	16
What is "feasibility?"	Possibility, likelihood, and feasibility; consideration of socio-political factors in feasibility; is feasibility present without the financial resources;	10	22
Enablers to reassessment	Factors that Recovery Team members believed would help support or promote reassessing recovery feasibility	12	60
Reassessment is valued by the Recovery Team	Positive perspectives on the value of reassessing recovery feasibility, including as a way to account for efforts thus far as well as to investigate whether changing approaches may be needed	8	25
The Recovery Team as an organizing hub	Discussion on how the Recovery Team itself can enable a reassessment of feasibility; its role as a multi-stakeholder organization	11	38
Leveraging resources among Recovery Team member organizations	Greater involvement of provincial governments to provide personnel capacity; leveraging of finances available for First Nations or angler initiatives; opportunities for collaboration, Fundy Salmon Recovery program	11	19
Recovery Team's role in applying pressure on DFO about iBoF salmon	The role of NGOs in early iBoF recovery successes; multi-stakeholder engagement; political support and pressure	4	10
Better integration of non-DFO information	The value of non-DFO primary literature, TEK, LEK, and grey literature for evaluating both biological and technical feasibility; pathways to better integration of such information	4	8
Clarifying the definition of recovery feasibility and its assessment	ECCC Policy on Survival and Recovery and its adaption by DFO; eliminating ambiguity from both definitions and processes; a "fresh start" for regularly reassessing iBoF salmon recovery feasibility	4	5

Appendix C: Key quotations tables

Table C.1: Key quotations from interviews about biological feasibility

Participant	1. Progress towards recovery objectives	2. Ecological changes
AC1	**Abundance, distribution, survival** - "[The LGB] hasn't resulted in a self-sustaining population: on one hand it's been very successful [at maintaining survival], but it hasn't met the second part of that." **Recovery at a different level** - "Going into it, at least what I've read from that 2010 document, it was very much "We're going to bring it back to the natural state," which is not a bad goal by any stretch, but that just may not be the future. There's lots of examples where this "natural population" just doesn't quite exist in its previous form. Doesn't mean that there's not a new natural, and that's OK too, but people have to say, "OK, this is our new natural." To me, that's a big step that we need to work through."	**Freshwater and marine conditions** - "[T]he landscape has changed greatly, and it's changed at all levels and in every way, shape or form. So, what once was may just never be—ecologically, with taking salmon out of the picture, the environment that was 20, 30, 40, 50 years ago, it just may not be there." - "[F]rom the ocean view, it's big, it's vast, it's unknown. We know there's been large scale ecosystem changes within the food web and so that adds to its complexity…" - "When we talk about good quality freshwater habitat, we tend to look at it from a very abiotic standpoint: oxygen, water clarity, those kinds of things. From that perspective, I would absolutely agree that by and large, the freshwater habitat is good. From an ecosystem function perspective, from a biotic perspective, I would argue that it's not, simply because in order to have a high functioning freshwater ecosystem, especially in many of these rivers, salmon play a critical role. We were seeing it in the Fundy National Park, and we've seen it in other rivers outside the inner Bay, that when you have salmon, the river functions at a higher level, you have more primary productivity, you have more bugs, which means more food for the salmon and other fish, they grow bigger, they grow faster. From that perspective, I would say it's not functioning at the level that it that it could or should be."

Participant	1. Progress towards recovery objectives	2. Ecological changes
DFO1	**Abundance, distribution, survival** - "The initial collections to support the live gene banking program occurred in 1998. A formal program for the protection and maintenance of biodiversity started, really, in the early 2000s. We've done a three-generation review of that, and we're now four years past that, maybe? There is no evidence of recovery within the population ... I have probably more concern for the long-term persistence of that designatable unit now than I did in say 2007, 2008, 'cause we haven't seen any real progress in terms of life cycle closure and reduction in the mortality it's seeing." - "The survivorship in the marine phase has not changed in 20 years..." - "[A]t the moment, there's no evidence to indicate improvement or even persistence in ... three to five years without continuing our interventions." - "The key point being, would that population persist if we ended the live gene banking program? Most of the evidence indicates it would swiftly fall to extinction. So, I have a lot of concern at the moment." **Recovery at a different level** - "Does [the distribution objective] have to be 10 rivers?"	**Freshwater and marine conditions** - "The one thing that's changed now is time. We're now 10+ years farther on, and things haven't changed at all. Are we in a different environmental regime that maybe not be conducive to life cycle closure? Those types of questions now start to crop up." - "I'm trying to think of a scenario where we would say it was not feasible but where we still had extent habitat and we had an effective population size that wasn't in an extinction vortex. I don't think Inner Bay is there…" - "...we have ongoing telemetry work looking at overlap with smolts and aquaculture—they don't overlap..." - "One of the things that's most concerning for us is the reduction in overall high-quality thermal regime in the Bay of Fundy—it's warming a lot, and there are times of year now in the summer where, in the last five or six years occasionally, where we can't find surface water in their thermal preference. That's bad! It's too warm for them, so where do they go?" **Allee effects** - "My concern with inner Bay is, did the population gets so small that now we're in the allee effects environment where maybe you can't get out of it?" - "We think what may have happened in the past with the marine run is that [the salmon] would overwhelm predators. There would be enough of them where they'd all go out at once and they would just swamp the predator field and then be able to get out into open water. But now we think the numbers game is against them"
DFO2	**Abundance, distribution, survival** - "I'd say more pessimistic. Just nothing's improving." - "It's probably one of the tougher ones that you could pick as a pilot project, just because it is in such a drastic state."	**Freshwater and marine conditions** - "You can conserve genetic material, but if the environment that you're putting them into is full of the threats that caused them to decline in the first place, they're never going to recover."

Participant	1. Progress towards recovery objectives	2. Ecological changes
DFO3	**Abundance, distribution, survival** - "Some of the discussion around the RPA on feasibility were that we can't really say it is or isn't feasible. We don't know what the specific limiting factors are. We've done quite a bit of work to narrow down the window in their life cycle where we have issues. But at the same time, without knowing what that is… Having just read the new policy, there would probably be some correct option, but at the time of the RPA that was still an open question. […] we haven't been successful in identifying exactly what the mechanism of marine mortality is, so I think we remain with an unknown feasibility, and we think we still have fish in the Live Gene Bank program that will be sufficient for rebuilding populations if survival changes." - "I'm not completely pessimistic about the state of inner Bay of Fundy salmon: the Live Gene Bank maintains the potential for these things to happen, but without it, well there's no hope."	**Freshwater and marine conditions** - "[T]here's research components that have gone on looking at productivity and freshwater, and we think the rivers still reasonably produce salmon—the Live Gene Bank shows that quite well ... the live gene bank program and Parks Canada's work does demonstrate that we can produce smolts at rates similar to what we used to see back when we thought the populations were healthy…" - "[A] key determination in choosing a site are [sic] the winter temperatures. And Passamaquoddy Bay and Annapolis Basin happen to be two places where the water mostly remains warm enough that salmon can survive through the winter. So, I wonder if—this is all very much speculation since there's no way to test it really—but if those are areas, particularly Passamaquoddy which has the better conditions for survival of salmon, did we lose that when aquaculture was developed?" **Allee effects** - "The other thing that comes in is, there's always the potential of depensation: there might be some minimum threshold [of abundance] below which the survival relationship changes. At that point, during the early increase in abundance from a very, very low level, the curve is in the in the other direction … we talked about depensation occurring in freshwater—possibly there, it's possible, but we haven't found evidence of that."
DFO4	**Abundance, distribution, survival** - "When you think about it, you've now had another decade under your belt, and you have to look at yourself and say, well, how much progress have we made towards achieving those goals? And the answer is, if you gave it another look: not much progress. ... We've retained the genetic diversity in the Live Gene Bank, and looked at preventing inbreeding depression, but if we haven't been able to actually increase populations or the number of animals coming back to the rivers, then I would say it doesn't make sense to set the same goal for the next 10 years when we've made no progress yet." - "We did a survey around 2013 where we sampled juveniles, took tissue samples from them, and looked at the diversity of the adults that would have contributed to those juveniles, which would help our understanding of whether there were adults coming back and spawning in the Stewiacke or other rivers... And that was a very discouraging survey, because we seem to sense that there was very, very little adult returns. That did add a level of discouragement to me in terms of whether in fact biological feasibility was still there now."	**Freshwater and marine conditions** - "Right off the bat, the first assumption is that this is a fairly precipitous phenomenon, not something that happened over like 75 years, but maybe over less than a decade. So, if it happened that quickly, then maybe whatever had caused it to happen would go away and they would recover. I remember that was the first thinking about feasibility of recovery. But they didn't recover on their own." **Allee effects** - "One of the questions we had to answer was, was there enough genetic diversity in the extant population that still survived in the wild? When they did genetic analysis of these original collections, they were quite pleased to see that there was quite a bit of diversity still among the fish that were left ... So that goes into feasibility: if there's enough genetic diversity at the start of your recovery approach, that increases your potential feasibility of recovery. I would say that the potential for feasibility, I think, was very high, and that was long understood once we had done some digging in terms of genetic diversity."

Participant	1. Progress towards recovery objectives	2. Ecological changes
IN1	No direct quotes provided, by interviewee request	
NGO1	**Current abundance, distribution, survival** - "So the work has not been for naught, but it is sort of hanging on by a thread." - "Where DFO or Parks has put a lot of focus—the Point Wolfe, Big Salmon and the the other one… I forgot the name of the other river there… they're next to the [Fundy] park—from what I hear at the recovery table, they seem to be doing OK. I think they're no worse than they were ten years ago, and I get the impression that probably a little bit better, but, you know, zero times a thousand is still zero. ... But I can tell you from the other five rivers—'cause there's ten critical habitat rivers in total—the five that we work on, it's definitely gotten worse. And so I would say the feasibility has gone down quite a bit just from [that balance]." - "We know that 100 years ago there was tons and tons of salmon—that's even in the Western science—but we know today that there's virtually nothing for IBoF salmon."	**Freshwater and marine conditions** - "[T]here was just a number of assumptions: we had people telling us "Oh yeah, that certain brook or this certain section of the river is beautiful habitat, there's always been a ton of salmon there," blah blah. You know, if you're going to be doing work, you should really go back and look at this area. And we're going back and finding out there's just no way that habitat could support a salmon redd, just no way: the water is, you know, the water is that tall in the summertime, and it's eight feet tall and rushing like crazy in the spring and the fall, it's digging out and rechannelizing every year, the frazil ice, and everything else… You just can't sustain a redd, let alone juvenile salmon ... We have DFO telling us that these five rivers that we work on are critical habitat and they're really good habitat, and we're looking at it saying "we've done work on these five rivers over the last four or five years, six years and we don't see it." Right. And so, feasibility? Yeah, we'd say there's no feasibility." **Allee effects** - "In 2010 it was like, yes, it's feasible, but there was this big cloud sort of hanging over... It wasn't quite outright said in 2010, but everybody was thinking it was like really this genetic thing. Sure, we save the last of the species, but it might all be for naught over 100 years where you're left with a population that is so dysfunctional that it can't survive by itself. Interesting enough, though, since that time we had a meeting a few years ago to talk about that genetic diversity ... and I believe that we've been able to maintain almost all of that genetic diversity. ... I think the biggest problem is that the population numbers are so low that any amount of harm is keeping the population from coming back.

Participant	1. Progress towards recovery objectives	2. Ecological changes
NGO2	**Current abundance, distribution, survival** - "We may learn to realize that there is no recovery available: it is gone, because there was a finite time. I mean, we're almost 60 or 70 years into efforts—in fact the Cobequid hatchery was doing salmon in 1940." - "I don't really think that we would say in the recovery plan that we don't really need the involvement of humans, or that it won't be required..." - "Will we ever come to never needing to get involved again? I don't know. I mean, maybe if we would have been involved 400 years ago or 300 years ago, and much more conscious of how we were harvesting it" **Recovery at a different level** - "At that time, involvement was peripheral because from an aboriginal point of view, we're saying that we're dealing with a very important fish that has been lost."	**Freshwater and marine conditions** - "Many believe that the biggest problem was the habitat. So that's what happened and so ever since, you know… The salmon is gone. Will it come back? I doubt it. Because we've destroyed this habitat." - "There's something unique about the Atlantic salmon when she comes back: she's coming back to where she was born to start the process all over again. It's unique. But if the home is not there? Then she's got problems trying to lay the eggs, to get them fertilized by the male. And in the water system, the pesticides, the herbicides—in PEI, now potato farmers have a veto to do whatever they want—in Nova Scotia, we had bulldozers put into river systems to divert, to create channels, to prevent flooding. We had the aboiteaux, the unique Acadian invention which drained a lot of the marshlands, it became good farming land. It wasn't one big aboiteau, it was a series of aboiteaux, but you know back in the '20s and '30s. Someone had this grand idea, why don't you build these big aboiteaux, dykelands. And you know…"
NGO3	**Current abundance, distribution, survival** - "Based on the feasibility assessment of what was needed, I mean live gene banking obviously was critical and they had done that and it just would be completely extinct by now. So fisheries and oceans did a pretty good job at keeping the population alive through the live gene bank or hatcheries at the time … Now, if they pulled the plug on the hatchery program back then, and I would dare say even today, then it would be done." - "[Y]ou got the salmon hanging on by a thread from the Live Gene Bank program…" - "Now, in terms of the influence from people i.e. hatchery keeping things going versus when they get to a certain level to go on their own, past that stage that they consider a higher chance of recovery… That's nowhere near being done or achievable at this point in time." **Self-sustainability** - "Now with the Parks program, they're seeing fish come in the river, but I mean, it's not enough for self-sustaining." - "[U]ntil you address the threats, it's all for naught."	**Freshwater and marine conditions** - "So I mean, even if all the threats were removed, we still don't know if this population will recover because of at-sea conditions and what's changed out there, but that's where you get the side projects to start evaluating that. We may find that the conditions that these fish do remain in the Fundy-Gulf of Maine region, just the changing sea conditions, has now made it uninhabitable for Atlantic salmon, unless they moved to Greenland, right? And that wasn't their original strategy. There's so many unknowns that we just don't know if the fish do stand a chance at recovery. … And I even think under best conditions, the probability of getting to those numbers is very low right now, unless things changed in the ocean."

Participant	1. Progress towards recovery objectives	2. Ecological changes
NGO4	**Current abundance, distribution, survival** - "NGO4: It's over. PI: You think so? Why so? It's just gotten too bad? NGO4: Well, I have a camp on the Stewiacke. I see shad, I see Gaspereau. I see striped bass—I don't see salmon. I must say I did see smolts, or I used to at least, but whether or not they were wild? I'd like to know whether they were wild, or if they were progeny of the Live Gene Bank. It's the only thing that's keeping the system alive, the Live Gene Bank. They've worked well since '97, but that's a long time, and if we're seeing no wild fish… forget it. Take the Live Gene Bank somewhere else where it can work. I mean, you're asking me, and I'm saying, in my opinion, after 17- or 20-some odd years, if the only thing that's coming back is Live Gene Bank, then is it worth it? Can we save something somewhere else?" - "PI: Yeah, well, that's the other question too. Is that part of recovery, right? If we're saying it's feasible to recover them, we're asking if it's possible for them to get to a point where they no longer need the gene bank to survive. Right now, they need it. NGO4: Yeah, yeah. But will that occur? PI: What do you think? NGO4: I don't know."	**Freshwater and marine conditions** - "[I]n order to protect the fish, you have to protect the habitat!" - "[I]f the only thing that's keeping this is the Live Gene Bank, and environmental conditions are changing in a negative pattern, pull the plug and put your money somewhere else." - "The Petitcodiac, from some of the readings I've done, was also the most prolific river on the inner Bay, that probably produced 60% of the stock. OK? In the inner Bay, Petitcodiac basically became a non-river anymore with the dams. And that cut down a lot of breeding going on. And I would say the Petitcodiac also was a contributor to all other systems in the Bay of Fundy: you had stragglers going from there to different rivers." - "Or are we talking about 2021 'cause I would say some of the rivers have probably deteriorated in terms of spawning habitat and some may have been improved. I know, I know. So, I know the ones in some of them on the Stewiacke probably because of the work that my conservation group is doing and the work that the Cobequid salmon association done, they probably improved spawning habitat. Anywhere where the Adopt-A-Stream people were working, I would say have improved situations." - "In the early years they had salmon cages over in Passamaquoddy Bay in that area. And then they decided that they would put some over on the Nova Scotia side. And there are scientific papers out there, and work was done in the mid 90s […] that found out the area where they have some of the cages now in Nova Scotia was an area where the fish stayed. It was a staging area.[…] The inner Bay of Fundy recovery team also talks about essential or critical habitat. That was one of the areas that were critical habitat, but yet even though the species is at risk, we allow aquaculture to occur in a critical habitat. So, I mean, we can't have it both ways. And that's the concern I've got, you know: if we want to save the fish, then why are we contributing to their demise by allowing cages in an area which has proven to be critical habitat?"

Participant	1. Progress towards recovery objectives	2. Ecological changes
PC1	**Current abundance, distribution, survival** - "We, in Fundy National Park, I find have made good progress with what we have had to work with. Last year we had returning adults that we haven't seen in 30 years. They are the product of restoration activities and judged by some to be not wild and therefore not counting. But there's 100 salmon in Fundy National Park rivers, and there are zero salmon in 38 other rivers that are doing presumably "the right thing" in the inner Bay of Fundy." **Self-sustainability** - "PC1: Huh. So, the question, in other words: is there a future where there is a self-sustaining inner Bay of Fundy Atlantic population that is not requiring input? PI: In your opinion? PC1: No. I don't think the ability is there." - "in that case, I don't know who could conclude that recovery for Inner Bay of Fundy is feasible. It will require significant inputs to exist in our lifetime: there's no fast way out of this."	**Freshwater and marine conditions** - "Salmon trends are not going in a favorable direction anywhere, so if self-sustaining populations are your bar, you might be better to invest in something else, because the number of populations requiring support, they're only going up, and this is a long game." **Allee effects** - "We could legitimately be criticized in the inner Bay of Fundy, Parks Canada, DFO, whoever is working on this, for beginning with a lost population. I think it would be a credible argument and it could be articulated and defended."
PROV1	**Current abundance, distribution, survival** - "I would say that there are probably individual systems within that inner Bay that are capable of recovery."	**Freshwater and marine conditions** - "I think that recovery in some systems, from my hundred-mile view, it seems that North Shore, the Fundy, and the Petitcodiac seemed better off than what we were facing in some of the Nova Scotian systems that are really suffering from hydroelectric facilities, poor fish passage, poor land management practices, aquatic invasive species. In those more remote sections of New Brunswick it, it seems like, you know, much more realistic to consider, that they will recover to the point where humans are not needed for them to survive."
DFO Written Response	**Current abundance, distribution, survival** - Despite recovery efforts to date, there have been ongoing range-wide river-specific extirpations and ongoing low abundances, even in supported rivers.	N/A

Table C.2: Key quotations from interviews about technical feasibility

Participant	1. Current approaches	2. Understanding & addressing threats
AC1	**Focus on LGB and genetics:** - "In terms of maintaining that genetic diversity, and in terms of what was left when they started to preserve and maintain it so it wasn't lost, DFO and the collective have done a really good job. The Live Gene Bank is class for that, to preserve those genetics, to have something even available to conserve, I think they need to be commended for that. But it hasn't resulted in a self-sustaining population... And so, I think that's where we need to separate the two and say, "OK, here's a tool to preserve the genetics, but it's not a recovery tool." Don't get rid of it because we need it, but we need to move beyond that." **Changing management approaches:** - "If we wanna meet the goal of 10 or 19 rivers, we need to start thinking about doing conservation at scale. Unfortunately, most of the recovery is focused on a handful of rivers, for a whole host of reasons... but we need to get out of that mindset that we can only focus and work on these few rivers, and somehow it will magically fix itself." - "Although the recovery team and everything is focused on the population, recovery actions aren't at the population level, but focused on a river-by-river aspect. There's definite positives to that for sure, but at some point, in order to meet any of those criteria, we have to step beyond that and link together these four, five, six, seven projects so that designatable unit scale has to be the unit of conservation."	**Addressing threats:** - "I think there's this idyllic view that at some point the population will return to what it once was. And whatever that means, I guess, is again up for debate. But the landscape has changed greatly, and it's changed at all levels and in every way, shape or form. So, what once was may just never be—ecologically, with taking salmon out of the picture, the environment that was 20, 30, 40, 50 years ago, it just may not be there. And so, I think we have to come to terms with that."

Participant	1. Current approaches	2. Understanding & addressing threats
DFO1	**Focus on LGB and genetics** - "Our work is allowing it to persist, but it's not leading to recovery, and I don't know if it can under current conditions." - "The department's recovery program is focused on maintaining that genetic signature because that's what the population is defined by. However, that's different than saying we need to keep Atlantic salmon in that portion of the species' range. Right now, we're doing all this pedigree work to maintain genetic diversity and minimize inbreeding expression, but another argument could be made: is that really what the goal should be?" **Changing management approaches:** - "This is where we're starting to have internal discussions, not as the recovery team but among scientists, that maybe we're not seeing long-term positive outcomes from what we're doing right now, so is it time to consider other approaches that may impact on that genetic definition of the population? Like, maybe is it worth doing two or three years of a whole whack of smolts put out through our supplementation programs and see, maybe a couple of pulses like that get things over the hump. I don't know."	**Research on threats:** - "[Finding the causes of marine mortality] has turned out to be a particularly wicked and intractable problem." - "It turns out that it's very difficult to determine what happens to individual smolts or salmon as they grow and mature in the Bay of Fundy or out into the ocean. It's very difficult to follow them, and there's not a lot of them to begin with, so they get lost in this huge 3D environment. Even with the work we've done with tagging and telemetry, being able to determine what happens to a fish in time and space has turned out to be very, very difficult to do with the technology that's available now. And I hate to say it, but in five years of studies by many groups, not just DFO, we haven't moved the needle very much on that one." **Addressing threats:** - "With inner Bay, if it is determined that it is feasible for recovery both biologically and technically, then you could almost throw out the other channels and just say "first we need to focus on persistence," and what do we need to do to ensure habitat quality, reduction of human induced mortality? There's not a lot we can do around other things, but habitat quality we can directly interact with, and we can mitigate human induced mortality. We've removed most of those barriers."
DFO2	**Focus on LGB and genetics** - "I think it's true what the reports say, that if you want to conserve genetics, you're doing the right stuff. But "how does that relate to recovery" is the question that never got asked. There's conserving genetics and then there's recovery, and those connections were never explicitly made." - "You can conserve genetic material, but if the environment that you're putting them in is full of the threats that caused them to decline in the first place, they're never going to recover. You can't do one without the other." - "Nothing is getting better by waiting. Waiting is like... basically waiting for a long death. I think it could very well turn out to be that way."	**Addressing threats:** - "I think the live gene bank is doing its job, but making the environment a place where recovery could occur... that job's probably not [being done]." - "The recovery potential assessments are a science process, and what they generally tend to focus on is the status, the general conditions for there to be recovery. Where science meets management is all in the mitigation, and evaluating any actions that might come out of that. I just saw that in general, that was the least meaty section in those documents."

DFO3	**Focus on LGB and genetics** - "One side [of iBoF salmon management] is preventing extinction through actions like the Live Gene Bank, which as far as we know has preserved something close enough to an inner Bay of Fundy salmon. The other side is recovering to the point where you're at the recovery target, and when it comes to feasibility, I don't know if the distinction was made about the difference between those." **Changing management approaches:** - "If the first objective in the Recovery Strategy is to maintain genetic diversity, is that good? We've had this debate, but diversity gives you the ability to adapt to changing conditions. That means you will have fish in your populations that are not well-adapted to current conditions. An alternative is to maximize fitness, but it's a tradeoff, right: do you do so at the cost of diversity?" - "Choosing to run the Live Gene Bank using hatcheries was a practical decision: we know how to deal with freshwater, and we have hatcheries, so we can do it this way. That probably happened initially without really thinking about the direction the Live Gene Bank would take; people just knew they were losing fish and they wanted to do something about it."	**Research on threats:** - "We've done some research to narrow down what that window is [of mortality in the ocean], but we still haven't identified that final cause. This is the unknown category." - "There is a technical limitation: right now, the work we do on marine survival is almost entirely using tagged fish, and the size of the smolts, and the size of the battery needed for the tag, and the need for a the receiver array that can reasonably detect fish in the ocean--we haven't resolved that technical issue to further and better understand where the mortality is and how that happens, you know." - "I mentioned the work with [X], trying to find correlates with marine survival for inner Bay of Fundy salmon: we put aquaculture production in that [model]. The problem we had with that was there wasn't variance in the aquaculture production: it was just an exponentially increasing curve. And as soon as you differenced that data to deal with the time series issues, there's really no information in that signal [unintelligible]. We tried looking at it that way but couldn't get it... there is room to look at that a little bit further." - "It's like so many things with uncertainty: there is research being done in that direction, right? So it's not being ignored; I think it's more accurate to say that it's identified as an uncertainty, and that there's research like the tracking work, and the work done here with influence and survival of fish around the cages, that is all geared to help address the issue." **Addressing threats:** - "Freshwater, we have a lot of control: you can see what we're doing, we know how land use impacts aquatic ecosystems, we know what habitat looks like, we know how to do habitat restoration. There's a lot that we can do there. In the marine environment, we have very little control other than activities like fishing or mineral exploration, but that that's pretty much it. And then the estuaries sit in between, where we have some control, but not the same amount that we do in freshwater.... the trick is if you can somehow offset the mortality in the ocean with work in freshwater. Is there anything occurring in freshwater that's going to affect their survival at sea? The reason I'm interested in questions like that is very much because it puts us in a place in working in an environment or habitat where we can control the conditions. If there are some gaps in information, in terms of the recovery planning process, to me, that's kind of the big one." - "On the Inner Bay Fundy, the marine survival is somewhere around two or three adults per 1000 smolts that leave the river; on the Southern Uplands it's around two or three per 100. And what that does is, it changes what you can do in terms of recovery activities." - "I wonder if—this is all very much speculation since there's no way to test it really—but if those are areas, particularly Passamaquoddy which has the better conditions for survival of salmon, did we lose that when aquaculture was developed? Did we lose a component of populations that would have overwintered there? And then when we do our studies now, we assume that we have similar salmon to what we had in the past, but it's not out of the question that we've lost a component with different behaviors. PI: Interesting. And is that not really being explored much? DFO3: I don't know how you would do it."

Participant	1. Current approaches	2. Understanding & addressing threats
DFO4	**Focus on LGB and genetics** - "But they didn't recover on their own. And as the population decline persisted and increased, then the interventions started to increase, mainly with the hatchery intervention trying to maintain a salvageable population." "There was a review that occurred in Ottawa, a National Review and there's a document that came out of that. There were scientists recruited from across the country to participate and so somebody who was a scientist but he was actually working for senior management in Ottawa led the charge and actually chaired the meeting, and out of that came a document and it dealt with—it wasn't just strictly related to feasibility, it was whether in fact genetic diversity can be protected through their Live Gene Banking program. So, it was more of a review of whether the Live Gene Bank was an effective way to approach that aspect of the recovery process, which would contribute to the feasibility because if you couldn't protect genetic diversity through the Live Gene Banking program, then it was not going to be feasible because if you don't have a diverse population, then you're chasing your own tail."	**Research on threats:** - "For example, everyone believed that they were migrating out of the rivers, then not returning back, so where are they dying when they've left the rivers? Are they dying 10 kilometers from the rivers, were they dying at the end of the Gulf of Maine, were they dying when they left the Gulf of Maine? And what was killing them when they did? So that's expensive to find out. How do you find that out? That takes a lot of marine research, some of which was successful, some of which was not." - "The outstanding question was not a great understanding of the threats, and that was because of the cost, the expense, and the time it would take to actually do an exhaustive investigation into the threats. In other words, you have to make a decision, do we ask or not ask? We've got 100 questions to answer, let's go answer 100 questions, but then the population is gone, you know what I mean? So, you certainly see that part of your answer is no, we didn't really have enough understanding of the threats, but we did have enough knowledge to know that if we waited to get all that understanding, the feasibility would have declined considerably." **Addressing threats:** - "There are still a dozen potential threats: certainly, narrowing down those would improve the prospects of feasibility if they're tractable threats. If it's climate change, for example—in other words, changing the ecosystem as a result of climate change—well that's not tractable, because we already know where climate change is going. So, I guess that goes to feasibility as well, if you're trying to address a threat and you can't do anything about it. I mean, even on the practical front, let's just say we said "OK, we've now discovered that the grey seals are harvesting too many salmon, they're eating too many salmon when they get out of the rivers, so we have to go out and we have to kill 50,000 grey seals a year for the next five years." No one's gonna do that. It's not gonna happen. So, we might as well call it a non-tractable solution, so that means feasibility could go out the window."
IN1	No direct quotes provided, by interviewee request.	

Participant	1. Current approaches	2. Understanding & addressing threats
NGO1	**Focus on LGB and genetics** - "If we could somehow magically find 100,000 salmon adults and put them in the water that you know that there would be enough there to withstand the predation or interactions with humans or whatever, that would be able to repopulate. But when you've only got returns of a few dozens on river systems come, then you don't have too much hope other than to at least catch those, spawn them out, and maintain the genetic diversity." **Changing management approaches:** - "I think the river-by-river approach is the appropriate approach for recovery. It does come down to habitats and it comes down to people doing work on those habitats, and people are going to be most concerned about what's in their backyard." - "I'm excited with the work that has been done by Parks Canada, looking at taking some of the some of these younger smolts, raising them in at-sea cages and then letting them back."	**Research on threats** - "The other really big thing sort of hanging over everybody's head was that we just had no idea what's happening now in the marine environment. As I said, these fish go up to Greenland or beyond, and there's a number of fisheries out there, some directed like long lines, trolling and everything else, as well as bycatch of salmon. We know that there are sharks and other things that eat salmon. But these were all still very unknown in 2010 as to the extent." - "Since that time there's been better reporting of SARA Bycatch. There's been better methods employed to direct catch and reduce bycatch, and there's been additional satellite tagging studies that have shown just how much sharks or seals or whatever are eating salmon. And so, I think we're starting to unveil what's happening out in the marine environment." **Addressing threats:** - "Over the last 10 years, 12 years, I think it's become more realized just how much work this really is, and how much more work needs to be done. And I think if we knew in 2010 what we knew today, particularly under the government in 2010, I don't know if the plug may have been pulled, because there was just so much effort that need to go into it." - "And then there was just a number of assumptions: we had people telling us "Oh yeah, that certain brook or this certain section of the river is beautiful habitat, there's always been a ton of salmon there," blah blah. You know, if you're going to be doing work, you should really go back and look at this area. And we're going back and finding out there's just no way that habitat could support a salmon redd, just no way: the water is, you know, the water is that tall in the summertime, and it's eight feet tall and rushing like crazy in the spring and the fall, it's digging out and rechannelizing every year, the frazil ice, and everything else… You just can't sustain a redd, let alone juvenile salmon."

Participant	1. Current approaches	2. Understanding & addressing threats
NGO2	**Changing management approaches:** - "Will we ever come to never needing to get involved again? I don't know. Maybe if we would have been involved 400 years ago or 300 years ago, and much more conscious of how we were harvesting it, rather than doing it just like the cod fishery where it got fished to collapse.	**Research on threats:** - "When I was starting to look at it, there was a lack of empirical knowledge about the salmon itself" - "Through the process of developing the strategy or the recovery plan, more and more information was brought to light, and I think if anything, it wasn't the fact that it [the process] was going to actually recover the salmon, but what it did do was start to raise awareness about the lack of information, or what was being found." **Addressing threats:** - "So, we've done a tremendous amount of destruction. Human beings are good at two things: destroying and trying to repair. But unfortunately, there's some things you can't repair, and I think that… That's why I said you picked an interesting subject, because I think it's gone. And it's gone just because of the human destruction of its habitat." - "I mean, we have people saying there's hatchery problems, lice, inoculations of pesticides and herbicides in the rivers, mixing of domesticated salmon versus a natural growing salmon, things like that. I think we have crossed a point of no return. PI: I see, it's changed so much that it's hard to imagine it going back. NGO2: Within the last 50 years, I think we may have crossed the point of no return."

NGO3	**Focus on LGB and genetics** - "I guess one of the big issues that the Atlantic Salmon Federation has had is when the efforts were made for the recovery program with Live Gene Banking- all great when said and done- they ignored what the problems were that needed to be addressed, and [the LGB] is really a band-aid solution at this point." - "DFO was really focused on the LGB, and has not looked at the overall management and what needs to be done to address the threats." - "Information that came out within the last three to four years suggests that illegal European stocks have been used in the [aquaculture] industry, and that has shown up actually in iBoF rivers. There have also been indications from talking to now-retired geneticists from DFO that there's probably a large component of aquaculture escapees whose genetics may have been brought into the program. So the LGB program itself, in my opinion, has been jeopardized over the years." **Changing management approaches** - "Now with the Parks program, they're seeing fish come in the river, but I mean, it's not enough for self-sustaining."	**Research on threats:** - "If you aren't recovering, you've got to identify what the issues are that are constraining the recovery to begin with and DFO has not done a good job at that. They still haven't identified critical habitat—that was one of the priorities with recovery program that has never been done, to my knowledge, in terms of identifying where these fish are spending their time in the ocean. Issues such as salmon aquaculture have not been addressed either, and that has played a huge role in not allowing the recovery" - "[I]t's other issues that you have to deal with in terms of water temperature and predator-prey dynamics, have the fish adjusted to that or not, and if they have then they stand a chance of recovering. But then because of climate change, who knows? We may find that the conditions that these fish do remain in the Fundy-Gulf of Maine region, just the changing sea conditions, has now made it uninhabitable for Atlantic salmon, unless they moved to Greenland, right? … There's so many unknowns that we just don't know if the fish do stand a chance at recovery." - "Yeah, there's a lot of unknown threats that needed to be researched to identify where the threats lie. Now, without a doubt—and not just with the inner Bay of Fundy, but outer Bay of Fundy and Newfoundland stocks too—aquaculture has been listed as one of the key threats, being when these fish get into freshwater and interbreed with salmon, that's where it is proven without any doubt that that is a threat. A potential threat is parasite load, for which the information is lacking here in North America: it has been shown on the parasite side, at least with sea lice in Europe, but the information hasn't been proven over here yet. A lot of potential threats were initially identified in the in the very first review, where we put the information forward to have the listing. Those threats and studies have not been carried out. It's basically just move forward with Live Gene Bank, and nothing of much other substance from DFO." **Addressing threats:** - "[T]he goal of trying to set the stage so that the fish have a chance at recovery has never been met from DFO to date. That's never been met. So, to me they're still kind of at stage one or stage 2, many decades on." - "[I]f you don't address the threats to the salmon, which—that's where I'm going with this, it's not just aquaculture, these other threats to that have not been addressed right? DFO, in my opinion, hasn't addressed hardly any of the threats in terms of funding." - "I'll just use the example of changing water temperatures and food availability: if that's something that is a huge threat, it's really out of our control, and that may minimize the chance of recovery, and it's more or less, "What are we putting our efforts into this [for]?"" - I think the idea of feasibility in my mind, or my opinion, is lower than it was back in the 2000s in terms of chances of recovery Even best-case scenario, if you get rid of the aquaculture threat and it… well, put it this way: if you can get rid of threats that you can actually control, but because of the changing ocean, especially in the southern range, I think the feasibility chances are somewhat lower due to climate change, and the reason being is if these fish do overwinter and spend their entire at-sea residency in the Gulf of Maine-Bay of Fundy region, these waters have changed, and they may not be as hospitable to Atlantic salmon."

Participant	1. Current approaches	2. Understanding & addressing threats
NGO4	**Focus on LGB and genetics** - "When I was there, I got the feeling that something was being done- like the LGB is what they were using in the Stewiacke River. But I felt there wasn't enough being done... the LGB was a good program, and it was doing what it was supposed to do, putting fish back into the river. But we don't know how successful it was. We still don't know: are there adults coming back? Are there adults going out? And no one has ever told me that yes, there are more coming back and going out now than there ever was before." - "If these are fish that are only from the live gene bank, then we're in trouble. We've shown that the species is alive only because of the live gene bank, then how much longer do we want to put money in the live gene bank? It's telling us that it won't support wild salmon."	**Research on threats:** - "PI: In fact, I believe marine critical habitat still hasn't—like it's been preliminarily identified. NGO4: Yeah, it has. It's been identified, but they haven't turned any screws on it yet." - "For a couple of years we had a smolt wheel, but it worked, it didn't work, and so forth. I don't think we worked hard enough at that... We had, for a couple of years, a fish ladder, but there wasn't enough monitoring done on that fish ladder... It wasn't being operated properly, and it's finally disappeared." **Addressing threats:** - "The inner Bay recovery program state basically at the end that there were four potential problems for the inner Bay of Fundy salmon. Three of them were environmental, prey-predator relationship and so forth, or the population is too small, it can't look after itself, this type of thing, inbreeding, all that other stuff. Yeah, the other one, which we could do something with, was aquaculture." - "Now after I've said that, we can't control food webs and food chains, the chemistry and the physics of the ocean. There is one thing that was mentioned that we can control. So that's where you are." - "And I'm not too sure whether or not they can be saved. It may not be possible: those are the facts of life. More and more species from the south are coming here.... Things are moving."

Participant	1. Current approaches	2. Understanding & addressing threats
PC1	**Changing management approaches:** - "We, in Fundy National Park, I find have made good progress with what we have had to work with. Last year we had returning adults that we haven't seen in 30 years. They... are judged by some to be not wild and therefore not counting, but there's 100 salmon in Fundy Park rivers, and zero salmon in 38 other rivers that are doing presumably "the right thing". So we'll let the public judge what they would rather, but I feel we have done our job to the public to maintain this animal... moreso than just saying, "We've got a genetic code in a captive environment somewhere, so we're holding onto it for you and we've done a good enough job."" - "That's the evolution of thinking here that this is more than an Atlantic salmon restoration situation: it's an ecosystem function restoration. And with salmon in Fundy National Park, our ecosystem is functioning at a higher level than without it: for the reason of ecosystem function, we have done a good job for taxpayers by keeping Fundy National Park's ecosystem functioning." - "this is the seat that I want to sit in, you know, 100 returning fish is better than any single river in the Bay of Fundy. Even though those fish were themselves released in previous years, they came back on their own and that is not perfectly wild, but it is better than the zeros that are everywhere else. And I can't see or what metric I would say, "Ah, we should have stayed with the traditional method only," because look what they- like- There's nothing there in my opinion. So I like this."	**Addressing threats:** - "I don't think the ability is there [to have a self-sustaining population]. It's not that the ocean or the rivers of the iBoF are entirely incapable of doing this, but I also don't think it's possible to wind back the human impact clock by pretty well 100 years and have that environment exist in the future. I don't think we will stop enough urbanization, agriculture, aquaculture, high seas fishing, forestry, mining, damming, and wind back all those metrics to some heyday that people would hope for. The trends of all those lines have gone in one direction, and I just don't see us going back there." - "On the inner Bay of Fundy, I wish after 20 years of work that we had started 20 years before, because I think that it would have been a much easier mountain to climb to get to where we are right now." - "But I still feel that I deserve criticism for not-- after 20 years!-- should be a little further down the road than we are. So that recovery team can be criticized for not getting enough done fast enough"

Participant	1. Current approaches	2. Understanding & addressing threats
PROV1	**Focus on LGB and genetics** - "With DFO prioritizing genetic integrity as a key component to recovery strategies, it's almost as if it would not be considered a recovery success if genetic integrity was not maintained. And so they've put that as one of the pillars to recovery, that genetic integrity, and you know, I'm sort of a mixed feeling for the reasons that I mentioned earlier with respect to losing salmon anglers, losing that connection to the people: if we're so focused on [genetic] diversity that we lose the fish, short of them just existing in a facility for the sake of maintaining genetic integrity, then I think that we've done ourselves a disservice." **Changing management approaches:** - "One of the biggest challenges is you need to have a culture shift and a change in societal values that would be, I guess, more salmon-conscious in land-use practices, in support and recovery planning."	**Research on threats:** - "But I mean, the collection of data. I mean we only have—is there only one counting fence that tracks upstream and downstream movement on the inner Bay, at the Gaspereau river? So I mean, that's the only system that they're tracked. Why, 10 years ago, was there not some other assessment or effort made, even counting fences or something? I do question that." - "I guess what I have become apparent to is there's still a lot that we don't understand. I thought at this point, we would have a better grasp on those stressors: of what's causing at-sea mortality, loss of habitat juveniles… I don't really know. I thought we'd have a better handle on what the issue was at this point, 10 years into recovery. When I came on to this committee, I thought, "OK, we must know a little bit more—" No, we don't! And of no fault of anybody's on the team." - "I mean, that's the nature of science: sometimes you do experiments, and the results aren't conclusive in in a way that is meaningful, or is interpreted—it's funny when you see the same data can be interpreted it by different parties in different ways and giving conflicting results. A wicked problem, yeah." **Addressing threats:** - "I feel like the meetings that I have been a part of are not information-seeking meetings, they're information sharing meetings, up to this point. There hasn't been a lot of "how do you think we should do it?" I think that's probably just the stage that we're at in the recovery plan." - "I don't know if it's changed… I guess what's been more apparent is that the struggles are real. The challenges are real. Recovery isn't as easy—it's far more complex than we think it is... And so, have my perceptions changed? No, I don't think they have, but I guess more solidified that this is going to be a challenge, that this isn't gonna happen quickly."
DFO Written Response		**Research on threats:** - "Despite the uncertainty regarding the causes of low marine survival and hence recovery feasibility, it would be premature to conclude that recovery is not feasible without further effort to understand limiting factors."