Recovery of Atlantic Salmon in Fundy National Park

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List of abbreviations

COSEWIC	Committee on the Status of Endangered Wildlife in Canada
DFO	Department of Fisheries and Oceans (Fisheries and Oceans Canada)
FNP	Fundy National Park
FSR	Fundy Salmon Recovery
iBoF	Inner Bay of Fundy
LGB	Live Gene Bank
PCA	Parks Canada Agency
SARA	Species at Risk Act

Executive summary

Parks Canada is a key player in ecological restoration practice and policy-making in Canada. To illustrate how the federal government agency carries out ecological restoration work, we examined ongoing recovery efforts to bring the endangered wild Atlantic salmon (*Salmo salar*) of the inner Bay of Fundy back to Fundy National Park (New Brunswick). Our study offers a first close look at their trajectory. We used a case study approach based on document analysis and semi-structured interviews with park restoration practitioners to address three objectives:

1. Describe the components of an ecological restoration project implemented by Parks Canada.
2. Discuss the effectiveness of applicable ecological restoration policies based on the perceptions of practitioners.
3. Identify challenges and opportunities for improvement in ecological restoration practice and policy.

The Upper Salmon River and Point Wolfe River in Fundy National Park (FNP) have historically hosted salmon populations and constitute two of the 10 river systems considered critical habitat for the recovery of inner Bay of Fundy Atlantic Salmon. Implementation of recovery measures within the park started in 2002 when FNP joined the Live Gene Bank, a program that rears and breeds Atlantic salmon in captivity to conserve the genetic diversity of populations in the region. FNP and its collaborators later established the Fundy Salmon Recovery program, the first wild salmon marine conservation farm in the world. Fundy Salmon Recovery uses a customized aquacultural setting to grow wild salmon in net pens until maturity, when adult salmon are released back into rivers to spawn naturally and produce offspring with no captive exposure. These measures are complemented with monitoring that follows the performance of salmon over life stages and across generations, and three visitor experience programs that combine interpretation, volunteering, and training opportunities to engage the public.

Several policies, largely compatible and overlapping, have shaped the restoration work at FNP over time. The Species at Risk Act has provided an overarching framework for recovery planning, leading to the regional goal and objectives the national park follows. FNP has additionally incorporated the agency's operational policies and the restoration guidelines adopted by Parks Canada's Conservation and Restoration program in developing park-specific objectives for the restoration project. Practitioners highlighted two common elements across these policies as key features of the project: collaboration and adaptive management.

All practitioners agreed that collaboration was a key factor for the success of the project so far. The recovery of inner Bay of Fundy Atlantic salmon has relied on joint contributions by federal agencies, First Nations, provincial government from New Brunswick and Nova Scotia, municipal government, academics, industry, interested civic groups, and volunteers. This broad collaboration has afforded the park multiple forms of support (e.g., facilities, equipment,

human resources). Based on documents and interviews, collaboration seems to have happened throughout every phase of the project, starting with stakeholder involvement at an early planning phase. While best practices for ecological restoration typically cite the need to work collaboratively in early stages, projects too often omit this step. Our study suggests FNP provides an exemplary case in this respect, but a research need is to further understand collaboration by including the perceptions of additional project partners and collaborators.

Based on the perception of practitioners, adaptive management has been successfully applied in the national park and is best represented in the use of monitoring data and experimentation to develop the marine conservation farm. At the same time, practitioners recognized that new risks and trade-offs may emerge as measures are applied over time, even in a project deemed successfully implemented. Several reasons are potentially related to the perceived success of adaptive management in FNP (e.g., stakeholder engagement, use of pilot projects, prompt application of gained knowledge). An opportunity for future research is to clarify their relative contributions and that of other factors not considered here (e.g., how stakeholders participate in the adaptation process).

In the short term, the restoration project at FNP is expected to continue evolving to increase the spawning efficiency of adult salmon grown in the marine conservation farm. Ongoing research is also targeting the impacts of salmon reintroductions on ecosystem productivity. In the short to long term, the social dimension of Atlantic salmon restoration is a major frontier for the project, linked to the idea that engagement is key to restoration success. Priorities in this respect are to better understand and facilitate the involvement and stewardship of local communities, develop indicators of success for public engagement, and assess the impacts of these initiatives. However, social researchers make up a noticeable gap in expertise that will need to be addressed to advance this project dimension.

Atlantic salmon populations within FNP are showing hopeful but moderate signs of improvement: the densities of wild born juveniles have increased, a portion of wild smolts is migrating to the sea, and a portion of adults reintroduced to rivers is surviving at sea and returning in the following years. Nevertheless, the two park populations make a small portion of the inner Bay of Fundy population assemblage and will need sustained restoration efforts in the long term. This prospect suggests recovery efforts may face two challenges in the future. On the one hand, it may need to address an important question for ecological restoration practice: is it justifiable only if sustainable? In FNP future restoration may turn its focus to maintenance of ecosystem functions rather than self-sustaining populations. On the other hand, long term efforts may call for new approaches to engage the public and local communities. Conflicts among stakeholders surrounding access to Atlantic salmon in FNP were not evident in this study but could emerge as community stewardship is pursued while access remains restricted. Finding solutions to the challenge of restoring human-nature interactions with an endangered species may be a future policy-making task in this case.

Introduction

The Atlantic salmon (*Salmo salar*) is an anadromous fish species with 16 population groups in eastern Canada (COSEWIC, 2010). The populations of the inner Bay of Fundy (iBoF), nested between New Brunswick and Nova Scotia, make up one of the five population groups currently endangered within the Canadian range of Atlantic salmon (COSEWIC, 2010). Different management interventions have targeted iBoF salmon for more than 30 years since a marked decline was observed in the 1980s.

Fundy National Park (New Brunswick) includes two of the 10 river systems considered critical habitat for the recovery of Atlantic Salmon in the iBoF region (Department of Fisheries and Oceans [DFO], 2010). To bring wild salmon back to these rivers, Parks Canada has worked alongside many collaborators to develop and integrate measures to conserve the genetic diversity of wild salmon and increase its numbers. Fundy National Park (FNP) combines traditional captive breeding, an innovative aquacultural rearing program and public engagement initiatives to recover a species with ecological, cultural, and economic values. These recovery[1] approaches are part of the larger, collaborative ecological restoration plan to recover Atlantic salmon across iBoF.

Parks Canada is a key player in ecological restoration practice and policy-making in Canada. The federal agency had a pioneering role in developing national level principles and policies for restoration (Parks Canada and the Canadian Parks Council [PC & CPC], 2008) and is currently in charge of more than 70 projects nationwide (K. Prior, personal communication, May 7, 2021). Parks Canada has also influenced international restoration policies as its *Principles and Guidelines for Ecological Restoration in Canada's Protected Natural Areas* (PC & CPC, 2008) provided a foundation for the International Union for Conservation of Nature (IUCN)'s ecological restoration guidelines (Keenleyside et al., 2012). In iBoF, Parks Canada is both an important restoration practitioner and policy maker for the recovery of Atlantic salmon.

By using a case study approach, we aim to illustrate how the federal government agency Parks Canada (PCA) carries out ecological restoration work. We combined document analysis and semi-structured interviews with three key informants (see Appendix A) to address three objectives:

1. Describe the components of an ecological restoration project implemented by Parks Canada.
2. Discuss the effectiveness of the applicable ecological restoration policies based on the perceptions of practitioners.
3. Identify past and present challenges, and opportunities for improvement in ecological restoration practice and policy.

[1] "Recovery" is used here as both the outcome and process of restoration. While the Society for Ecological Restoration has reserved the term for the outcome (Gann et al., 2019), we use its dual meaning to reflect its usage by the Species at Risk Act and those involved in this case.

Our findings are presented in a predominantly chronological narrative, structured to clarify (a) the relationship between the recovery work at site level and its regional framework, and (b) the general restoration process followed by FNP. The restoration process has been configured by multiple policies over time, showing different degrees of detail and slightly different orders for tasks, but exhibits six common phases: 1) collaborative problem definition; 2) assessment of conditions; 3) development of a plan; 4) implementation; 5) analysis and adaptation; and 6) knowledge sharing (see Table C1 in Appendix C for a comparison of policies). We reference these phases below to help depict the recovery trajectory. However, it must be noted that, as is often the case, recovery work for iBoF Atlantic salmon has not happened in an ordered sequence – within the national park or across the region – and at times more than one phase were co-occurring.

Significance of Atlantic salmon to iBoF

The Atlantic salmon of iBoF is unique to this region of eastern Canada. A combination of observations on genetic differentiation, phylogeography, distinctive environmental conditions, behaviour, and life history has set iBoF salmon apart from other population groups in North America and Europe (reviewed by COSEWIC, 2006). While the morphology and life cycle of iBoF Atlantic salmon is representative of the species (DFO, 2010), iBoF salmon is distinguishable by generally remaining within the waters of the Bay of Fundy and the northern Gulf of Maine during its marine phase; typically reaching sexual maturity after their first winter at sea; and having a greater reliance on repeat spawning for population stability (COSEWIC, 2006; DFO, 2010; Marshall, 2014).

Beyond making up a unique lineage, iBoF Atlantic salmon is valued for cultural, economic, and ecological roles in the region (COSEWIC, 2006; DFO, 2010). Atlantic salmon is a food and spiritual component of traditional meals in Indigenous communities of iBoF (DFO, 2010). For many people, the presence of Atlantic salmon is an indicator of the health of rivers and oceans, a sign of passing seasons, and a local identity symbol (DFO, 2010). Atlantic salmon fisheries in iBoF supported commercial harvesting and recreational catches. They also helped sustain trade relationships among Indigenous communities, and between Mi'kmaq and English groups during the creation of treaties in Atlantic Canada (DFO, 2010). Additionally, Atlantic salmon provide a connection between freshwater and marine ecosystems in iBoF by transferring energy and nutrients throughout its life cycle (COSEWIC, 2006). How these energy and nutrient inputs impact other organisms across trophic levels in rivers is a present focus of research on the ecological role of the endangered species.

Decline of the King of Fish

Data records from recreational fisheries point to the historical presence of Atlantic salmon in at least 32 rivers of iBoF, although it is suspected that they may have occupied 42 of the 50 rivers and streams in the region (DFO, 2010). The marine distribution of iBoF salmon is known to include the entire Bay of Fundy outwards to the northern Gulf of Maine (USA) between May and October, while their locations afterwards and through winter are still unknown (Marshall 2014). Atlantic salmon would also occupy estuaries across iBoF as smolts on their way to the ocean, and as returning adults (Marshall 2014). It has been estimated from historical recreational catch that Atlantic salmon may have exceeded 46,000 adults in iBoF (Amiro, 2003, as cited in COSEWIC, 2006, p. 27).

The Upper Salmon River and Point Wolfe River, the two rivers now mostly contained within FNP (Figure 1), have historically hosted salmon populations. These populations, however, had been extirpated by the 1930s since access to the rivers was blocked by logging dams and buildings such as sawmills (Dadswell, 1968 as cited in Hutchings, 2003, p.8; PCA, 2020a) (Figure 2). Dams were still present, albeit not in use, when the national park was established in 1948, and continued to impact salmon populations afterwards. One of the practitioners interviewed pointed out anecdotal reports describe schools of salmon returning to the river and bumping into the dams. For decades, no natural spawning of Atlantic salmon occurred in these rivers (Hutchings, 2003).

Atlantic salmon populations recolonized Upper Salmon and Point Wolfe after dams were removed from both rivers in the 1960s and early 1980s, respectively. Recolonization of Upper Salmon occurred naturally (Fraser et al., 2007), likely with an important influx of stray salmon from the Petitcodiac River which became increasingly inaccessible over the construction of a causeway (Hutchings, 2003). Adult abundance peaked at 1,200 in 1967 -months before the causeway was finished (DFO, 2010; Hutchings, 2003). The salmon population of Point Wolfe, on the other hand, was assisted through a collaboration between PCA and the Department of

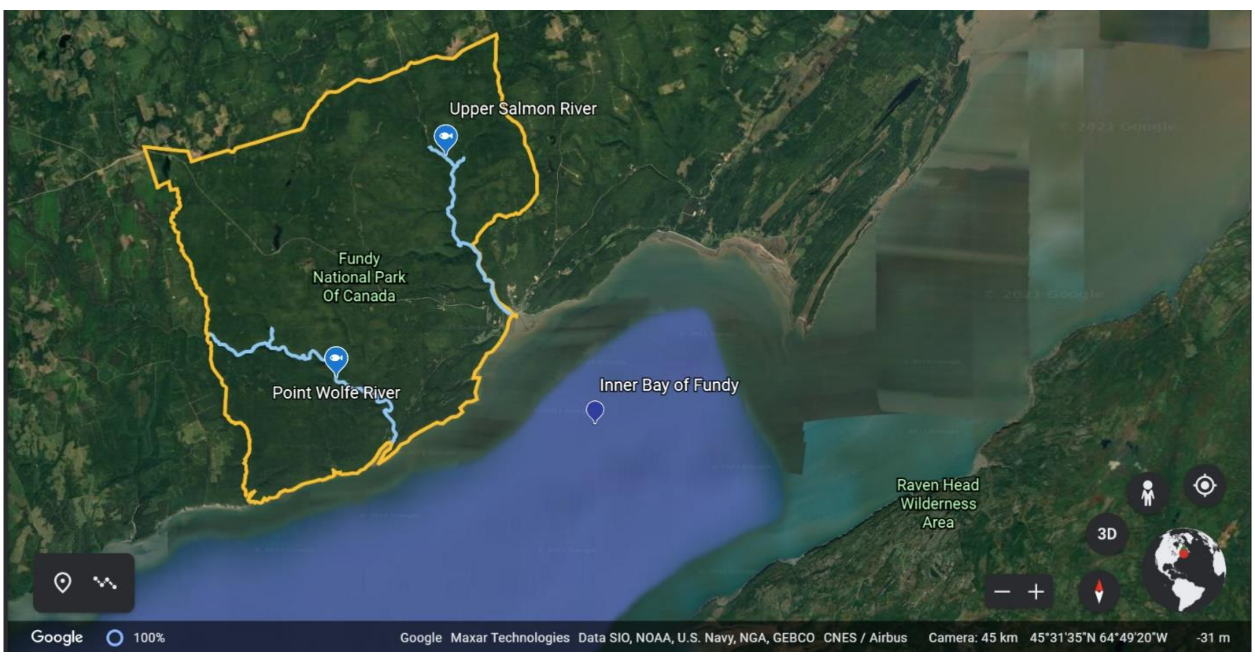

Figure 1. Fundy National Park covers 207 km^2 of land traversed by the Upper Salmon River and Point Wolfe River. Both rivers provide critical habitat to the inner Bay of Fundy Atlantic Salmon (DFO, 2010). Image from Google Earth (map data: Google, Maxar Technologies, Data SIO, NOAA, U.S. Navy, NGA, GEBCO, CNES/Airbus).

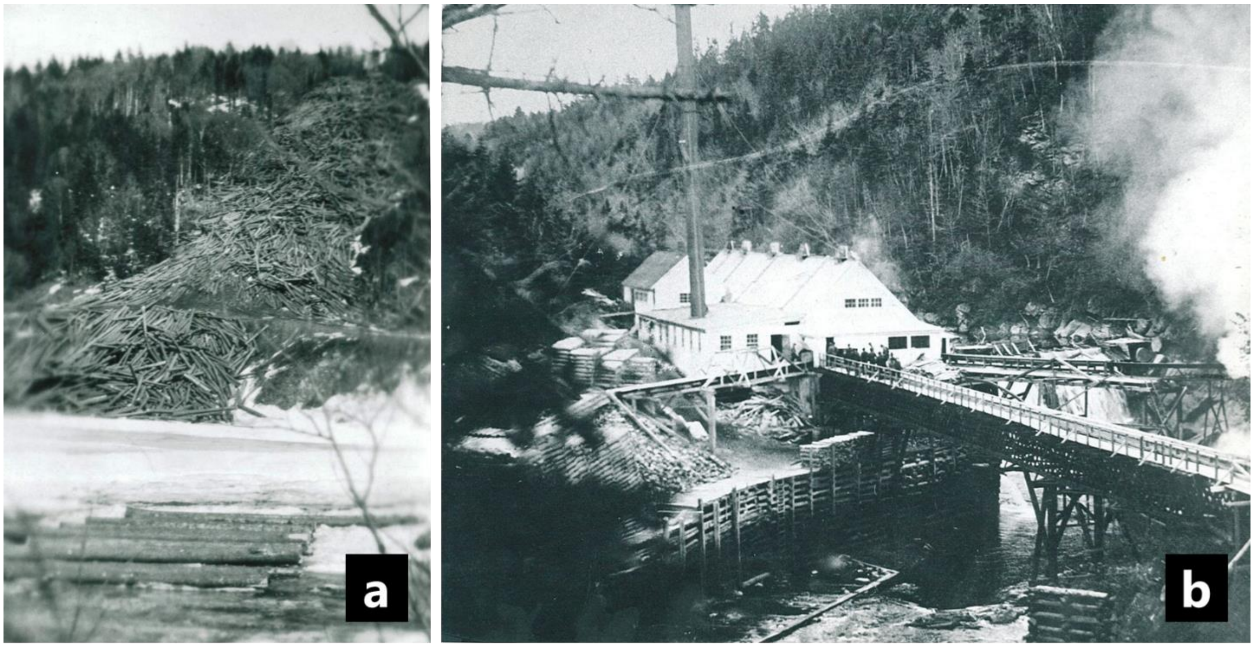

Figure 2. Logging was one of the main past land uses across the inner Bay of Fundy, including the current area of Fundy National Park. Rivers were dammed to control water flow as they were used for the transportation of logs (a). Point Wolfe River also featured a sawmill (b). Photos courtesy of Parks Canada. Adapted with permission.

Fisheries and Oceans (DFO) to release approximately 42,000 hatchery raised fall fingerlings (i.e., fry that show scales and extended fins) from Big Salmon River each year from 1982 to 1985 (Semple and Mercer, 1987).

Despite the recolonization of park rivers, salmon populations soon showed a downward trend in line with the regional decline that commercial catch data had showed post 1974 (COSEWIC, 2006). Between 1991 and 1994, the annual abundance of adult salmon in the Upper Salmon River did not exceed 50 (Amiro, 2003, as cited in DFO, 2010, p. 20). Juvenile abundance in Upper Salmon and Point Wolfe, monitored since the 1980s, also evidenced a downward trend by the early 2000s (DFO, 2010). At this time, populations in two long monitored rivers, Big Salmon River and Stewiacke River, had shrunk by more than 90% in the previous three decades and juveniles in most rivers that had not been previously stocked were far below the levels required for the conservation of populations (COSEWIC, 2006).

Diverse interventions aimed to increase the abundance of Atlantic salmon at multiple scales. The launch of a program to retire commercial fishing licences in 1984 culminated in the closure of commercial fisheries across the Maritime provinces (i.e., New Brunswick, Nova Scotia and Prince Edward Island) in 1985 (DFO, 2010). Although stocking of recreational fisheries had been very common throughout the 20th century (COSEWIC, 2006), recreational fisheries were restricted to a fishing season (August to October), subject to seasonal and daily catch limits, required to release large salmon (≥63.0 cm), and restricted to use artificial fly only (DFO, 2010).

Despite these limits, most recreational and Indigenous fisheries were closed in iBoF by 1990 (DFO, 2010). FNP had its last fishing season that year (Figure 3). At a local scale, management of salmon populations often meant re-establishing access to rivers by removing physical barriers to salmon or installing passages (e.g., fish ladders). These attempts were ultimately unsuccessful.

Figure 3. Adult Atlantic salmon male caught at Fundy National Park in 1967. Recreational salmon fishing was banned in the park after the fall of 1990. Photo courtesy of Parks Canada. Reprinted with permission.

The beginning of recovery efforts

The path to an ecological restoration plan initiated in 1998 when the first group of wild juvenile salmon was transferred to the DFO-administered Mactaquac Biodiversity Facility in New Brunswick for the beginning of the Live Gene Bank (LGB) (DFO, 2020) (Figure 4). The LGB combines captive breeding and rearing of salmon to conserve the genetic diversity of populations across iBoF until recovery becomes feasible (DFO, 2018). For this purpose, all fish housed in the biodiversity facility are genotyped (i.e., individual genetic makeup determined) and pedigreed (i.e., genetic lineage determined), and a portion of adults strategically crossed to optimize the diversity of the next generation (DFO, 2018). The LGB has been crucial to the persistence of iBoF salmon and continues to operate, now focused on brood stocks of four rivers, including Point Wolfe (DFO, 2019).

Around the formation of the LGB, regional stakeholders met for the first time and formed the iBoF Atlantic Salmon Conservation and Recovery Team (hereafter "Recovery Team") in 2000 (DFO, 2010) (Figure 4). DFO and PCA co-lead the group that includes FNP representatives, federal agencies, First Nations representatives, provincial governments, conservation NGOs, industry, academia, and special interest groups (DFO, 2010; Appendix B). The Recovery Team advises DFO on recovery planning and coordinates recovery activities (DFO, 2010). Since 2000, it has produced two recovery strategies and one action plan (DFO, 2010, 2019).

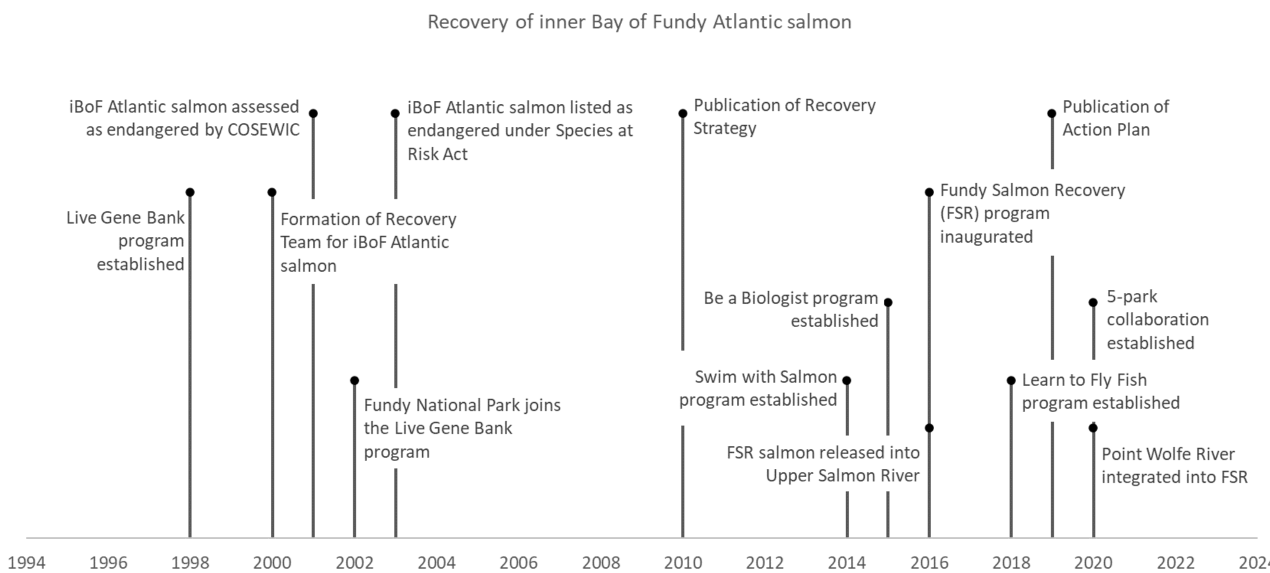

Figure 4. Important events in the recovery trajectory of inner Bay of Fundy (iBoF) Atlantic salmon at the regional level and at Fundy National Park. COSEWIC= Committee on the Status of Endangered Wildlife in Canada.

Designation as endangered

The iBoF populations of Atlantic salmon were first declared endangered in 2001 when the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) assessed their status (DFO, 2010). IBoF Atlantic salmon was then listed as endangered under Schedule 1 of the Species at Risk Act (SARA) upon its enactment in 2003 (Figure 4). Without pausing recovery actions, the federal listing caused a reformulation of the recovery planning process that was underway. Under the federal law, a strategy for the recovery of an endangered species must be prepared by the competent minister(s) after the species is included in the federal registry (SARA, 2002, subsections 37(1) and (2)) and one or more detailed action plans (SARA, 2002, section 47) should follow when recovery is deemed feasible.

Defining the problem and assessing the conditions of iBoF salmon

Before and after the federal listing by SARA, an ongoing restoration task has been to identify population trends, threats, and recovery feasibility for Atlantic salmon across iBoF (e.g., COSEWIC, 2006; DFO, 2008). Assessments have integrated efforts and information from multiple stakeholders, including FNP where monitoring was intensified after COSEWIC first declared iBoF Atlantic salmon as endangered.

The reasons for the collapse of Atlantic salmon across iBoF remain unclear but it is considered that several factors have combined, including past and recent impacts along with river specific and regional impacts (COSEWIC, 2006; DFO, 2008). Salmon migration barriers, habitat modification, and habitat loss followed the expansion of forestry and transportation infrastructure and agriculture (PCA, 2020a), while commercial and recreational fishing persisted for decades. Aquaculture of Atlantic salmon arrived later to the Bay of Fundy, expanding in the 1980s and 1990s (Carr et al., 1997). Escapes of farmed salmon were common and at times, in large numbers (Atlantic Salmon Federation, 2019; Carr et al., 1997), potentially impacting wild salmon through competition, spread of parasites and disease, and production of maladapted offspring (DFO, 2010).

At present, marine survival is considered the principal limitation to the recovery of iBoF Atlantic salmon (DFO, 2010) although the precise cause is still unknown. Multiple studies have documented a decrease in smolt to adult survival across Atlantic salmon populations that started in the late 1980s (COSEWIC, 2006). Immature salmon mortality at sea was estimated at 97% by 2003 (DFO, 2008). Several conditions remain potential marine threats to the persistence of Atlantic salmon in iBoF including the negative consequences of salmon farming, changes in the ecological community, environmental changes, and incidental catch (DFO, 2010). Freshwater threats on the other hand, include reduction in habitat quality and extant barriers to fish migration (DFO, 2010). In addition, both the freshwater and marine stages potentially face an obstacle in having low number of individuals. At very low abundance Atlantic salmon may experience inbreeding depression, abnormal behaviour, and the inability to form shoals as a defense from predators (i.e., depressed population phenomena) (COSEWIC, 2006; DFO, 2010). The relative importance of each of these threats remains to be clarified. One practitioner, for example, perceives depressed population phenomena may be more important than realized at present.

Planning for recovery actions

SARA has provided the overarching framework for the recovery of Atlantic salmon in the iBoF region by establishing the conditions for recovery planning. SARA, however, does not prescribe a protocol to conduct ecological restoration; rather DFO and PCA, with input from the Recovery Team, have decided on this aspect throughout the planning process. Adaptive management, for example, is not prescribed by SARA but was identified as a necessary approach for the recovery of iBoF Atlantic salmon (DFO, 2010, 2019).

A SARA-compliant recovery strategy was published for iBoF salmon in 2010 that incorporated a first recovery strategy produced in 2002, COSEWIC and DFO assessments, and public comments (DFO, 2010) (Figure 4). The overarching regional goal established then is to "re-establish wild, self-sustaining populations as required to conserve the genetic characteristics of the remaining anadromous iBoF Atlantic salmon" (DFO, 2010, p.2). As long as marine survival continues to be the main limitation for recovery, this goal is to be pursued in ten rivers participating in the LGB program, including the two rivers within FNP (DFO, 2010).

Five recovery objectives, each pursued through several approaches, further define the regional goal: a) conserve genetic characteristics, b) address threats in the marine environment, c) address threats in freshwater environments, d) population assessments, and e) communications (DFO, 2010). The first Action Plan for iBoF Atlantic salmon, published in 2019 (Figure 4), detailed 35 ongoing and future actions needed to achieve recovery objectives in addition to costs and benefits of implementation, and responsible parties (DFO, 2019). PCA is involved in at least 11 of these actions (DFO, 2019).

Restoration work in FNP is guided by the regional goal, objectives and approaches set out in SARA mandated documents. The federal law has also influenced work in the park by increasing access to resources for restoration, as noted by one of the practitioners:

> I find that the species at Risk Act has certainly been a huge help. The fact that our salmon population is schedule one listed federally as endangered allows us, I think, access to more funding and profile and leverage than we would without it. (Practitioner G)

Recovery actions are additionally informed by the Parks Canada mandate to protect and present nationally significant natural and cultural heritage ensuring its integrity for future generations (PCA, 2018c). Ecological restoration interventions are also planned and implemented in accordance with the guidelines used by the Conservation and Restoration Program of PCA (PCA, 2018b), the major funding source for restoration work in national parks. Projects are expected to follow the principles of effectiveness, engagement, and efficiency (Keenleyside et al., 2012) and recently, expected to apply the Conservation Standards (Conservation Measures Partnership, 2020). As a result, the restoration work in FNP is directly tied to a mix of restoration policies that address site and regional requirements.

Implementation at FNP

Park-specific objectives have been developed over the past 19 years that, while framed by its regional context, respond to the conditions of the park's salmon populations and park-specific interests. From the beginning, recovery actions in FNP have had abundance and genetic diversity targets in line with the priorities of the regional plan. FNP has later adopted public engagement objectives and an ecosystem productivity research objective, shaped primarily by the PCA mandate. These targets have been addressed through a combination of programs incorporated over several project cycles.

1. Live Gene Bank and supplementation

Fundy National Park joined the Live Gene Bank in 2002 (Figure 4) as juvenile salmon began to be collected from Upper Salmon River and Point Wolfe River to be reared and spawned in captivity. The first brood stock was developed from smolts collected between 2002 and 2005 (Clarke et al., 2016). Recovery measures were initiated just a few months after Atlantic salmon entered the federal list of endangered species in Canada.

The LGB general protocol is followed with mating plans specific for FNP. Biologists and geneticists from DFO and academic institutions (e.g., Dalhousie University, University of New Brunswick) have helped develop and adapt those mating plans for the conservation of desired genetic traits in the FNP brood stock. Every year at least 100 adult crosses are carried out to achieve enough family variation in the brood stock and each family is equally represented among juveniles to be released in the park. Hatchery juveniles are released in an isolated brook within FNP that functions as an extension of the LGB (i.e., the "in river" LGB), a feature that keeps "copies" of the brood stock in two environments to prevent loss in case a catastrophe happens in one of them. Here they grow for a couple of years gaining exposure to wild conditions and natural selection. Juveniles are collected from the isolated tributary before they start migration to the sea. This salmon collection happens with significant help from Fort Folly Habitat Recovery, an Indigenous conservation organization and major partner for recovery activities at FNP. Collected salmon are then taken to the LGB facility where they are reared to adulthood and crossed, continuing the cycle.

An initial challenge in implementing the LGB program in FNP was defining abundance and genetic references for the park populations given the likely influence of strays and past stocking events. During the first years, several studies were undertaken to identify appropriate conservation targets and breeding strategies. Hutchings (2003) updated the habitat-based conservation target previously calculated by DFO for the region, and determined a park-specific, minimum viable population size of 300-475 spawners per river each year -a target that is still used today. At this time, the brood stock included salmon from Point Wolfe River, Upper Salmon River, and Big Salmon River. Big Salmon River, the geographically closest river to FNP, was included to achieve a critical level of diversity in the brood stock and with it the chances of rebuilding the populations.

In 2004 a study reported signs that the Upper Salmon River lineage had been affected by inbreeding and contaminated with aquacultural strains, potentially from escaped farmed salmon (O'Reilly, 2004, as cited in Bentzen, 2004, p. 2). The breeding protocol for the park's LGB program then adopted a strategy to exclude spawners from aquacultural strains and from the nearby, outer Bay of Fundy Saint John River population (Bentzen, 2004). This approach aimed to curate the captive brood stock for conservation of any local adaptations present in lieu of a historical reference for the genetic identity of the population (Bentzen, 2004). Eventually, as one of the practitioners explained, Upper Salmon River genes were outbred.

In contrast, genetic analysis of the Point Wolfe River brood stock in the early days of the program revealed an unexpected high presence of genes characterizing the iBoF populations group. The reason is unclear but could be related to stocking and/or strays after the Point Wolfe dam was removed in the 1980s. Practitioner G explained the finding helped shape the salmon conservation program in the park: "We have what we call this Point Wolfe High Ancestry Strain and we basically have tried to maintain that, above all, in our salmon conservation efforts." Big Salmon River genes continued to be part of the brood stock afterwards, but the Point Wolfe River lineage became the priority of mating plans.

Around 2010, signs that inclusion of Big Salmon River salmon might be disadvantageous to conserve the Point Wolfe lineage led to a major shift in the park's LGB protocol. One practitioner explained the shift was based on DFO's advice to avoid "losing potentially the most unique thing we had." Practitioner M explained that DFO then genotyped and pedigreed the brood stock to separate Big Salmon River and Point Wolfe River lineages. In 2012, LGB-produced juveniles of pure Point Wolfe High Ancestry strain origin were first released into park rivers to initiate production of future spawners for the continuation of the lineage. Since 2015, all adults released in the park are from the High Ancestry strain. Conserving this lineage is the current indicator of success for the genetic objective of the project.

In addition to supplying juveniles from strategic matings, the LGB had a secondary role helping supplement park populations with surplus fish. Hatchery raised adults not needed for planned matings were released into rivers to help enhance wild spawning. A review of the effectiveness of this supplementation strategy in Point Wolfe found that released adults had helped increase juvenile abundance, but their contribution noticeably varied from one year to the next in the number produced and their parentage. Additionally, they found a low number of effective breeders (<30) and a loss of genetic diversity over a single generation (O'Reilly et al., 2010). The review called attention to the role of spawning efficiency in the outcomes of the recovery program and its potential connection to captivity exposure, recommending management actions such as control of environmental conditions in the hatchery, naturalization of hatchery conditions for juvenile rearing, and the naturalization of conditions for rearing smolts to maturity (e.g., by using net pens) (O'Reilly et al., 2010).

The impacts of captivity on the performance of salmon were further examined in a series of field studies motivated by observed differences in the phenotypes of juveniles. Clarke et al. (2016) followed two cohorts of salmon with different amounts of exposure to captivity and their offspring. To document adult performance, smolts were captured before migration and reared to adulthood in aquacultural net pens. The findings of this study confirmed that the amount of captivity exposure impacted salmon performance: salmon with little exposure as juveniles (i.e., released as unfed fry) had better measures of wild fitness (e.g., larger body size at time of migration, larger eggs) and later produced more viable embryos (Clarke et al., 2016). This study prompted the reduction of captivity exposure for LGB juveniles which are now released soon after they hatch, as unfed salmon fry. It also showed the possibility of a new recovery program approach: marine rearing.

2. Fundy Salmon Recovery

Fundy Salmon Recovery is the second major component of FNP's efforts to restore wild Atlantic salmon. It emerged in connection to the methods and findings of Clarke et al. (2016)'s study.

> That project helped open our eyes almost inadvertently to a partner which was the aquaculture industry, who could grow, and does grow, millions of large salmon and the findings of this work said that it would be ideal if we could reduce captive exposure for these animals as much as we possibly could, and maybe if we could even eliminate it,

> that would be the best. And following this logic began the Fundy Salmon Recovery model, which […] is just aimed at releasing large numbers of native adult salmon so that they spawn in the wild and their offspring have zero exposure to captivity and therefore reduced compromises to wild fitness that we've documented happen if you keep them in captivity. (Practitioner G)

Built up from the original experimental setup and after a pilot test of the marine rearing and release strategy in the fall of 2015, the Fundy Salmon Recovery (FSR) program was officially inaugurated in 2016 (Figure 4). Located in the Dark Harbour of Grand Manan Island in New Brunswick, FSR features the first marine conservation farm for wild salmon in the world (FSR, 2021b) (Figure 5).

For this strategy, late stage parr and smolts are collected from rivers before they migrate to the sea. Salmon are taken to the LGB facility and those that will not be used for captive breeding to maintain the Point Wolfe strain are transported to the FSR marine farm where they are grown to adulthood, until ready to spawn (approximately 18 months). Customized marine net pens and special diets to support gamete production are key adaptations of the aquacultural setting to grow wild salmon (FSR, 2021b). On the day of adult releases, all fish are implanted with a permanent passive integrated transponder (PIT) tag, monitoring data is collected, and salmon are distributed among bins to be transported to the park where trucks and/or helicopters take the bins to the otherwise inaccessible release sites along the rivers (Figure 6). At the park, the public is able to watch the operations. Adults are reintroduced into their natal rivers in the fall, when adult salmon would naturally return to spawn. Contrary to LGB produced juveniles, these adults are released into open portions of the park rivers to mix and spawn naturally.

A remarkable number of collaborators make these operations possible. Cooke Aquaculture and the Atlantic Canada Fish Farmers Association had a major role developing the program and are key for current project management (FSR, 2021a). Fort Folly Habitat Recovery and DFO offer extensive operational support, and the University of New Brunswick leads research on the impacts of adult reintroductions. Additional support (e.g., funding, law enforcement) is provided by provincial and municipal government, conservation NGOs and industry (Appendix B). Volunteers also contribute to the success of operations, helping on a wide range of tasks such as transportation, data collection, coordination of shore activities, communications, receiving the bins from the helicopter as they are delivered along the river, and releasing fish. Volunteers are matched with tasks based on safety requirements, their experience or training (e.g., training for work in swift water), and efficiency needs, as Practitioner M explained.

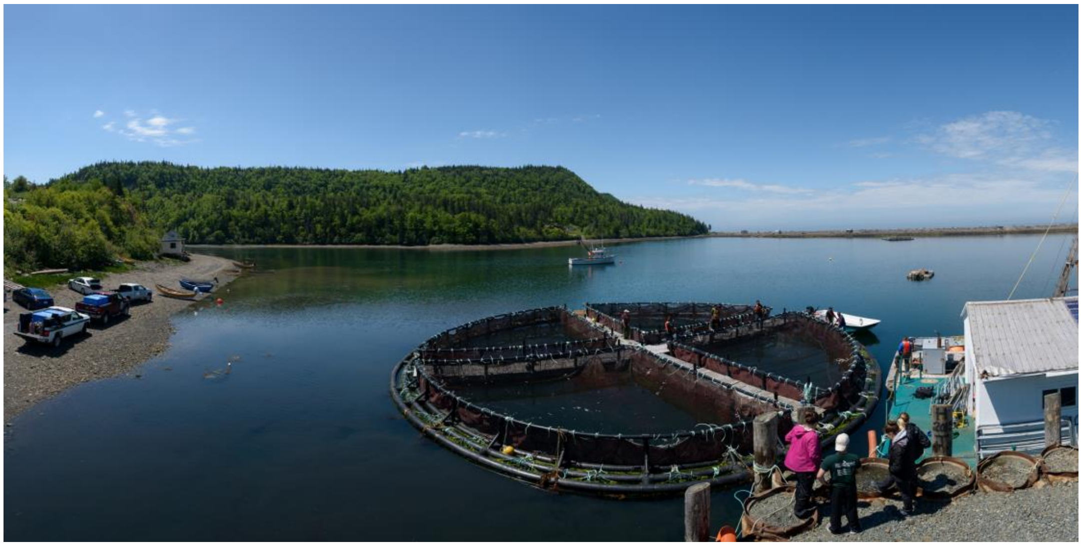

Figure 5. Fundy Salmon Recovery grows juvenile salmon in customized aquaculture net pens located in Dark Harbour, Grand Manan Island in New Brunswick. Photo by Nigel Fearon Photography for Parks Canada. Reprinted with permission.

Figure 6. On the day of releases, adult salmon grown at the marine conservation farm are distributed among bins (a) to be transported to the park. Monitoring data is collected in the process (b). Helicopters aid in delivering fish to remote release sites along the park rivers (c). Photos by Nigel Fearon Photography for Parks Canada. Adapted with permission.

FSR is starting to see some signs of success. In 2016, 846 adult salmon were released into the Upper Salmon River (FNP, unpublished). The following year wild-born juveniles were found in this river, signaling adults had successfully reproduced (PCA, 2018a). From 2017 to 2020, the number of released adults in Upper Salmon River varied between 362 and 970 (FNP, unpublished). The densities of wild hatched juveniles have increased in park rivers, and since 2018, a portion of wild hatched smolts have been migrating to the sea again. Adult returns have increased as well, although only for adults reintroduced to rivers as a portion of them are surviving to return on their own in following years.

> Year over year, we're finding a significant number of them are coming back the next fall. […] And we've seen numbers of adult salmon returns as a result of this in numbers that we haven't seen in 30 years here in Fundy. […] We're seeing that those fish that come back on their own are better at spawning and producing offspring as the fish that we release in a given year. So if I release this fish in year one, you know maybe one out of 10 of them produce babies. But if that fish happens to make it back on its own next year, five or six out of 10 of those fish are good at producing babies, so that's an excellent sign for our program, for sure. (Practitioner G)

FSR entered a new phase in 2020 aimed at rearing a larger number of salmon and including Point Wolfe among its recipient rivers. That year 312 adults were released into Point Wolfe (FNP, unpublished). Adult salmon had been largely absent from this river in recent years, recording a total of 6 across 2019 and 2020 (FNP, unpublished). Currently, three rivers receive adults reared in the marine farm: Upper Salmon River, Point Wolfe River, and Petitcodiac River. The latter is being restored by Fort Folly Habitat Recovery.

3. Monitoring activities

Before Atlantic salmon was listed as endangered, FNP routinely monitored juvenile and adult salmon abundance in park rivers. Practitioner G explained adults could be counted by wardens walking along a river, counting how many fish were resting in the pools in late summer and fall. Practitioner G also mentioned several academic partners studied the park populations. Monitoring of juveniles started in the 1980s, based on electrofishing surveys to calculate juvenile densities (DFO, 2010).

Monitoring was expanded when recovery interventions started in the park to assess the status of populations, measure the outcomes of interventions, and support the adaptive management of the project. Monitoring occurs in the rearing facilities of the LGB and FSR (e.g., to track fish health) and in the field. Currently, all life stages of Atlantic salmon are monitored every year across the different components of the park's recovery program, occurring for most of the year except winter. Together these different pieces of information allow to follow the performance of salmon over life stages and across generations in connection to the rearing and breeding methods applied.

In spring, covering about a month and half from May to mid-June, monitoring targets the emigration of smolts to the sea. Rotary screw traps in Point Wolfe River and Upper Salmon

River collect a portion of smolts as they travel downstream (Figure 7b). During this time, traps are checked daily to gather data on the timing of emigration and smolt characteristics (e.g., length, weight, age at time of emigration). The smolt collection –which feeds both the LGB and FSR programs-- also allows to estimate the reproductive success of adults previously released into rivers as smolts are genotyped and pedigreed when they arrive to the LGB. Smolts are injected with a PIT tag to track individuals through the rest of recovery operations (Figure 8).

During the summer, monitoring focuses on juvenile densities in both park rivers. Using backpack electrofishers, staff revisit permanent sample plots to estimate the densities of fry and parr every year (Figure 7a). This is an additional element of the reproductive success of adults released in previous years.

Between July and September, sometimes extending into October, monthly snorkel surveys are used to count adult salmon returning to park rivers – "culturally or historically kind of the gold standard of monitoring measures", as Practitioner G pointed out. These observations are supplemented with PIT tag tracking information. PIT tag antenna arrays are set up in Point Wolfe River and Upper Salmon River to log the date, time and unique identifier of fish passing through. Towards the end of the adult returns window, adult salmon from the LGB and FSR are released into rivers. The number and identities of released adults are recorded and used as a reference to examine the contribution of these adults to the population in the following years.

Figure 7. Monitoring of Atlantic salmon in Fundy National Park includes electrofishing for juveniles surveys (a), smolt collections using a rotary screw trap (b), and snorkel surveys to count returning adults. Photos by Parks Canada (a) and Nigel Fearon Photography for Parks Canada (b). Adapted with permission.

Figure 8. Atlantic salmon are injected with passive integrated transporter (PIT) tags. The black, pill-like tags may be found in predator feces, as in this coyote scat. Photo courtesy of Parks Canada. Adapted with permission.

4. Public engagement and knowledge sharing

FNP plays a major role in engaging the public with Atlantic salmon restoration activities via three visitor experience programs that combine interpretation, volunteering, and training opportunities. Two of the programs take advantage of salmon monitoring activities to deliver hands-on experiences intended to get people interested in restoration while directly contributing to monitoring. These public engagement initiatives are part of FNP's restoration project proposals. As described by Practitioner Y, FNP is striving to bring together the technical and social dimensions of ecological restoration, "keeping the two systems that might traditionally be separate and sort of putting them together and moving forward that way".

"Swim with Salmon" teaches participants to identify and count adult Atlantic salmon in snorkel surveys (Figure 9a). The program runs in September, during the adult returning season and ahead of adult releases. For Practitioner Y the significance of this experience is revealed by people's reactions:

> When they […] see their first salmon and they realize you know how big it is, how real it is right in front of them, and then I think it clicks for people that it's an endangered population and I think it's this really sort of magical connection that people make.

Two of the practitioners highlighted that observations made by participants also help fill a gap in adult returns data collected by park biologists.

> In September, we might have a […] formal snorkel survey with our biologists, maybe at the beginning of the month, and then maybe at the start of October, but if any wild fish returned during that time, […] if we didn't have 'Swim with Salmon' we wouldn't really have any eyes on some of those key salmon pools. (Practitioner Y)

Participants have improved data coverage by observing fish without tags, or fish that had been missed by the PIT tag antennas.

“Swim with Salmon” started in 2014 (Figure 4) with a pilot phase, growing in popularity and demand the following years. However, the program is necessarily limited in the number of spaces it can offer due to the equipment required and the need to minimize harassment of animals. To manage demand, the program has implemented an application system. Before the covid-19 pandemic forced its temporary suspension in 2020, 68 people had participated in the program (FNP, unpublished).

“Be a Biologist” started in 2015 (Figure 4) as an interpretive hike for visitors to learn about Atlantic salmon, its history within the park, the reasons for its decline, and the smolt wheel operations (Figure 9b). The program received different names in the past (e.g., Smolt Wheel Open House, Eco Evidence) but it has continued to revolve around smolt monitoring: installation of the rotary screw traps, daily monitoring of traps, sampling processing, and tagging salmon. Practitioner Y explained that visitors loved this experience and wanted to volunteer. Consequently, “Be a Biologist” expanded to include a volunteer training option for visitors that want to go beyond the hike experience. These volunteers learn about monitoring techniques, how to identify and count Atlantic salmon, and how to record monitoring data (PCA, 2020c). Trained volunteers work along biologists during the smolt monitoring season but are also prepared to collect data on their own (PCA, 2020c): “a true value for our monitoring program”, said Practitioner M. “Be a Biologist” runs through May and the first half of June. To date, 386 people have participated in the program (FNP, unpublished).

“Learn to Fly Fish” is the most recent visitor program, established in 2018 (Figure 4). The program commemorates the traditional salmon fishing practice of the local community, which has a large portion of fishers, and aims to offer a way for the cross-generational transfer of the skill. Participants attend a workshop to learn the fishing method and get an opportunity to fly fish brook trout in the park lakes instead (Figure 9c). Learn to Fly Fish happens twice during the summer with a monthly session in July and August. Practitioner Y pointed out these sessions were very popular and spots available would fill out quickly. Previous to Covid-19 related restrictions, between 2018 and 2019, at least 250 people participated in the program (FNP, unpublished).

Other forms of engagement are based on communication products (e.g., YouTube videos) and training arrangements with academic institutions. Every year, one or two universities will bring a class to learn how to collect and measure fish. For one of the practitioners, this offers hope for the continuation of conservation work: “That is sort of dear to my heart to maintain a connection with academic institutions so that students can come and be part of these things and I hope envision themselves doing some kind of work like this.”

Indicators for the success of the social component of the project are in development. Data on visitor experiences and public engagement started to be collected recently, although mainly in terms of numbers of participants and basic characteristics (e.g., age). Media monitoring (e.g., tracking social media mentions) is used to help assess public engagement, too. Visitor feedback may be voluntarily submitted on comment cards or social media. Practitioner

M recalls most if not all feedback to be positive so far. Nevertheless, practitioners mentioned additional outcomes they considered successes of the project, like achieving a level of collaboration that allows for such a large scale of operations and facilitating the application of restoration approaches outside of the park through capacity building and knowledge transmission.

> I feel like the great thing about Parks Canada is we can kind of perfect these innovative models of collaboration or experimental conservation design […]. We can be this cradle of conservation and we can perfect these ideas that then go forth just like Fort Folly [Habitat Recovery] is doing on the Petitcodiac River now. They're applying a model that we took a decade to figure out together, got it right, and then we packaged it up and they could take it outside and I feel like that is the best part of Parks Canada's conservation mandate that I could describe. We only have like 1% of the landmass of Canada. We could do a perfect job in national parks. It's only 1% so we [got to] do that job to engage people so that they take those messages outside. (Practitioner G)

Figure 9. Fundy National Park offers three visitor programs to engage the public in restoration activities and the cultural heritage around Atlantic salmon. "Swim with Salmon" teaches participants to do a snorkel survey of returning adults (a); "Be a Biologist" offers an interpretive hike to juvenile monitoring sites (b); and "Learn to Fly Fish" teaches the angling technique used in the past for the recreational fishing of salmon (c). Photos by Nigel Fearon Photography for Parks Canada (a) and Parks Canada (b, c). Adapted with permission.

Lessons along the way

Considering the park's recovery trajectory up until 2020, when a new project cycle began, three main lessons can be pointed out.

1. Collaboration is key

All three practitioners agreed that collaboration was a key factor for the success of the recovery project so far. The recovery of iBoF Atlantic salmon has relied on joint contributions by federal agencies, First Nations, provincial government from New Brunswick and Nova Scotia, municipal government, academics, industry, interested civic groups, and volunteers (Appendix B). Based on the information gathered here, collaboration seems to have happened throughout every phase of the project, starting with stakeholder involvement at an early planning phase. For Practitioner G this is a best management practice: “polling the community before starting to make actions, I couldn't think of a better best management practice”.

Collaboration has brought together the necessary resources to pursue recovery: people to carry out operations, different areas of expertise, funding, instruments and equipment, and facilities. Two of the practitioners offered FSR as the best example. Practitioner M described it as a huge endeavor where everyone involved is needed: “truly like we could not do it without one another”. Similarly, Practitioner G said:

> The first thing that I think of when I think about the success of this program is, the power that collaborating widely has allowed us. Like, the idea that multiple levels of government, First Nations, academics, and industry are working together on this. That has worked particularly well. There's no way that we could produce thousands of adult salmon, wild adult salmon to release into a river without the industry collaborating with us. They have the capacity and infrastructure to do that, so. That has worked particularly well. The idea that, it required all of those groups to make that. When I think of the groups that have been involved, we couldn't have what we have if we took the academic component out, or the Indigenous component out, or the other government component out, they were all required.

Two of the practitioners perceive this level of collaboration to be extraordinary when compared to other collaborative projects.

> I've worked on a lot of other conservation programs, but I'm not sure if there's any that [is] quite like this one. I think it's very special in that it's, it's very collaborative, it's very community based, and I mean that in sort of all sense of the word, community as far as the community for Atlantic salmon, including many different organizations and groups, community as far as connecting […] local and sort of regional and national communities. (Practitioner Y)

Collaboration cannot be traced back to a single policy. Stakeholder engagement is required by SARA for the preparation of a recovery strategy and action plan (SARA, 2002, sections 39 and 48) and is featured in all three sets of restoration guidelines used by PCA over the years (Conservation Measures Partnership, 2020; Keenleyside et al., 2012; PC & CPC, 2008). In all of them, stakeholder engagement is part of the first step in the restoration process. Furthermore, “collaboration and cooperation” stands as one of PCA’s guiding principles (PCA, 2017a).

While best practices for ecological restoration typically cite the need to work collaboratively in early stages, projects too often omit this step. As the practitioners noted, that step was – in their opinion – key to success at FNP. This is consistent with the literature where ecological restoration successes depended most on this phase (Allison & Murphy, 2017). The nature of the collaboration varies with project scope and stakeholders, but care must be taken to identify both actors and should-be actors (Gann et al., 2019; Higgs, Harris, Heger, et al., 2018; Higgs, Harris, Murphy, et al., 2018). The latter was not addressed in this study and stands as a research opportunity to better understand how collaboration was initiated and sustained in this case.

2. Adaptive management has benefits and challenges

Adaptive management has guided the gradual transformation of the recovery project plans and interventions as was observed in the adaptation of LGB mating plans, the reduction of captive exposure for LGB-produced juveniles, and the development of a marine conservation farm for which there was no prototype. All practitioners agreed it had been beneficial to the project and two of them listed it as the second most important factor to the success of the project. Practitioner Y considers it has worked well in promoting a lot of learning along the way, allowing continuous improvements towards restoration objectives, and promoting innovation. Although unclear how, Practitioner Y also mentioned that adaptive management has helped keep the project staff working together even as they are divided over project components.

The impact of adaptive management is in part related to the quantity and quality of monitoring. Practitioner G explained that the chances to make right decisions to adapt a project are better the more a system is studied and recommended intense monitoring as a best management practice to support adaptation. Thinking of things that have worked well for the project, this practitioner added that monitoring effectiveness is aided by the sensitivity that is afforded by a natural protected area. Having both rivers almost completely enclosed within the national park reduces the number of confounding factors to be considered when interpreting data.

For Practitioner Y several factors combine for adaptive management to be effective, suggesting that in other cases it may not work as well.

> Any approach has to be fit to your specific situation, your specific team, your specific project, and I think it's having […] the patience and having the right people, you know, in the room and to put that plan not only in place and drafted, but […] continuously be checking it and be implementing that plan.

Indeed, academic literature highlights that successful implementation of adaptive management is often not achieved (Allen & Gunderson, 2011; Walters, 2007). Based on interviews, FNP seems to have avoided common pitfalls in the use of adaptive management, such as the lack of stakeholder engagement or failing to adapt plans when new information is available (Allen & Gunderson, 2011). On the other hand, FNP shows several ingredients for success, like the use of pilot projects for faster knowledge generation, access to resources for experimentation, and the institutionalization of adaptive management (Murray & Marmorek, 2003).

Like collaboration, adaptive management is part of multiple restoration and conservation policies guiding FNP's work over the years (Conservation Measures Partnership, 2020; Keenleyside et al., 2012; PC & CPC, 2008). Adaptive management was also selected by the Recovery Team as the approach for recovery work in iBoF (DFO, 2010). While PCA's operational policies, established in 1994, do not name adaptive management, they emphasize the need for research-based decisions and monitoring (National Parks Policy 3.0: PCA, 2017b), possibly facilitating implementation of adaptive management later.

Still, one of the practitioners offered an important caveat to clarify that adaptive management is not synonymous with eliminating all uncertainty in a restoration project. Rather, adaptations may introduce new risks that must be balanced with benefits.

> I wouldn't want to paint the picture that […] we're conquering this system through the prudent use of monitoring and research and monitoring and research and we're just kind of iterating our way through this to perfection, because when we release adult fish we lose a very key control that the Live Gene Bank maintains. […] We don't know if they're going to mate when we release them in the wild. And… They may not. And if they don't, they don't contribute to the next generation, and that's the risk we take for the hopeful reward that nature will prevail and make the right combinations of males and females at the right time and at the right place. […] We are doing our best through our […] isolated brook system to keep the Live Gene Bank. So even if [FSR] fails, we're still doing that circulation of Live Gene Bank process in the park. But what we basically decided was that when the Live Gene Bank mates [salmon], […] they might produce a combination of offspring that would have never happened in the wild, like there's a risk to that too. And what's almost certain is that when a human hand releases those offspring back to the wild, it's impossible that they would do it at a time and at a place and at a density that nature would have. […] The adult release method, […] we forfeit that ability to make that exact cross, and we realize that, but everything after that is natural and that's an attractive element of the program. It is adaptive, but it is not without risk. (Practitioner G)

A risk in fine tuning the project in response to one of its components is the potential emergence of trade-offs in relation to other project components. Trade-offs in this case may be seen in terms of the genetic diversity of wild hatched juveniles or unintentional selection for less successful spawners.

> I think the downside of that […] is that we do lose some genetic control when we release the adults to mix and mate freely. And if something we have introduced, like farming them […], maybe the food we give them or the way we farm them makes them not want to spawn, then they don't spawn when we release them in the wild and we have artificially avoided those genes contributing to the next generation where the Live Gene Bank method would ensure that those genes are [present] […]. We try to have our cake and eat it too by maintaining our Live Gene Bank stream in an isolated stream so that that doesn't happen, but it's, we fully recognize that that could be a downside to our adaptation. Basically, we adapted for one type of value which is increased numbers of returning fish that are better fit and we've probably compromised, in some way, the genetic value, so it's certainly a trade-off, and we fully admit that. (Practitioner G)

The time required to adaptively manage a project is one of the challenges of the approach, but Practitioner M argued it was not inherently negative.

> Certainly, some of this adaptive management is, by its very nature, kind of taking a step back, taking a pause and re looking at things. […] But as far as calling that a negative I certainly wouldn't go there. I think the trade offs are well worth it. So I wouldn't call that a detriment. […] It creates a challenge, I guess, more accurately.

Practitioner M added that this challenge can be pronounced in the context of funding timelines: "Sometimes, the predefined sort of, project timelines […] it doesn't always nurture that sort of pause and analysis and adaptive management."

3. Institutional culture is a potential factor for innovation

Although not explicitly identified, institutional culture emerged as a potentially important third factor in the success of the project. PCA was perceived to have a character that facilitated innovation in Atlantic salmon restoration, especially in relation to FSR. Practitioner G described PCA management as being very supportive of the FSR proposal, while Practitioner M described a general acceptance and willingness to adaptations.

> If we are seeing something that we feel we need to take a pause on and change direction or adaptively manage the design, I feel the environment is very sort of accepting and willing and really sort of built on that kind of approach. (Practitioner M)

Two practitioners used the word "courage" to describe the agency's disposition to engage in an unorthodox partnership with the aquaculture industry to pursue wild salmon restoration. Furthermore, both practitioners perceived this courage to be exceptional for a federal agency. While one of them said they don't think "every agency would have had the courage to do that", another said:

> I'm really sort of proud and I think […] that is really meaningful to be able to be fluid and have the support of Parks Canada managers for us to do that […]. I do feel like Parks Canada has a little more appetite to uh… in their willing to accept kind of creative […] methodology and projects. (Practitioner M)

It must be noted that practitioners also praised the courage and open mindedness shown by partners.

> I think all around it was really open minded dedication to trying something to conserve wild salmon. So I think it's adaptive, but I would just come back to I think everybody took a bit of a risk on it too. (Practitioner G)

Better understanding the extent to which PCA's culture may have provided a context for building trust among stakeholders and sustained collaboration in Atlantic salmon recovery efforts, to the point of trying a new approach, can be an objective for future research.

Present and future of recovery at FNP

Currently the recovery project at FNP is in its second year of a five year project cycle (2020-2025) funded by PCA's Conservation and Restoration Program. For this project cycle, FSR is rearing a larger number of salmon in the marine farm to supplement Point Wolfe River and to achieve more natural spawning in park rivers. Spawning efficiency continues to be a concern for the recovery project as the reproductive success of adults reared in the marine farm is lower than expected based on the pilot phase of the program and compared to that of completely wild spawners.

Understanding factors of natural spawning is one of the present research focuses of FNP. As part of this project cycle, several adult release protocols are being used in an experiment to compare salmon reproductive success across methods and rivers. Higher reproductive success for FSR adults would further reduce captivity exposure and take the project closer to using only wild hatched juveniles for FSR. Practitioner M explained the latter would be a priority in the future. Research on methods to minimize the genetic impacts of captive rearing and to understand the genetic impacts of rearing in the marine farm versus the LGB is continuously needed as captivity remains essential to recovery operations. In the future, research may also address ways to further naturalize the diet and farm conditions in FSR, potentially contributing to the emerging field of conservation aquaculture, explained Practitioner G.

The current project cycle has also established a new collaboration between FNP and four parks that host Atlantic salmon populations in different stages of decline: Kouchibouguac National Park (New Brunswick), Cape Breton Highlands National Park (Nova Scotia), Gros Morne National Park, and Terra Nova National Park (Newfoundland and Labrador) (Figure 4). These parks will apply various recovery approaches, including those used in FNP, to evaluate the impacts on populations at different levels of risk and their aquatic ecosystems. Research in these areas is organized by the recently created Parks Canada Research Chair in Aquatic Restoration, the agency's first research chair (PCA, 2020b). The position, made possible by the joint efforts of the five partnering national parks and the University of New Brunswick, is occupied by Dr. Kurt Samways who is studying the productivity impacts of salmon reintroductions and their corresponding fitness effects on juveniles. Additional research opportunities have been identified across and within the five national parks and are open for interested researchers, targeting the aspects of population diversity and genetic variation in Atlantic salmon, freshwater and marine ecosystems, and community stewardship (PCA, 2020b).

Some research gaps were linked to a lack of dedicated researchers within the federal agency:

> We don't have sort of academic researchers that you know, primary function is research and primary publications, […] that is sort of why we have, or at least one benefit of the development of the Parks Canada Research Chair so that can be our academic sort of connection that can start filling in some of these research gaps. […] Researchers I think are something we don't have internally, but we are always striving for ways to collaborate. [It] is something we would like to solicit help on. (Practitioner M)

Social researchers, in particular, represent a gap in expertise for the project suggested by Practitioner M: "It would be valuable to perhaps tap into those that are experienced in the social sciences and the community connection piece. That's a tough one for us […], and it's not our expertise."

Difficulty in access to Parks Canada data is an important consideration if the federal agency seeks additional collaborations with academic partners. One of the practitioners explained PCA discontinued its grey literature series featuring annual technical reports: "So if you want that information, you can call your local park or park ecologist and get it. But it's not in a prepackaged form anymore. […] I would like to see that type of thing kind of reborn." A "national ecosystem database" is in place instead, but the practitioner expressed doubts it could fill the same role.

On the other hand, long-term data is generally unavailable for the area before becoming a national park in 1948. This applies to knowledge of salmon populations, public engagement with past visitor experiences or volunteer programs, community stewardship, community involvement, and recreational fishing. Again, this gap is more pronounced for social research on conservation and restoration. Practitioner Y explained that, in contrast to researchers on the biology of Atlantic salmon, there would be no data sets to provide social scientists with to base their work on.

> If a researcher wanted to come into and research Atlantic salmon we're able to provide them of, you know pretty extensive data set in order to sort of start their research, whereas for any social scientists that wanted to come in and start doing work […], unfortunately, we don't really have that really extensive data set to really be the basis for them to sort of accelerate.

Overall, a social science foundation to the conservation program is a gap perceived by Practitioner Y:

> A gap that I've seen […] in our conservation projects specifically, is that social science base and I would love to see more of that happening […] around conservation. […] There is more social science work happening there around […] visitation and programming and things like that, but not necessarily about conservation. So even getting some of those basic understanding, some studies on […] how informed people are about conservation and where they're finding their conservation research and sort of breaking that down into demographics.

Lack of data on past visitor experiences stands as a current challenge to build a reference for the engagement component of the restoration project. The recently initiated monitoring of visitor programs is the first step in addressing this gap. Practitioner Y explained that Parks Canada has regularly conducted surveys that examine visitor experiences with their Conservation Program but these surveys, even at the park level, are not specific enough to examine the performance of park initiatives such as "Swim with Salmon" or "Be a Biologist": "They might talk about conservation programming in general, but they're not going to get into specifics of Atlantic salmon. So really having someone specifically looking into that community stewardship, community connection piece for Atlantic salmon would be really valuable." Practitioners identified at least three areas of interest concerning public engagement and community stewardship: impacts of the experiences offered at the park; indicators of community engagement in salmon conservation; and changes in community attitudes towards salmon conservation.

All practitioners agreed that continuing to address public engagement was a project priority for FNP. “Be a Biologist” and “Swim with Salmon” are still in development, seeking ways to broaden their scope and reach. For example, “Swim with Salmon” participants may document other wildlife in the future to help understand broader impacts of salmon recovery. FNP also aims to reach a wider, more diverse audience and to communicate effectively across demographic groups. Reaching all demographics is a challenge for public engagement.

> Because you know sometimes […] people turn off their brains when they hear ‘science project’. […] So you have to sort of put it in a way that that will pique people's interest, because once you do, even those people that thought they didn't care, they actually find it really interesting and engaging. So it's just finding those right words to grab people and to really bring it into their world. So I think that's the most challenging piece as far as the sort of engagement side of things. (Practitioner Y)

In the short term FNP plans to establish working groups with the local community of commercial and recreational fishermen. Work on this objective is temporarily suspended following restrictions for in-person meetings due to the covid-19 pandemic and the inadequacy of a virtual forum for this purpose. In the long-term, additional forms to engage the community and commemorate the cultural heritage around Atlantic salmon will likely come to the fore. As an example, one of the practitioners suggested some form of angling experience could create strong connections with the community given the importance of angling to the local culture but recognized it would need to be compliant with permitted activities under SARA.

> If Parks Canada could bring the community of Southern New Brunswick, a salmon angling opportunity again, even a very limited opportunity which has anglers accompany PCA staff to collect critical conservation data , where there have been no opportunities since [1991], and we could do it safely, and we could do it without harming the chances of recovering salmon at Fundy National Park, there would be a buzz of salmon conservation optimism […] that we could bring about by this. (Practitioner G)

It is unclear from the interviews whether this perceived need for more public and community engagement originates in a proactive approach, observed obstacles to restoration outcomes in the park, needs identified by the public and local communities, or a combination of those. Regardless, practitioners described a crucial link between effective engagement and restoration success.

> As we go on, we're just trying to fill some of those […] community engagement pieces that the people really need and they are really important to telling the story and getting people involved. Something that I say a lot […] is we need people to be engaged. If people don't really care about Atlantic salmon then […] we can't accomplish everything

> that we need to accomplish or that we want to accomplish. People have to be sort of shown and educated and then I think they really grow to sort of be inspired and want to be engaged. And then they tell someone else about it and it sort of continues the process. So we really need that engagement for […] for us to even continue this important work of conserving and protecting the species and the population. (Practitioner Y)

> Parks Canada staff, I think, are of a mindset of how important people are for conservation, and, to get society interested in conserving your salmon population, […] they need to be compelled, they need information, they need the story. They often need to see it with their own eyes in person […]. So I'm definitely of the school that apathy is a growing, if not the most important threat to the recovery of Inner Bay of Fundy Atlantic salmon. If more people knew about this, our chances for conservation would be far greater. (Practitioner G)

As recovery work continues, future policy may need to address this challenge to re-establish human-nature connections when an endangered species is involved. The Recovery Strategy (DFO, 2010) and Action Plan (DFO, 2019) for iBoF Atlantic salmon focused on involvement of stakeholders in planning and implementation, and on communications (e.g., sharing information on recovery milestones), likely in response to the critically low numbers of the populations when assessed as endangered. In FNP, measures beyond communication seem necessary to help meet PCA's mandate to protect cultural heritage to the extent possible. Because recovering Atlantic salmon will still require long term efforts, discussing future forms of community engagement is important, especially as it concerns an activity like angling that may in turn support conservation (Cooke et al., 2019). In Terranova National Park (Newfoundland and Labrador), a collaborative restoration plan was developed for the declining Atlantic salmon population of the Northwest River, where recreational fishing had been a long tradition (Cote et al., 2021). After an unsuccessful banning, a retention fishery was implemented in coordination with local communities (Cote et al., 2021). Since the establishment of the fishery 20 years ago, salmon abundance has significantly increased, along with an improvement of relationships between managers and residents and a reduction in signs of illegal fishing (Cote et al., 2021). A pathway for future policy-making in the inner Bay of Fundy and/or FNP (e.g., updating the recovery strategy) may be defining when more activities might be allowed as restoration benchmarks are achieved (see Allison & Murphy, 2017) –for example, determining an abundance target over which closer interaction with the species would be possible, as suggested by Practitioner G.

Bigger picture

The restoration of iBoF Atlantic salmon in FNP relates back to two prevalent issues for restoration practice: climate change and sustainability. Practitioner M pointed out an ongoing challenge for the project is to achieve recovery under present conditions while building resilience into the populations for the impending effects of climate change. Similarly, Practitioner G called for more discussion on the selection of reference states to guide ecological restoration practice, especially under climate change when reference states are far from evident.

> There's a lot more thinking needed on, restore to what? […] Sometimes it's obvious […]. But in places where climate change is removing balsam fir from the landscape, should we be replanting balsam fir on that landscape? […] So with kind of my colleagues facing similar problems in other species and populations, we often talk about like, what do you want me to restore it to?

For Practitioner G this is part of a greater reflection of when and where restoration will be prioritized.

> I think society probably needs to think a little bit about, partitioning the landscape into places that are kind of going to be natural, places that are going to be maybe intensively managed, and places that we will let happen whatever happens, it's OK if it strays from natural. […] So where we commit as a society that things will be natural, perhaps that's where we would commit to restoration being important when things stray from those natural processes and that could be a place like national parks.

Ultimately, the future of the recovery of Atlantic salmon in iBoF may require facing an important question for ecological restoration practice: is it justifiable only if sustainable? While Atlantic salmon populations within FNP are showing hopeful but moderate signs of improvement, the two populations make a small portion of the population assemblage. Limited recovery interventions across the region challenge recovery within the park in the long term if depressed population phenomena and/or stray dependence (Hutchings, 2003) play significant roles in park population dynamics. In addition, park populations remain subject to low marine survival as a threat. Thus, restoration success in achieving self-sustaining populations may be unattainable in the foreseeable future. Notwithstanding, sustained Atlantic salmon reintroductions may be justified by their contribution to ecosystem functions at the national park.

> We have seen that the re introduction of this important population of fish to a river is powering an ecosystem to a level of productivity that likely hasn't been seen since the population disappeared. And now I see a discussion emerging that that's increasingly the reason that this work is important. That ecosystem is functioning even if the salmon [disappear] after they leave the river. […] And I think that that's a good example that especially when it comes to national parks, ecosystem function is very, very important. […] I like the emerging discussion of, does sustainability matter when it comes to restoration investments or thinking […] and, sometimes I don't know. Initially I [thought] […] if it can't sustain itself, we're going down the wrong path, but I think sustained restoration could be a discussion of the future in some places for some reasons, we may want simply to hold our ecosystems where we want them to be. (Practitioner G)

Conclusion

PCA's work as a restoration policy-maker and practitioner for iBoF Atlantic salmon covers more than 20 years. During this time FNP staff has been involved in all restoration phases, including work with regional (e.g., recovery strategy for population assemblage) and local (e.g., implementation targets for FNP) scopes. At the national park, restoration activities have grown to address genetic diversity, abundance, ecosystem research, and public engagement objectives through a combination of traditional captive rearing and breeding, an innovative marine rearing approach, extensive monitoring, and visitor programs. Our case study has offered a first close look at this trajectory, highlighting practitioners' perceptions of policy effectiveness, challenges, gaps, and opportunities.

Further evolution of the restoration project at FNP is expected as ongoing research on spawning efficiency and ecosystem productivity impacts reveals ways to continue improving outcomes. Additionally, the social dimension of Atlantic salmon restoration is a major frontier for the project, linked to the shared idea that engagement is key to restoration success. Priorities in this respect are to better understand and facilitate the involvement and stewardship of local communities, develop indicators of success for public engagement, and assess the impacts of these initiatives. Social researchers make up a noticeable gap in expertise that will need to be addressed to advance this project dimension.

We found multiple policies have influenced restoration work, but they are largely compatible and overlapping (Appendix C). Stakeholder engagement and collaboration, for example, was featured by all policies. Our case study provides evidence this is a best practice for ecological restoration as it has afforded the national park multiple forms of support. Moreover, early and continuous engagement of diverse stakeholders is perceived by practitioners as the most important factor in the ongoing restoration of Atlantic salmon at FNP, a finding that suggests an exemplary application of restoration best practices. Nevertheless, as our case study was limited to the work done by Parks Canada and only captures the views of its restoration practitioners, a research need is to further understand collaboration in this case by including the perceptions of additional project partners and collaborators (Appendix B).

Similarly, adaptive management is a feature of the policies followed by the PCA's Conservation and Restoration program and chosen by the Recovery Team for implementation of the recovery strategy (DFO, 2010). Based on the perception of practitioners, adaptive management has been successfully applied in the national park, as best represented in the establishment of the marine conservation farm. FNP's case additionally offers an important reminder that new risks and/or trade-offs may emerge as measures are applied over time in a project, even one deemed successfully implemented. Several reasons are potentially related to the perceived success of adaptive management in FNP (e.g., stakeholder engagement, use of pilot projects, prompt application of gained knowledge), but in-depth research should seek to clarify their relative contributions and that of other factors not considered here (e.g., how stakeholders participate in the adaptation process; Allen & Gunderson, 2011). Additional research would also be needed to determine exactly how much adaptive management was used and how that was constructed (viz Allison & Murphy, 2017). We also recognize findings for this case are unlikely to apply to other sites with different conditions, such as lack of resources for experimentation or extensive monitoring, or no previous experience with adaptive management. Ideally, a future study would also investigate the application of adaptive management *outside* of the national park to be able to discuss its effectiveness for iBoF Atlantic salmon restoration at the regional scale.

While there are debates over whether ecological restoration is policy driven – because there are few policies that are specific to the discipline and little formal social science analysis to date – research reveals that policies governing resource development and conservation affect ecological restoration planning, management, and outcomes (Baker & Eckerberg, 2013; Jørgensen et al., 2013). Such influence may be critical if there is a high risk to failure (Allison & Murphy, 2017), as when addressing endangered species like Atlantic salmon in FNP. In our case, we observed this in two ways. Beyond its Conservation and Restoration program's approaches, PCA's operational policies are not specific to restoration but frame it. In FNP, restoration seems to have been advanced by institutional policies that coincide on the importance of collaboration, evidence-based decisions, and monitoring, as they set a precedent for recovery-focused actions. The second instance is in the overarching influence of the Species at Risk Act (2002) on the alternatives for managing an endangered species. Its legal requirements to manage and restore an endangered species may challenge meeting the expectations of some stakeholders. In the case of FNP, this arose in terms of potentially engaging the community via angling, which would be subject to prohibitions by SARA. Conflicts among stakeholders surrounding access to Atlantic salmon in the national park are not evident from the information gathered here but could emerge in the long term as community stewardship is pursued while access remains restricted. Finding solutions to this challenge may be a future policy-making task for the recovery of iBoF Atlantic salmon.

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Appendix A

Methods and study limitations

We used a single case study approach based on two data collection methods: interviews and document analysis. We conducted semi-structured, one-on-one online interviews with three key informants in January and February 2021. Participants were Fundy National Park (FNP) employees that held or had held administrative or managerial roles in relation to the restoration project. Recruitment was done with assistance of a Parks Canada (PCA) employee at the Conservation and Restoration Program who invited eligible participants, and through referrals from participants (i.e., snowball sampling). Interview questions referred to the general characteristics of the project (e.g., dates, locations), reasons for intervention, actors involved, restoration techniques applied, measures of project success, applicable policies, perceptions of those policies, and perceptions of challenges, gaps, and opportunities for restoration policy and practice. Interviews were video recorded, and an initial automatic transcription was generated using the live caption function in Microsoft Teams (Version 1.4.00.4167). Afterwards, we manually edited transcripts for accuracy. Transcripts were de-identified and each participant received a unique alias.

We reviewed publicly available documents about the restoration project including official reports, planning documents, and magazine and newspaper articles identified from project partners' websites. Additional information on the recovery project was gathered from the content of project partners' websites and from internal reports (a) identified as relevant by participants and (b) provided by them. Relevant academic publications were obtained from the databases Scopus and Web of Science combining the search terms "Fundy National Park" and "salmon". The search was last updated in March 2021. Thirty-nine unique publications were found and screened using a two step process. Publication titles were screened first. Publications whose titles had a clear or ambiguous relationship to the restoration project (N=16) were then screened based on their abstracts. Only three publications had relevant abstracts and were included in the analysis. All documents analysed, from all sources, were in English.

Interview responses and document information were initially coded with respect to six main themes: project partners, reasons for restoration, restoration methods, monitoring activities, policies, and challenges/opportunities. Additional codes were developed inductively around project components and participants' perceptions of policy effectiveness and project challenges, gaps, and opportunities. All coding was done manually. A complete draft of the study findings was shared with each participant for a chance to make corrections or reconsider anything said. Only one participant provided feedback.

Our case study had several limitations. Not all relevant documents are publicly available (e.g., COSEWIC's assessment in 2001, first recovery strategy produced in 2002) and due to time constraints, no arrangements could be made to request and review them. Our study was also limited in the number of participants that were eligible and therefore offers a small sample of perceptions about the effectiveness of policies, challenges, gaps, and opportunities. Additional interviews with other staff involved in the project (e.g., past employees, non-administrative personnel) would complement our findings. Similarly, our case study focused on the work done by Parks Canada and only captures the views of its restoration practitioners. Because several collaborators work along PCA inside and outside FNP (Appendix B), investigating their perceptions is necessary for a better depiction of the recovery process.

This study received ethics approval from the University of Waterloo Office of Research Ethics (ORE#42723).

Appendix B

Organizations and groups involved in the recovery of inner Bay of Fundy Atlantic Salmon
List of organizations and groups involved in recovery activities for inner Bay of Fundy Atlantic Salmon over time. Organizations and groups are presented in alphabetical order, not representative of the extent or date of involvement. This list is not exhaustive. Sources: Recovery Strategy (DFO, 2010), Action Plan (DFO, 2019) and Fundy Salmon Recovery website (https://www.fundysalmonrecovery.com/).

Acadia University (represented by MSc student)
AMEC Earth and Environmental Inc.
Annapolis Valley First Nation
Aquaculture Association of Nova Scotia
Atlantic Canada Fish Farmers Association
Atlantic Salmon Conservation Foundation
Atlantic Salmon Federation
Atlantic Salmon Law Enforcement Coalition
Canadian Wildlife Service- Environment Canada
Confederacy of Mainland Mi'kmaq, Mi'kmaw Conservation Group
Cooke Aquaculture
Crime Stoppers
Department of Fisheries and Oceans (several divisions)
Fort Folly First Nation
Fort Folly Habitat Recovery program
Glooscap First Nation
Indian Brook First Nation
J.D. Irving Limited
Kings County Wildlife Association
Maritime Aboriginal Aquatic Resources Secretariat
Maritime Aboriginal Peoples Council
Millbrook First Nation
Moncton Fish & Game Association
Nashwaak Watershed Association Inc.
Native Council of NS Netukulimkewe'l Commission
New Brunswick Aboriginal Peoples Council
New Brunswick Dept. of Agriculture, Aquaculture and Fisheries
New Brunswick Dept. of Natural Resources
New Brunswick Salmon Council
New Brunswick Salmon Growers Association
New Brunswick Wildlife Trust Fund
Nova Scotia Dept. of Fisheries and Aquaculture
Nova Scotia Dept. of Natural Resources
Nova Scotia Power Inc.

Nova Scotia Salmon Association
Parks Canada, Fundy National Park
Petitcodiac Sportsman Club
Samuels Seafood Co.
Sentinelles Petitcodiac Riverkeeper
Shepody Fish & Game Association
Sweeney International Marine Corp. (SIMCorp)
University of New Brunswick
Village of Grand Manan, New Brunswick

Appendix C

Policies influencing the restoration process in Fundy National Park

Table C1. Comparison of policies that have influenced the restoration process in Fundy National Park. Policies have different levels of detail or order of tasks but show overlap in general phases for the restoration process. (IUCN= International Union for Conservation of Nature)

Species at Risk Act (2002)	Parks Canada and Canadian Parks Council (2008) principles and guidelines	IUCN guidelines (Keenleyside et al., 2012)	Conservation Standards (Conservation Measures Partnership, 2020)	Restoration process phase
Section 39. Cooperative preparation of recovery strategy Section 48. Cooperative preparation of action plan	Step 1: Identify Natural and Cultural Heritage Values • 1.1. Identifying Values • 1.2. Legislative Requirements • 1.3. Engagement and Communications	Phase 1: Define the problem and engage stakeholders • 1.1: Define the restoration problem that needs to be addressed including likely costs • 1.2: Ensure initial stakeholder engagement • 1.3: Develop a communication strategy	Step 1. Assess • 1A. Define Purpose and Identify Project Team • 1B. Define Scope, Vision, and Conservation Targets	Collaborative problem definition
Section 41. The recovery strategy includes descriptions of the species, its general and critical habitat, and the threats to the species and its habitat Section 49. The action plan includes an evaluation of socio-	Step 2: Define the Problem • 2.1. Assessing Condition • 2.2. Environmental Assessment • 2.3. Visitor experience assessment • 2.4. Data Management	Phase 2: Assess the problem • 2.1: Assess condition • 2.2: Identify reference ecosystem(s) and departure of current conditions from desired • conditions • 2.3: Carry out an environmental and social impact assessment if necessary	1. Assess • 1C. Identify Critical Threats • 1D. Assess the Conservation Situation	Assessment of conditions

economic costs and benefits of its implementation		• 2.4: Ensure an information management system is in place		
Section 41. The recovery strategy must identify a broad strategy to address threats to the species and its habitat, a statement of population and distribution objectives, and a description of research and management activities to meet objectives Section 49. The action plan must state measures to protect critical habitat, implement the recovery strategy, and monitor recovery	Step 3: Develop restoration goals Step 4: Develop Objectives Step 5: Develop Detailed Restoration Plan • 5.1. Scope • 5.2. Project Design and Adaptive Management • 5.3. Monitoring • 5.4. Restoration Prescriptions	Phase 3: Develop Ecological Restoration Goals • 3.1: Develop restoration goals and outcomes Phase 4: Develop Ecological Restoration Objectives • 4.1: Identify measurable objectives and consider preliminary monitoring design Phase 5: Design Ecological Restoration Approach • 5.1: Define scope, consider a range of options, and select the most suitable • 5.2: Develop an implementation plan • 5.3: Develop monitoring plans, including criteria and indicators for process and outcomes	Step 2. Plan • 2A. Develop a Formal Action Plan: Goals, Strategies, Assumptions, and Objectives • 2B. Develop a Formal Monitoring, Evaluation, and Learning Plan • 2C. Develop an Operational Plan Step 3. Implement • 3A. Develop a Detailed Short-Term Work Plan and Timeline • 3B. Develop and Refine Your Project Budget	Development of a plan
	Step 6: Implementation	Phase 6: Implement Ecological Restoration Approach • 6.1: Carry out restoration	Step 3. Implement • 3C. Implement Your Plans	Implementation

	Step 7: Monitoring and reporting	Phase 7: Implement Adaptive Management • 7.1: Use appropriate adaptive management tools approach • 7.2: Monitor and evaluate results of restoration • 7.3: Adjust, as necessary, Phases 5 and 6, and occasionally Phase 4 based on evaluation results	Step 4. Analyze and adapt • 4A. Prepare Your Data for • Analysis • 4B. Analyze and Reflect on Results • 4C. Adapt Your Strategic Plan	Analysis and adaptation
Section 46. Report on the implementation of the recovery strategy and progress towards objectives Section 55. Monitor and report on the implementation of the action plan, progress towards objectives, and its impacts	Step 6: Implementation Step 7: Monitor and report	Phase 6: Implement Ecological Restoration Approach • 6.2: Communicate progress as per the communication strategy Phase 7: Implement Adaptive Management • 7.4: Communicate results and continue, as appropriate, with stakeholder engagement	Step 5. Share • 5A. Document What You Learn • 5B. Share What You Learn • 5C. Foster a Learning Environment	Knowledge sharing