

Beyond Fish: Exploring the Social Outcomes of Hatcheries in Atlantic Salmon  
Conservation

By

*Michael T. Fabiano*

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**Abstract**

Atlantic salmon are an important species of fish in Canada from ecological, sociocultural, and economic perspectives. Due to numerous issues including habitat degradation, ocean mortality, climate change, and invasive species, Atlantic salmon populations in many rivers have or are experiencing a precipitous drop in the number of returning adult spawners. Hatcheries and stocking programs have historically been viewed as a solution to dwindling salmon runs. A more recent body of literature points to the ecological and genetic dangers of these practices. However, many hatcheries are still operational in the Maritimes today. This begs the question, why? While some literature would attribute this to human delusion in believing any issue can be solved with human ingenuity, or an inability to let go of the act of stocking, this paper explores the range of implicit yet desirable conservation, social, and psychological outcomes (more broadly referred to as social outcomes) derived from Atlantic salmon hatcheries in the Maritimes other than the fish they release. Findings include hatcheries serving as repositories of rearing knowledge, catalysts for holistic river restoration, coping mechanisms for ecological anxiety, and bridges fostering human-salmon connections. While some hatchery practices may harm wild populations, these broader social outcomes must be documented and acknowledged to have more informed and transparent management approaches. The goal of this paper is not to give implicit permission to stock due to social outcomes, but to urge regulators to consider both the ecological and social sides of this socio-ecological system in management to maximize its effectiveness and acceptance.

**Keywords:** Atlantic salmon, conservation, hatchery, stocking, socio-ecological system

**List of Acronyms**

ADAM	Aquatic Development Association of Margaree
CAST	Collaboration for Atlantic salmon Tomorrow
DFO	Department of Fisheries and Oceans
LGB	Live Gene Bank
NGO	Non-Governmental Organization
SARA	Species at Risk Act
SAS	Smolt-to-Adult Supplementation
SES	Socio-Ecological System
SWOT	Strengths, Weaknesses, Opportunities, Threats

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## Chapter 1. Introduction

Atlantic salmon (*Salmo salar*) hold great ecological, social, economic, historical, and Indigenous importance in the Maritime provinces of Canada (Nova Scotia, New Brunswick, Prince Edward Island). Early accounts from European colonizers describe salmon (perhaps with some hyperbole) as being so abundant that one could cross a river without getting wet by walking on their backs (Dunfield, 1985).

However, since and largely due to European colonization, Atlantic salmon stocks have declined across their Canadian range, especially in the southern extent of this range including in the Maritime provinces. This decline is believed to be caused by the cumulative effects of multiple stressors. Early stressors to Atlantic salmon included the damming of rivers blocking access to spawning habitat (Scruton et al., 2008), pollutants entering river systems such as acid rain (Watt, 1987), pesticides and industrial runoff (Elson, 1967; Saunders & Sprague, 1967), and a commercial fishery which was eventually closed in the Maritimes in 1984 due to declining stocks (Dunfield, 1985; Fisheries and Oceans Canada, 2022a; Paloheimo & Elson, 1974). More recently, Atlantic salmon aquaculture (Ford & Myers, 2008), the proliferation of aquatic invasive species and other endemic predators (Beland et al., 2001; Valois et al., 2009), and increasing river temperatures associated with climate change (Thorstad et al., 2021) have added to the list of stressors afflicting salmon.

Today, some Maritime Atlantic salmon populations such as the Inner Bay of Fundy are on the verge of extinction (Parks Canada, 2023), and formerly world-class salmon fishing rivers such as the Miramichi are seeing populations decline at alarming rates (Atlantic Salmon Federation, 2020).

For almost as long as Atlantic salmon populations have been declining in the Maritimes, humans have been intervening to try and halt their decline. Reports from the 1850s and 60s showcase recognition of a need for and attempts to implement fisheries protection measures in the face of declining salmon populations due to unregulated harvest (Dunfield, 1985). Shortly after confederation, Canada's first fisheries act (1868) afforded numerous considerations to protect Atlantic salmon such as the creation of

fishing seasons, minimum size requirements, gear restrictions, and spatial exclusion in salmon spawning streams (Dunfield, 1985). Additionally, fish culture stations or hatcheries were established with the primary goal of rearing Atlantic salmon (Dunfield, 1985). One of the earliest hatcheries established was the Miramichi hatchery which opened in 1873 to address declining salmon stocks due to habitat loss by dam construction on the Miramichi (Dunfield, 1985; Miramichi Salmon Association, n.d.-a). More recently, engagement with the Department of Fisheries and Ocean's (DFO) strategy for the restoration and rebuilding of Atlantic salmon identifies enhancement as a key issue that requires policy guidance (Fisheries and Oceans Canada, 2023). As of today, there are nine hatchery facilities stocking anadromous Atlantic salmon in the Maritimes (stocking as defined by the deliberate release of Atlantic salmon into the wild at any stage of its life cycle for any purpose (NASCO, 2024)). Hatcheries as a conservation technology have been utilized in salmon conservation for over 150 years and are still discussed today. The question now remains, are they an appropriate tool to use to combat the current Atlantic salmon crisis?

### 1.1. The Hatchery Debate

The perceived effectiveness—and subsequent use—of hatcheries has seen dramatic increases and declines throughout the 1900s and 2000s (Maynard & Trial, 2014). New advancements in hatchery technology were often met with excitement, leading to its widespread adoption as the latest tool in conservation (Maynard & Trial, 2014). However, as science and long-term monitoring caught up, many in the scientific community began to critique hatcheries, citing neutral or even adverse effects on wild fish populations (Maynard & Trial, 2014). This led to a decline in hatchery use until the emergence of the next technological innovation, at which point the cycle would start anew (Maynard & Trial, 2014).

In recent decades, there has been a shift within the scientific literature that has raised numerous criticisms about the efficacy and overall usefulness of hatchery and stocking programs as conservation tools. This shift is described by the expanding body of

literature showcasing the 1) detrimental impacts of the hatchery rearing environment on fish (generally known as the hatchery effect), and 2) the impacts these hatchery-reared fish have when released into wild populations of salmon.

### *1.1.1 The Hatchery Effect*

The hatchery effect is a term that refers broadly to the range of negative behavioral and physiological impacts that the hatchery-rearing environment can exert on salmonids (Anderson et al., 2020). Chittenden et al. (2010) analyzed performance metrics in hatchery-reared versus wild reared individuals. Results showcased that hatchery-reared individuals experience physical deformities (high proportion of abnormal otoliths), as well as inferior physical performance (lower swim endurance, decreased predator avoidance, and lower migration length) in comparison to naturally reared individuals (Chittenden et al., 2010). Other studies have shown that hatchery-reared individuals experience decreased reproductive success (Milot et al., 2013). Research has highlighted that these impacts may be due to genetic and epigenetic changes occurring due to the hatchery-rearing environment (Busack & Currens, 1995; Le Luyer et al., 2017)

### *1.1.2 Impact on Wild Fish*

These hatchery effects are of greater concern when hatchery-reared fish are released into 'wild' environments. The impact of hatchery fish on wild salmonid populations (wild defined as produced by natural spawning and having spent its entire lifecycle in the wild) has fueled the debate over the use of hatchery fish for conservation and enhancement purposes. The most commonly cited impacts focus on the genetic dilution and implications for effective population size, as well as ecological issues in increasing competition for wild individuals (Araki & Schmid, 2010).

Ecological impacts arise when hatchery fish interact with wild fish in natural environments. River environments where the release of hatchery fish often takes place have limited resources, thus adding large amounts of additional fish can increase competition for wild individuals (Kostow, 2009). Further, evidence suggests that hatchery fish may have advantages over wild fish in terms of size and aggressiveness, leading to

hatchery fish outcompeting wild individuals for resources such as food and spawning locations (Kostow, 2009). This issue is compounded by the inferior reproductive success of hatchery fish in the wild (Milot et al., 2013), contributing further to the decline in populations.

Genetic impacts arise when hatchery-reared individuals are released into and spawn in wild populations. Hatchery fish may impact the demographics of entire populations as the genetics from a relatively small number of broodstock individuals can be amplified through hatchery intervention to increase their frequency as compared to naturally produced individuals, which may decrease effective population size (Naish et al., 2007). Further impacts may be caused in spawning between wild and hatchery-produced individuals as local adaptations accrued through generations of natural selection in wild individuals may be diluted through mating with less fit hatchery fish (Naish et al., 2007).

A 2023 report on the effects of hatchery fish on wild salmonid populations found that of the 207 papers included, 70% (or 144/207) were labeled as discussing adverse effects with another 13% (or 26/207) found to discuss minimally adverse effects of hatcheries and stocking practices on wild salmonid populations (McMillan et al., 2023). This overarching evidence that hatchery and stocking practices produce fish that can negatively impact wild salmonid populations has shaped the viewpoints held by many natural scientists and by extension, many fisheries managers and organizations.

### *1.1.3 Benefits of Hatcheries*

While a considerable amount of the stocking and hatchery literature points to their negative impacts, there is a portion of the literature that is more nuanced. With such a wide array of hatchery types and stocking programs, some argue that labelling hatcheries and stocking as inherently bad or good is misleading (Waples, 1999). Further, many papers advocates for the benefit or utility of hatcheries and stocking under certain conditions. Perrier et al., (2013) argues that hatcheries may be a beneficial way to maintain salmon populations until more robust conservation measures can be put in place, and Stark et al., (2018) argues that in small populations, the risk of extinction

outweighs potential fitness losses, so certain forms of stocking may be beneficial. Beyond the peer reviewed literature, information regarding the efficacy of hatcheries and stocking efforts is often released in the form of grey literature reports put out by the stocking agency which may be missed if only considering peer reviewed literature (i.e. Stopha, 2017).

#### *1.1.4 Why Hatcheries Persist*

Despite the plethora of literature highlighting the detrimental impacts of hatcheries, these hatchery facilities persist. One explanation as to why is proposed by Meffe (1992), in which he explains that humans have adapted an attitude that places technological advances as superior to the natural order when it comes to dealing with environmental problems. This “techno-arrogance” as he terms it, fails to recognize the detrimental impacts of attempting to control nature, and uses the Pacific salmonid fishery and its continued decline despite investment in numerous hatcheries as an example of this concept in the real world (Meffe, 1992). Similarly, Young (2017) posited his “7 H’s” (habit, high, hubris, honor, hope, heresy, h-index) explanation for why humans continue to stock. He proposes explanations such as the hubris of believing technology can outperform nature; the honor of continuing a stocking tradition; the hope stocking provides in the face of scientific literature; and heresy in the denial of scientific consensus as explanations as to why stocking activities persist (Young, 2017).

An emerging body of literature is shedding light on the social benefits derived from hatcheries and stocking activities. This research offers a clearer and more in-depth rationale for the persistence of hatcheries that extends beyond the dismissive explanations of human delusion and irrationality offered by Meffe (1992) and Young (2017). These benefits have been identified as social, cultural, and economic outcomes of hatcheries and stocking practices, and occur in addition to the actual release of fish (Harrison et al., 2018, 2019). These “non-fish” outcomes of hatcheries can in themselves lead to conservation, psychological, and social benefits in individuals and communities of salmon advocates, and the salmon populations these advocates are aiming to conserve (Harrison et al., 2018).

Harrison & Berseth (2024) further this discussion by arguing that the pressures of the ecological and genetic-based literature that discuss the harm caused by hatcheries, in conjunction with the ecological pressures of a rapidly changing climate and human-influenced ecosystems is forcing community-based low-resource fisheries managers into immobility. They argue that any “permissible” salmon conservation program requires intensive resources and knowledge which these fisheries managers do not have access to (Harrison & Berseth, 2024). They argue that instead, these hatchery facilities, if employed with the best intentions can be seen as facilitating the human-salmon relationship and act as an avenue of doing something to prevent further salmon decline (Harrison & Berseth, 2024). In addition, hatcheries and stocking practices can act as a contemporary form of connection between Indigenous communities and salmon (Berseth & Matthews, 2021) in a world where traditional relations between Indigenous communities and salmon have been fundamentally disrupted by colonization and subsequent proliferation of western society (Atlas et al., 2021; Dick et al., 2022; Harrison & Berseth, 2024). The consideration of these social outcomes of hatcheries could be the missing component in finally fully understanding a key question in the hatchery debate: why hatcheries persist despite their documented risks posed to wild Atlantic salmon?

### 1.2. Theoretical Position: Socio-Ecological Systems Thinking in Salmon Cultivation

This paper uses Socio-Ecological Systems (SES) thinking to examine the interconnected social and biophysical factors underlying the issues seen in the included case studies. SES thinking assumes that systems are filled with complex interactions between social and biophysical agents interacting at heterogeneous spatial and temporal scales (Janssen & Ostrom, 2006). A common challenge in many conservation attempts is that there is a strict focus on the biophysical aspect of the issue at hand (Ban et al., 2013). SES thinking emphasizes that successful conservation requires the consideration of both biophysical and social aspects of an issue (Ban et al., 2013). Gaining a deeper understanding of the non-biophysical components of the SES can offer

a more holistic view of the motivations, challenges, and potential solutions in conservation (Cote et al., 2021).

SES thinking connects to the topics discussed in this paper as humans and salmon are both parts of an SES. Up until now in the Maritimes, the management of Atlantic salmon and their hatcheries have largely focused on the biophysical or ecological side of this SES. Concurrently, the hatchery debate continues to highlight the negative impacts of hatcheries, and hatcheries continue to persist. As Lejano (2019) discusses, relationships between different objects in an SES (such as between humans and salmon) can explain what rational decision-making can not (such as why we stock despite the natural science evidence of its dangers). This paper aims to explore the social side of this SES, so that when combined with current management approaches, a full and clear view of the entire SES is seen and can be used to inform future decisions.

A reader note: the array of additional conservation, social, and psychological benefits provided by hatcheries will be referred to as social benefits for the remainder of the paper, as they fall under the social side of this socio-ecological system.

## **Chapter 2. Marine Management Problem**

To date, much of the decision-making processes around hatcheries and stocking programs have been primarily based on the genetic, ecological, and other natural science focused perspectives, and focused solely on the impacts of releasing fish into water. While these natural science impacts are the most visible/apparent outcome of hatchery and stocking efforts, the social outcomes of these programs are very much present yet are frequently overlooked when decisions are made to permit or deny a stocking initiative.

This paper aims to highlight the wide array of outcomes facilitated by hatcheries beyond the fish they produce, as well as perspectives on the current landscape of hatcheries and stocking management in the Maritimes. This is done to aid in answering a key question in the hatchery debate: why hatcheries persist despite their documented harms. The consideration of these social outcomes of hatchery and stocking endeavors is integral to understanding the whole story behind this hatchery debate, and ultimately

integral to effective planning and management of hatchery and stocking strategies in the Maritimes. DFO is currently developing a stocking policy for Atlantic salmon in the Maritimes. This is of significance as many believe the window to save Atlantic salmon is closing in the Maritimes, while in other provinces such as Quebec and Newfoundland and Labrador, there is still time to slow declines. Through having a more holistic understanding of this hatchery debate, it will allow for more informed decisions to be made regarding the future of Atlantic salmon conservation in the Maritimes, and where hatcheries fit into that future. While important to consider, these social outcomes should not function as permission or the sole reason to conduct stocking or hatchery work.

### **Chapter 3. Background**

Responsibility for the protection and management of Atlantic salmon is shared across multiple jurisdictions and levels of government. The federal Minister of Fisheries, Oceans and the Canadian Coast Guard has the authority and tools under federal legislation to manage Atlantic salmon and protect its habitat, while Parks Canada Agency assumes management authority where Atlantic salmon occur within its boundaries. Provincial governments also have powers with respect to the management of Atlantic salmon and their habitat in inland waters. In the Maritimes, provincial governments issue licenses for recreational angling and provide support for science, restoration, and stewardship activities. At the species-level, DFO's "Wild Atlantic Salmon Conservation Policy" and "Wild Atlantic salmon conservation: Implementation Plan 2019 to 2021" have served as the primary documents outlining the goals and guidelines for Atlantic salmon conservation (Fisheries and Oceans Canada, 2019b, 2022a).

Though these high-level conservation policies provide a broad framework for the management of Atlantic salmon in the Maritimes, they fall short in offering specific, actionable guidelines regarding the stocking of Atlantic salmon. Notably the "Wild Atlantic salmon conservation: Implementation Plan 2019 to 2021" does recognize this gap and call for a federal policy to provide more specific stocking guidance (Fisheries and Oceans Canada, 2019c), but as of writing no document has been released yet. As a

result, fisheries management must rely on relevant documents such as the Fisheries Act (*Fisheries Act (R.S.C., 1985, c. F-14)*) and the National Code on Introductions and Transfers of Aquatic Organisms (Fisheries and Oceans Canada, 2017). The primary aim of these documents is to manage the potential biological, ecological, and genetic risks associated with the movement, captive rearing, or introduction of fish to protect biodiversity, as well as ecological and genetic integrity while maintaining human benefits provided by these resources (Aas et al., 2018). However, members of the Atlantic salmon community have increasingly called for a more comprehensive approach that incorporates more of the social, economic, and Indigenous perspectives into this decision-making process, as these perspectives are not adequately considered in the current guiding documents (Denny & Fanning, 2016; Steel et al., 2021).

DFO divested from Atlantic salmon hatcheries supporting public fisheries throughout the 1970s, 80s, and 90s as hatcheries were deemed no longer central to DFO's core conservation mandate (Marshall et al., 2002). The intent was for all facilities to be divested to not-for-profit groups dedicated to preserving Atlantic salmon (Marshall et al., 2002). DFO retained two facilities that are now concerned with the maintenance of genetic diversity within populations considered endangered under the Species at Risk Act (SARA; NASCO, 2017) using a gene banking model of enhancement. All other facilities were thereby taken up by NGOs, provincial governments, or Indigenous groups, or were permanently closed (NASCO, 2017).

The lack of standardized guidelines and alignment across hatchery programs as a result of this fragmented management structure highlights the need for updated policies that integrate ecological, social, and human perspectives. This inconsistency is evident in the varied goals and stocking practices across the four Maritime hatchery case studies included in this paper. These hatcheries are all unique in their history and current stocking practices, however, they are similar in that all fall under this complex Atlantic salmon management landscape and share in many of the same social outcomes and perspectives provided by the hatchery and stocking programs.

A draft document titled “Restore, Maintain, Thrive: Canada's national strategy to ensure the future of Atlantic salmon” is in the process of incorporating public feedback and will act as the guiding document on how to rebuild wild Atlantic salmon stocks in the Maritimes (Fisheries and Oceans Canada, 2022b). DFO published a “What We Heard” report which documents and discusses some of this public feedback and indicates that DFO at the very least has heard and documented these perspectives (Fisheries and Oceans Canada, 2023). In that report, section 5.1 highlights the public perspective on the cultural and economic importance of Atlantic salmon angling, and the role stocking can play in providing recreation angling opportunities in areas where populations have been effectively lost, and section 5.4 emphasizes perspective of a need for effective management of these conservation hatcheries. This highlights the salmon communities’ desire for policy that does more than focus on ecological and genetic impacts of hatcheries, but also recognizes the more benefits derived from Atlantic salmon. It also highlights the desire for more specific guidance on how to manage these hatcheries so that they may effectively integrate the previous focus on genetics and ecosystem integrity with these more human-centered viewpoints so that a balanced approach to stocking is taken.

### 3.1. Case Studies

#### *3.1.1. Fraser’s Mills Fish Hatchery, Nova Scotia*

The Fraser’s Mills Fish Hatchery is located in Antigonish, Nova Scotia. Built in 1928, this hatchery was operated by the Government of Canada as part of their federal hatchery network until 1982 when the federal government divested from the hatchery and the Province of Nova Scotia assumed its ownership and operations (Nova Scotia Fisheries and Aquaculture, n.d.-a). Today, this hatchery primarily raises and stocks brook trout (*Salvelinus fontinalis*), but also raises rainbow trout (*Oncorhynchus mykiss*), brown trout (*Salmo trutta*), and most importantly for the sake of this project, Atlantic salmon. This facility releases 500,000 - 700,000 fish annually with its main goal being to provide

recreational fishing opportunities to Nova Scotians (Nova Scotia Fisheries and Aquaculture, n.d.-a; Province of Nova Scotia, 2014).

This facilities' salmon program is carried out under permit from DFO with the intended purpose of improving the sport fishery and offsetting catch and release mortality (Mi'kmaq Rights Initiative, 2024). This stocking program utilizes wild broodstock that are captured annually and released as fry, parr, or smolt (NASCO, 2017). All parr and smolt releases are adipose clipped for later identification and adipose clipped individuals are not used as broodstock (NASCO, 2017). Stocking efforts are focused on the West River in Antigonish (NASCO, 2017).

This area is also home to various salmon and river associations that work closely with the hatchery to further regional conservation goals. Some examples include the Antigonish River Association and the Nova Scotia Salmon Association (Antigonish Rivers Association, n.d.; Nova Scotia Salmon Association, n.d.)

### *3.1.2. Margaree Fish Hatchery, Nova Scotia*

The Margaree Fish Hatchery is located in Margaree Valley, Nova Scotia. It was built in 1902 as part of the Government of Canada's federal hatchery network. In 1996, the federal government divested from this hatchery. A local community group named the Aquatic Development Association of Margaree (ADAM) took over ownership and operation of the hatchery, primarily funded by fundraising efforts and community support. The Province of Nova Scotia took over the hatchery in 2008 and has continued its operations since (Nova Scotia Fisheries and Aquaculture, n.d.-b).

The primary objective of the hatchery is to provide angling opportunities to the residents of Nova Scotia. This facility raises 150,000 salmon and 100,000 brook trout every year and releases them as fry or fingerlings (Nova Scotia Fisheries and Aquaculture, n.d.-b; Province of Nova Scotia, 2014). This facility's salmon program is carried out under permit from DFO with the intended purpose of improving the sport fishery and offsetting catch and release mortality (Mi'kmaq Rights Initiative, 2024). This stocking program utilizes wild broodstock that are captured annually and released as fry

or fingerlings (NASCO, 2017). All fingerling releases are adipose clipped for later identification and adipose clipped individuals are not used as broodstock (NASCO, 2017). Rivers stocked include the Baddeck River, Middle River, Mabou River, and Margaree River (Mi'kmaq Rights Initiative, 2024; NASCO, 2017).

This area is also home to various salmon and river associations that work closely with the hatchery to further regional conservation goals. Some examples include the Margaree Salmon Association and the Nova Scotia Salmon Association (*Margaree Salmon Association*, n.d.; Nova Scotia Salmon Association, n.d.).

### *3.1.3. Coldbrook Biodiversity Facility, Nova Scotia*

The Coldbrook Biodiversity Facility is located in the Annapolis Valley, Nova Scotia. It was built in 1938 by the Government of Canada and is one of only two federally run hatcheries still in operation in the Maritimes (Fisheries and Oceans Canada, 2019a). It was primarily built to enhance populations of Atlantic salmon and brook trout (Fisheries and Oceans Canada, 2019a). In the late 1990s and early 2000s, DFO held the position that fish culture production to support salmon fisheries would not be effective in the Maritimes due to low marine survival, and as such, DFO's focus should be on the preservation and recovery of endangered species (Marshall et al., 2002). After an unsuccessful divestiture attempt, where DFO transferred the facility to an NGO and the NGO went bankrupt within two years (Marshall et al., 2002), DFO retook control of and pivoted the Coldbrook Biodiversity Facility's infrastructure, operation, and objectives to better align with this focus. Today, the primary goal of the Coldbrook Biodiversity Facility is to function as a live gene bank (LGB) for species at risk populations of Atlantic salmon (Fisheries and Oceans Canada, 2019a).

The purpose of an LGB is to maintain the genetic diversity of a population through selectively breeding individuals. The LGB program involves "producing broodstock or adults at the facilities, selectively mating those adults to maintain the genetic diversity, early release of their offspring into rivers to maximize natural selection in freshwater and later collection of older parr or smolt for renewed production of

broodstock” (Fisheries and Oceans Canada, 2019a). The idea behind an LGB program is to maintain the genetic diversity of a population while bypassing the high mortality of the oceanic portion of the Atlantic salmon lifecycle. This offers advantages over traditional stocking programs as it maintains genetic diversity and ensures there is little to no extinction risk as the individuals are never released to the high mortality ocean phase of the salmonid lifecycle (Fisheries and Oceans Canada, 2019a). However important to note, the LGB program is not intended to recover the population, its only goal is to mitigate extirpation (Marshall et al., 2002).

#### *3.1.4. Miramichi Fish Hatchery, New Brunswick*

The Miramichi Fish Hatchery is located in South Esk, New Brunswick. It was built in 1873 and was originally owned and operated by the Government of Canada as part of its federal hatchery network (Dunfield, 1985). Its original purpose was to address declining Atlantic salmon populations due to damming of rivers and an intensive commercial salmon fishery (Dunfield, 1985). The aim was to increase the survival of these fish through the early life stages. In 1997, the federal government divested from the hatchery, and operations and ownership were undertaken by the Miramichi Watershed Management Committee. The site of the hatchery is also home to the Miramichi Salmon Association. It is more broadly known as the Miramichi Salmon Conservation Centre (Miramichi Salmon Association, n.d.-a)

Currently, the facility solely raises and stocks Atlantic salmon fry throughout the Miramichi watershed with the primary goal of enhancing Atlantic salmon populations (Miramichi Salmon Association, n.d.-a). This is done through traditional fry stocking methods (capture adults, express their gametes, raise eggs until fry, and then place in the river), and DFO approved research studies on novel fry stocking methods used to further scientific knowledge on stocking (Miramichi Salmon Association, n.d.).

One important event that is integral to understanding the recent history of the Miramichi Salmon Conservation Center is the Collaboration for Atlantic Salmon Tomorrow (CAST) group’s efforts and ultimate dissolution. CAST was a partnership of

scientists (i.e. University of New Brunswick, Canadian Rivers Institute), environmental groups (i.e. Atlantic Salmon Federation, Miramichi Salmon Association), and industry partners (i.e. J.D. Irving, Cooke Aquaculture). The goal of this partnership was to save Atlantic salmon on the Miramichi River by advancing scientific knowledge (CAST, n.d.). Four projects were taken up by the various partners. For the Miramichi Salmon Association, their goal was to undergo SAS (CAST, n.d.). This SAS program would involve capturing out-migrating smolts from two Miramichi tributaries, growing them at the Miramichi Fish Hatchery, and releasing them as adults to spawn and migrate, all the while testing these fish to compare the SAS fish to pure wild fish (CAST, n.d.). While the specifics of the reasoning behind their decision are unclear, this project under the CAST program came to an end when DFO opted not to permit the release of the collected smolts (C. Smith, 2019), and the adult fish were destroyed. The CAST project as a whole produced numerous outputs in the form of peer reviewed studies and maps that benefitted scientific knowledge surrounding Atlantic salmon on the Miramichi. However, the outcome of the Miramichi Salmon Association's SAS attempt created significant tension between the members of CAST including the Miramichi Salmon Association, and DFO.

## **Chapter 4. Methods**

### **4.1 Theoretical Approach and Data Collection**

Grounded theory was the primary approach used for this study (Strauss, 1987). Grounded theory is an inductive approach used to generate theory regarding the reality of the subject or phenomenon that is grounded in the data itself (Tarozzi, 2020). In this approach, data is systematically and rigorously collected and analyzed iteratively to build explanatory theory (Mohajan & Mohajan, 2022) about a given subject or phenomenon. It is best suited to study phenomena in a given context; in this case, the social outcomes of hatcheries in the Maritime hatchery network (Mohajan & Mohajan, 2022). As such, it pairs well with case study approaches as utilized in this study.

To recruit participants for this study, the "key informant" approach was used (Gilchrist, 1992). In this study, key informants were individuals who worked at or closely

with the hatcheries studied in this report, or individuals or organizations that publicly voiced strong opinions either supportive of or critical of case study hatcheries. Individuals were identified primarily through visiting their organization's websites. Subsequently, snowball sampling was utilized to identify further study participants as recommended by key informants (Noy, 2008). This study is part of a larger ongoing research project that aims to hear perspectives from all Maritime hatchery facilities. While the case studies presented in this paper do not incorporate Indigenous perspectives, future outputs of the project will specifically highlight these viewpoints.

Data collection was performed primarily through semi-structured interviews with research participants. Prior to an interview, participants would be sent a consent form to review. This consent form was then discussed prior to beginning the interview and participants then had the option to sign it electronically, give verbal consent, or sign a paper copy. The interviews were primarily held in person at a location of the interviewee's choosing whenever possible, practical, and safe to do so. On occasions where meeting in person was not possible, interviews were conducted virtually using Microsoft Teams. Interviews typically lasted 60-120 minutes, with participants allowed to request breaks as needed. Interviews were semi-structured and conversational in nature. Semi-structured interviews are beneficial as they provide researchers with the structure of having an interview guide (Appendix A) which ensures consistency across interviews, while also allowing space for different topics or trajectories to be explored depending on the flow of conversation or the expertise and experiences of the interview participant (Magaldi & Berler, 2020). For example, researchers would prompt participants at the beginning of the interview by saying, "We are interested to hear what you find interesting about this topic". All interviews were audio recorded for later transcription and analysis with the participant's consent. Handwritten notes were also taken during the interview, typically regarding larger themes that arose.

To complement the information learned during interviews, the researchers also engaged ethnographic techniques (Atkinson & Hammersley, 1994) to better understand the subject matter and the areas participants spoke of. This included watching or taking

part in hatchery procedures such as fish feeding or fish releases, or spending time on the rivers and in the areas that these hatcheries were aiming to protect or improve. The goal of these activities was to gain a greater appreciation for the work that is done and the value of these areas.

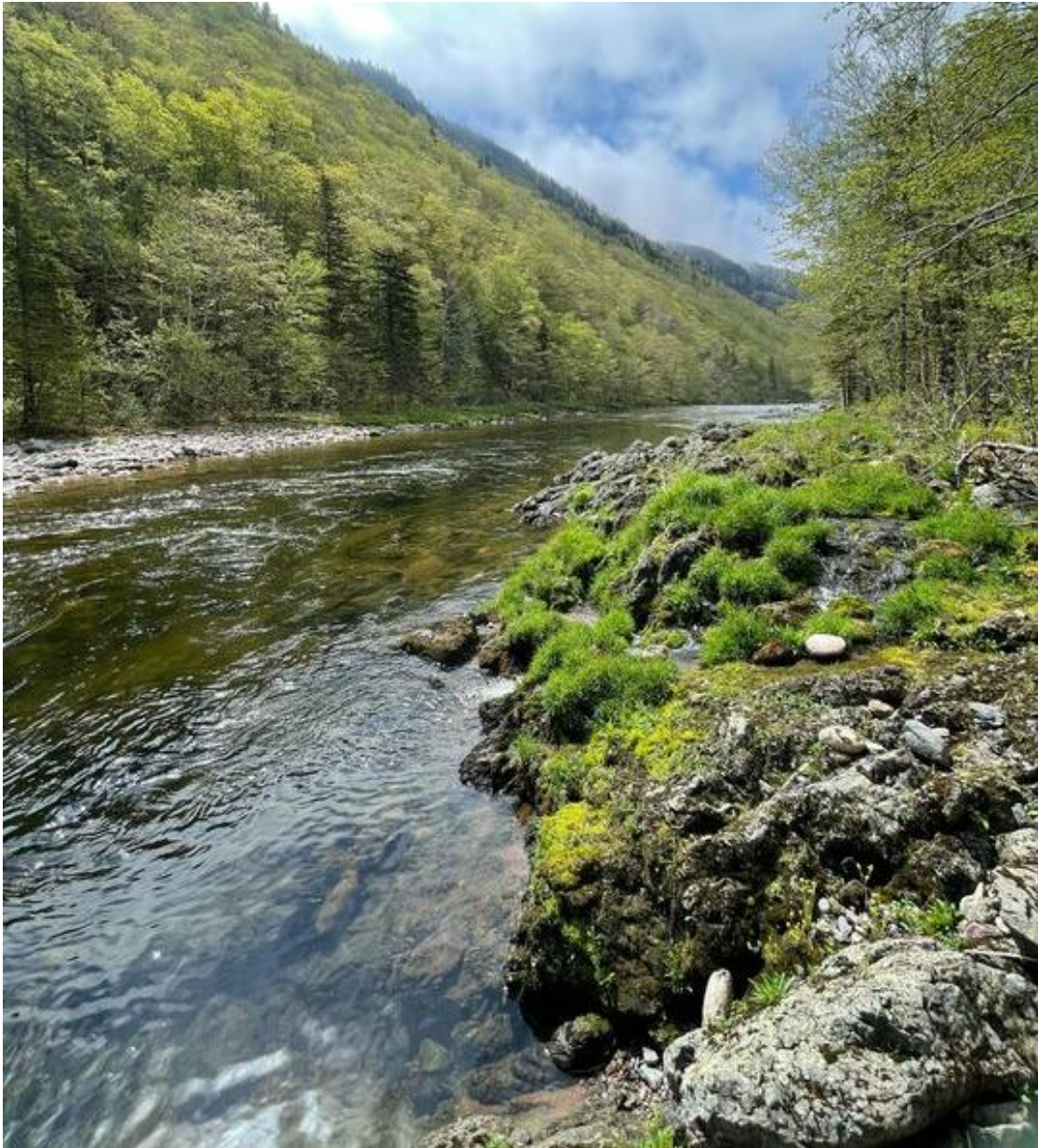


Figure 1. Margaree River, NS. Photo taken by author during an ethnographic exercise.



Figure 2. Releasing an adult Atlantic salmon at a Fundy Salmon Recovery fish release in October of 2024. Photo credit: Abby Christopher.

Data collection with human subjects was reviewed and approved by the Research Ethics Board at Dalhousie University for compliance with federal guidelines for research involving human participants (REB #2023-6591).

#### 4.2. Transcription and Analysis

Interview recordings were transcribed using OtterAI (OtterAI, 2024) or manually. OtterAI is a transcription software that transcribes audio files and produces transcripts with timestamps and speaker IDs assigned. All transcripts were subsequently manually checked and corrected by the author while listening to the interview to ensure accuracy and as part of the iterative process of data immersion.

Corrected transcripts were then uploaded to NVIVO (1.7.2) for coding. An open coding approach was used to analyze the data as is consistent with grounded approaches (Corbin & Strauss, 1990). As codes emerged, they were discussed with co-authors to situate them within the broader research topic. This iterative feedback process supported the development and refinement of the codebook throughout the analysis. Codes were then grouped into major themes (Khandkar, 2009). These code groupings were then discussed with the co-authors to help refine the codebook which formed the basis of the results and analysis of this paper (Corbin & Strauss, 1990; Khandkar, 2009). In this paper, all four case studies are presented together as organized by theme in the results unless otherwise stated.

### **Chapter 5. Results**

A range of conservation, social, and psychological outcomes were found to be derived from Atlantic salmon hatcheries in the Maritimes. Additionally, many hatchery managers, employees, Atlantic salmon advocates, and individuals in the greater Atlantic salmon conservation community identified what they believe to be the primary issues in Atlantic salmon governance. All results presented were identified across all case studies unless otherwise described. A reader's note: all quotations are presented verbatim or near-verbatim (with verbal fillers removed for clarity), and thus should be considered *sic* throughout.

### 5.1. Non-Fish Outcomes of Hatcheries

The results of this study demonstrate that while the hatcheries in this study had a primary objective of producing, rearing, and releasing fish for various purposes (i.e., conservation (Miramichi Salmon Association, n.d.) or compensating for catch and release mortality (Nova Scotia Fisheries and Aquaculture, n.d.-a, n.d.-b), they also produced a variety of non-fish outcomes that were valued by many study participants.

#### *5.1.1. Place for Science and Conservation*

Across all case studies, participants expressed that these facilities often served as epicenters for various means of salmon conservation and scientific activities. Concerning conservation aims, participants expressed that hatchery facilities and associated NGOs and Rivers Associations did not limit their involvement solely to stocking fish. Hatchery activities were seen to be one part of a more holistic river restoration approach complimented by the stocking. Some examples include habitat improvement, invasive species management, and protection from poaching. As one participant in the Miramichi case described:

“I think that there was a lot of [support] because we have been stocking the [river] for so long that it felt like it was a really huge asset to the salmon community to continue on with the various conservation programs we've run out of the hatchery besides just the fry stocking that we've been engaged in.” - Participant 0064

Across cases, conservation activities were often centered around habitat improvement, including the creation of cold-water refugia for salmon, and the removal of beaver dams to improve habitat connectivity. Participants believed that these activities benefit not only salmon but also make for a healthier river as a whole.

Participants expressed a belief that hatcheries were often also engaged in monitoring and actual science for Atlantic salmon, as many felt there was a gap left by DFO. One example is the Miramichi Salmon Association and their monitoring and science work. In the Miramichi watershed, the Miramichi Salmon Association operates a removable barrier where salmon are held prior to spawn to mitigate potential poaching further upriver and to allow for population estimates to be made (Miramichi Salmon Association, n.d.-b). Participants viewed this as furthering conservation and science objectives through the protection and long-term monitoring of the salmon populations.

Participants explained how these hatcheries partnered with other scientists and used the hatchery as a hub for Atlantic salmon and riverine-focused research and conservation work.

“The hatchery here is kind of like a hub. Yeah, so we have, especially during May, it's crazy here. Everyone keeps a gear here. So, everyone from universities will keep the gear here, like ASF [Atlantic Salmon Federation] they keep their gear here. You usually have a lot of departments from DFO... They have a mobile trailer that they keep here during May...And everyone just works with one another. Yeah. Especially gear wise. Everyone has their boat here, anchors. If they need Wi-Fi connection, they come up here stay at the [hatchery] apartment ... Yeah, that's all science people are staying on. Yeah UNB [University of New Brunswick] St. John.” -Participant 0061

“[The hatchery] is kind of like a center of excellence. I think was originally the, you know, the sort of guiding, I wouldn't say principle, but the guiding thought was that we can kind of use the facility to house the [River Association] but also provide a facility for people to do research, in addition to our baseline stocking programs.” -Participant 0064

One example of these hatchery facilities engaging in partnerships to further scientific knowledge is the Dunganvan project. In this collaborative project between the University of New Brunswick and the Miramichi Salmon Association, SAS-reared juveniles (capture smolts, rear smolts to maturity, spawn adults, release fry) are being compared to traditional hatchery-reared juveniles (capture adults, spawn adults, release fry) in a common garden experiment to test for fitness differences between the traditional hatchery-reared fish and SAS released fish in terms of genetic contribution to subsequent generations (Participant 0060).

Participants explained how hatcheries also serve as hubs for collaboration, interactions, and social networks. Dalby and Harrison (*in press*) demonstrated that social networks are facilitated by these facilities, connecting government, community groups, community volunteers, NGOs, First Nations, and research groups including some that are otherwise opposed to or uninvolved with enhancement activities

In the current study, many participants argued these connections were integral to the future conservation of Atlantic salmon.

“The government can't [conserve Atlantic salmon] all by itself, industry can't do it all by itself. And so, maintaining those relationships, and walking that boundary is always a challenge... how we navigate those, those tricky points. And recognizing that... everyone's got their, purposes, and everyone's got their roles, and everyone's got their sort of what they're trying to get out of things, whether that's a company trying to make some money or somebody trying to do conservation work or an Indigenous person trying to maintain their connection and culture. By understanding where everybody's coming from that helps to understand where we're common, and where we can build off of.” -Participant 0053

Overall, participants implicitly and explicitly identified that the case study hatcheries contributed more to Atlantic salmon conservation and science than just

putting fish in water. They were viewed as giving rise to and housing conservation organizations, monitoring populations, and acting as hubs for Atlantic salmon-related scientific studies and collaboration to take place. These hatcheries and associated volunteer organizations were viewed to play an important role in furthering locally specific salmon knowledge and conservation:

“Most of the work that has been done today in the conservation of wild Atlantic salmon is done by volunteer organizations. And with help from the Department of Fisheries and Oceans, but primarily, a lot of the research that's been done, and a lot of the hands-on work has been done, it's been done by river associations.” - Participant 0030

#### *5.1.2. Place for Local Knowledge*

Participants expressed that these hatcheries functioned as repositories for local knowledge. Time and time again, participants mentioned the maxim that “no two hatcheries are alike”. Further, many individuals believed that hatcheries would play a large role in the future of Atlantic salmon. Thus, these hatcheries served as places where knowledge on how to raise fish utilizing the specific hatchery was kept and passed down. Participants expressed that raising fish for conservation purposes is not an intuitive process. It takes years of on-the-job experience to learn all the skills and the nuances of each specific hatchery. This knowledge accumulated through decades of raising fish is passed down from hatchery manager to hatchery manager.

“It's pretty much having staff [at the hatchery] that are well seasoned, and definitely...they have a wealth of knowledge. We rely a lot on, on that on the knowledge and experience.” -Participant 0019

Many participants fear that with DFO's divestment from hatcheries came a loss of knowledge that will be needed if hatcheries are a tool to be used in future conservation efforts.

"I also must admit that it scares the hell out of me, because years ago, [DFO] had 14, enhancement hatcheries. So, you had a lot of folks that knew how to rear salmon, knew the nuances of mating and rearing and release regimes, that sort of thing. But now with two facilities, and a lot of new staff that skill set is pretty close to being nonexistent." -Participant 0056

### *5.1.3. Place to get Community Invested in the River*

Another outcome of these hatchery facilities that participants noted is their ability to garner community support and their ability to get the community involved in and excited about Atlantic salmon and general river issues. These hatchery facilities were seen to be engrained into the fabric of the community, and thus conservation and Atlantic salmon issues become community issues.

"I think there's a lot of parts that go into that value to community. For instance... the St. Mary's, right. The St. Mary's River Association is loud and proud. They have their own sort of museum building and it's it really, there's a culture there that they value, a history of catching salmon on this big river. And that's really important to the people who are part of that they take pride in that knowledge that this was a river Babe Ruth came to. Taking pride in in your community's culture and history, I think is great. So, I think I think that's a big part of how salmon enhancement [preserves], what hatcheries help support people to be part of that." -Participant 0016

Participants expressed the hatchery providing benefits in terms of education and creating energy around Atlantic salmon conservation and river restoration.

“I think that the stocking programs have been a real benefit they have this they really maintain people's interest in their rivers and their populations and their salmon populations.” -Participant 0055

“I think salmon need advocates. And I think hatcheries help support that.” - Participant 0016

## 5.2. Challenges to Governance

Concerns over salmon governance and management was one of the most ubiquitous themes across all case studies. Broadly, participants expressed feelings that DFO did not exercise adequate care or intervention for Atlantic salmon, and an unwillingness to do enough to prevent the declines seen in Atlantic salmon. As one participant described:

“But the fact that it just feels like a fight so much of the time. And that's not to say like, I mean, obviously there you know, there are good people at DFO and there are regulations are in place for a reason ... [but] the lack of accountability is frustrating, because we've often said, you know, if in 10 years if there's no salmon left in the [river], no one at DFO will lose their job. But we will... so like the accountability for the decisions that you're making. It's not there.” -

Participant 0060

Participants described this lack of care by DFO as reflected in the funding Atlantic salmon conservation efforts receive in the Maritime provinces. Participants across case studies drew comparisons between DFO salmon management and funding priorities on the east vs west coasts of Canada, where many felt that West Coast DFO salmon receive all the funding.

Participants also expressed frustrations over the structure of DFO salmon management. Many felt it was very difficult to get approval or make progress on salmon conservation projects due to systemic issues within DFO, including bureaucratic 'red tape', the substantial organizational size, high rates employee of turnover or internal movement, and an overly precautionary approach to management. Many participants worried that DFO's perceived slow pace of action and overly cautious attitude would lead to the eventual collapse of Atlantic salmon in the Maritime provinces. Across interviews, this sentiment was sometimes summarized as DFO will "do nothing until nothing can be done".

As one participant summarized,

"The science of enhancement, like affected populations, genetic integrity. And like, I feel that the discussions about genetic integrity are going to help wipe out salmon. We're so anti doing things for salmon, because we want to protect their genetics that were going to watch their genetics disappear." -Participant 0016

Many participants expressed that these aforementioned issues culminated in a confusing and complicated Atlantic salmon management landscape. Participants described concern about a lack of a centralized voice or widespread effective monitoring of population levels and hatchery versus wild contributions for Atlantic salmon. This was viewed to result in varied goals and measures of success across the Maritimes hatcheries, and a lack of cohesive strategy around hatchery-aided conservation. As some participants described, the problems within Atlantic salmon conservation are seen as fundamentally social and political, not ecological.

"[the salmon conservation world] is very political, and, and difficult because there's a lot of people who have different interests. And the poor fish are just kind of caught in that." -Participant 0031

Finally, many participants – particularly in Nova Scotia - expressed a sense of paternalism from DFO over Atlantic salmon. Participants expressed frustration with what they viewed as a paradox: DFO is viewed to be doing very little to help conserve Atlantic salmon while at the same time making it difficult for groups to undertake Atlantic salmon conservation on their own accord. Reasoning as to why was unknown, but many participants believed it was a function of their non-committal stance on stocking. Participants felt this management stagnation is detrimental to Atlantic salmon populations and hinders opportunities for human-salmon relationships through excessive paternalism by DFO.

“So, I kind of think that for us, where we have the five pairings, it's a little bit nothing to do with science, and a little bit everything to do with: ‘those friggin hatchery people don't shut up, let's throw them a bone of like a few fish so that they can grow some fish.’ Because DFO doesn't want to look like the people who just nixed enhancement. So, I think we do enhancement at such a small scale that it doesn't, it almost can't have an impact, right?” -Participant 0016

This example demonstrates the combination of management paternalism and local frustrations of conservation impotency that the Nova Scotian groups feel. Groups feel that even giving their best efforts may do nothing as they are simply not allowed to do enough by DFO.

### 5.3. The Human-Salmon Relationship

The human-salmon relationship refers to the emotional connection formed between humans and salmon and was expressed to be beneficial both for the fish and for the person. The most prevalent topics regarding this connection were the value participants placed upon salmon, debates over wildness, their fears over the future of salmon, and how having an established relationship with salmon leads to further conservation outcomes.

### 5.3.1. *The Value of Salmon*

The value of salmon refers to the reported benefits participants expressed they believed salmon to contribute to their local ecosystems, personal lives, or greater community. Participants identified the salmon ‘community’ extending well beyond those who work at the hatchery, indicating a pre-established appreciation of and connection to salmon that did not rely solely on the presence of the hatchery. All case studies featured river or salmon organizations comprised of salmon anglers and advocates, as well as an appreciation of salmon in the greater community. Participants reported valuing salmon for numerous reasons, but most commonly for their ecological, economic, and “intangible” value.

Participants who valued salmon for their ecological benefits often mentioned the influx of marine-derived nutrients inland. They believed the presence of salmon contributes to healthy river ecosystems. Additionally, participants reported valuing salmon for what their presence indicates about the health of the local ecosystem. As one participant described:

“Atlantic salmon are often kind of the weathervane for entire cold-water ecosystems. Atlantic salmon don't survive and thrive in isolation. You know, in Atlantic salmon conservation, where you could have the most impact is in freshwater, and it's not by going and turning a magic screw, you know, [its by] protecting forests around cold water, tributaries, removing barriers to fish passage, you know, preventing the introduction of invasive species like it's holistic conservation that benefits all species, including Atlantic salmon.” - Participant 0065

The presence of salmon was viewed as a positive feedback loop by many study participants, where the presence of salmon indicated a healthy river ecosystem and also worked to make the ecosystem more productive through nutrient input, further

benefiting the ecosystem. The presence of salmon was seen to indicate a healthy functioning ecosystem.

Participants also noted the economic value access to Atlantic salmon brings to the communities surrounding major salmon rivers (e.g., the Miramichi River, the Margaree River, etc.). Participants described that many small towns in such watersheds were built around having access to salmon fishing and to accommodate angling tourists. As a participant in New Brunswick described:

“Yeah, you look at Miramichi catchment - all these little communities, the Boiestowns, the Doaktowns, the Blackvilles, the Renous’, yeah, that's how they became established. Is salmon...the guiding services, the fishing services, the lodging, the food and services industry that is dependent on salmon being there.” - Participant 0072

Salmon were seen to contribute to a way of life in many of these communities. Numerous accounts were shared of how the job opportunities were tied to the salmon fishing season. Individuals in these communities explained that historically, residents would guide salmon fishing trips or work at the salmon camps during the salmon season, and then find other seasonal work during the off-season. The economy of these regions was seen to heavily depend on salmon.

The values participants placed upon salmon went even beyond the ecological and economic benefits. Numerous participants described intangible benefits derived from having salmon in the rivers that were often hard to describe. While they could not get these benefits into words, participants derived great value from simply knowing salmon were present in their local ecosystems. As one person attempted:

“There have been estimates of the economic value of [salmon] to the region, but there's, there's also the invaluable, unquantifiable aspects that are worth fighting for, you know, as much as the business” -Participant 0065

### 5.3.2. *Wildness*

The concept of wildness is closely tied to the hatchery debate and emerged strongly within discussions of how study participants valued salmon or saw salmon to be valued by regulators. From national governments to individual anglers, the salmon world has contested definitions and valuations of “wild” versus non-wild fish. This issue is of importance as the label of wild versus not wild changes how these fish are seen in the eyes of the law and in the eyes of many salmon advocates (i.e. the difference between aquaculture salmon and wild salmon). In Canada, DFO defines wild Atlantic salmon as having spent their entire life cycle in the wild and originating from parents who were also produced by natural spawning and continuously lived in the wild (Fisheries and Oceans Canada, 2022a). However, as Berseth & Matthews, (2021) point out, definitions of wildness vary greatly over geographic and jurisdictional space, meaning that fish can go from being wild to not wild by swimming from one jurisdiction to the next. This inconsistency in definition contributes to the confusing and contentious debate regarding wild fish and their value.

When discussing the concept of ‘wildness’, participants expressed a wide spectrum of opinions. Many participants appeared to define ‘wildness’ by metrics of whether the fish survived to spawn, valuing any fish that was able to endure the selection pressures of both the freshwater and marine portions of the lifecycle and successfully returning to spawn. As one participant described when comparing hatchery vs non-hatchery-reared salmon:

“So, I see no difference [in] them. They've both avoided all the predators leaving the river. They've avoided nets in Greenland, the Faroe Islands, and seals and made it back to the Margaree, which is amazing, because only maybe a bit better than 1% do. And yeah, they deserve the same gratitude for making that trip and being able to survive the shitshow from leaving to coming back...and they're putting eggs on the bottom of the river. I value both equally.” -Participant 0012

To these participants, wildness was defined by the action of the salmon and their contribution to future generations as evaluated by the successful deposition of gametes. Broader debates concerning genetic purity, number of generations removed from the hatchery, or other more technical measures were of less concern, as long as the fish was able to survive and contribute to future generations.

Conversely, other participants differentiated strongly between hatchery and non-hatchery fish both in their quality and value, particularly during the process of angling. As one participant stated:

“They're just different..., if you catch a wild fish that's come back from, like, sea... they're firm and hard and fit... [as] a conscientious angler, you're going to fight them hard and get them in, but they're jumping, they're doing all kinds of things, and then you land it, you revive them, but they kick off and it's just, it's all pure wild... Often, you can tell a hatchery fish from the coloring. And you can also tell them from like, they're they've been fattened up and fed in a certain environment... It's almost like a lazy fish...like a couch potato versus an athlete.” - Participant 0059

Between these two extremes, a large proportion of participants appeared to take a more agnostic view on the issue of wildness. Many expressed in various ways that genetics and overall fitness were of lower priority than the actual presence of fish. In other words, some participants expressed preferring a “genetically impure” hatchery-produced fish over having no fish at all. One participant summarized this idea by using the example of adipose fin presence, which is a differentiating factor between wild and hatchery fish as many hatchery fish have their adipose fin clipped prior to release to allow for monitoring.

“Are my great grandkids going to be able to go fish Atlantic salmon 100 years

from now? If the answer is yes, they still can. Do I really care if the adipose fin is there or not?" -Participant 0014

This stronger theme of "wildness agnosticism" within the larger discussion of whether and how wildness matters in hatchery-stocked systems is likely influenced by the recruitment strategy for the study. Though these findings cannot be generalized across all populations within the cases, or between these cases and others not studied, they do offer an interesting insight into the value of participants and how they might differ from those of management.

### *5.3.3. Advocacy and Relationships with Fish*

Participants reported beliefs that the relationships formed with Atlantic salmon contributed to the conservation of salmon. When asked about why participants chose to do work to conserve Atlantic salmon, the most frequent answer was because they were salmon anglers. As one participant described, many connections to salmon were formed by angling.

"The connection that people have to fish is through fisheries and fisheries are a critical part of the fish conservation movement. You know, it like you don't see the same passion and investment and care for like, insects. There's a special relationship between fish and people." -Participant 0065

Many participants shared personal anecdotes of how they formed this connection to Atlantic salmon.

"Back in those days, my mom could say to me when I was old enough to go to the river and catch a salmon for supper. ... So, I've always had a connection to Atlantic salmon. And through the years, I've always been an angler. And through those years, I've seen the resource diminish. And I felt, maybe I could be an

advocate for wild Atlantic salmon. And that's what got me started [in salmon angling and conservation work].” -Participant 0030

While angling was the most commonly reported form of connection within these case studies (likely a result of the sampling strategy), participants expressed that alternative avenues of connection exist. Some participants expressed that their care for salmon stems from a want to see a healthy river ecosystem, and that they simply enjoy seeing salmon in the river. One participant expressed that the connection he gets to salmon through hatchery work is enough for him. He expressed that he is an avid angler but tended not to angle as much as he feels he has interacted with those fish enough through rearing them (Participant 0012).

One of these alternative avenues of connection frequently mentioned by participants was the Fish Friends program (Nova Scotia Salmon Association, n.d.). In this program run by the Nova Scotia Salmon Association, students got a mobile fish hatchery in their classroom and got to watch juvenile salmon from an egg until they are released as fry all while learning a curriculum about the Atlantic salmon lifecycle. Hatcheries were involved in providing eggs required to conduct this program and to provide expertise on raising fish. Some participants viewed these programs as fostering a connection to salmon for Nova Scotian children. They valued this early contact with salmon, arguing that education and understanding of these fish can result in respect towards fish and the environment that students carry forward with them in life. Several participants detailed this point:

“Educate people on the biology of [salmon], because the more you know about them, the more you respect them.” -Participant 0031

“It's 100 fry. The kids come out and they put them individually, each have a little cup, and they dump them in the river... and they've learned the whole life

history, and they've developed an expectation that they should have salmon in those rivers” -Participant 0069

In addition to Fish Friends, hatcheries contributed to the connection people have to fish through them being open access for the public to tour. The facilities in Nova Scotia were completely open access for anyone to enter the facility and see the ponds, and the Miramichi facility allowed for full tours of the facilities. Participants expressed that people visiting and touring the hatchery have an opportunity to see Atlantic salmon grown there at life stages that were often not possible to see in the wild. The decision to keep these facilities open access was a choice made to allow for further development of the human-salmon relationship and to remain close to the community.

For hatchery staff, participants reported hatcheries offering other, non-extractive forms of connection between humans and salmon especially. In all cases, participants engaged in hatchery work expressed that hatchery employees can develop a nurturing and caring relationship with the fish. As two hatchery workers described:

“Yes. So it is exciting for someone to take [the salmon] out... So, after we're done spawning them, and we take in their eggs, and we know they're 100% okay to go back [to the river], we put them in a black garbage bag in a feed bag so it has support, put water in there, and we walked them or drive them down to the river. And if you got waders on you, you could wade in a little bit. You slowly uncovered the bag, and you hold her up and a little bit under the nose and under the tail. And you let her come to the way of the water. And when she's ready, she's out of there and gone. And you know that moment it's like, yes, there she goes. She knows what she's doing. She knows where she has to go. She's done her job. And she's gone free again. For how long you don't know, but it is pretty cool for you.” -Participant 007

“Yeah, if you're stocking parr, fry, or smolts into a system and you've raised those

fish, all of a sudden, the fish coming back, you have ownership.” -Participant 0069

While connections with Atlantic salmon were formed and supported in multiple ways including through hatchery facilities, angling, or Fish Friends, all forms were viewed as valuable in supporting conservation activities and building attitudes of advocacy and stewardship of salmon.

Participants believed that an integral part of Atlantic salmon conservation work and getting people to care about the salmon was access to salmon either through angling or hatcheries. In rivers where angling is restricted or salmon have been extirpated, many participants saw it as difficult to get momentum behind the conservation or rebuilding of Atlantic salmon stocks, believing that the human-salmon connection had become weak or forgotten. Perhaps unsurprising to the study population, many participants argued that angling is an important means of maintaining that connection. For example:

“Because if you don't have an open fishery, you don't have the lobbying for [salmon]. You don't have the community group support. You don't have people writing the minister.” -Participant 0018

Much like how participants expressed the presence of salmon contributed to a positive feedback loop of ecosystem improvement, participants feared that the loss of salmon and stewards is a positive feedback loop in itself. As a river loses fish, there would be fewer stewards, which leads to fewer stewardship activities, leading to fewer fish, and this will just continue until there is a generational loss of knowledge around salmon. The presence of salmon was viewed as integral to facilitating the human-salmon connection and its resulting advocacy.

“This is the concern, because I was just talking recently with an individual who

said that the concern is, now there's no salmon. For example, their kids, they don't pick up the fly rod anymore. They don't even know how to catch a salmon, even if it did come back, and it's not in their core anymore, it's not in their heritage. So, if this goes on for too long, yeah, you lose you lose those stewards, and you lose the interest [in salmon], because it wasn't something that you grew up with.” -Participant 0072

Hatcheries were viewed as helping to support these relationships with salmon as they theoretically boost fish populations, allowing for increased angling opportunities. They also contribute to alternative means of forming the human-salmon connection through their involvement in programs like Fish Friends. While concerns over wildness and the value of wild fish may be contested, as previously discussed, participants expressed that having access to any fish is beneficial in creating that human-salmon relationship- whether the fish is considered “wild” or not.

#### *5.3.4. Salmon Futures*

One theme that arose across all cases were feelings associated with the decline many participants were witnessing in salmon populations in their local rivers. Many participants expressed feelings of sadness, anxiety, uncertainty, or concern over witnessing this loss of salmon within or over the course of their lifetimes. Often, this dismay was expressed in the context of future generations being unable to experience or benefit from the salmon abundance enjoyed by themselves or those that came before them. One participant described this feeling in the context of his grandchildren:

“I think it would be just terrible shame for, you know, the potential of my grandchildren never to see [a salmon], and it's possible.” -Participant 0071

Participants expressed a belief that this is in part driven by climate change. Participants believed that salmon are facing an environment that is constantly changing, making it difficult for salmon to cope.

“There's striped bass in the estuaries of these rivers... there's smallmouth bass in the headwaters. There are factors like global warming. There's the multiple adverse impacts of the forestry industry. There's the Indigenous fishery. There's even like the non-Indigenous catch and release fishery...And then in some rivers, you have the aquaculture industry.... So, there's there are multiple factors, challenges facing wild Atlantic salmon.” -Participant 0054

A proportion of participants viewed the perceived decline of salmon as a justification for expanding or continuation of the stocking programs. As one participant described:

“I want to put [salmon] in the river so I can fish next year, and I can take my grandkids fishing.” -Participant 0014

Beyond allowing for the continuation of fishing, stocking was perceived to be playing a much more important role now and moving into the future. In an era of unprecedented weather events occurring regularly, participants expressed a belief that these hatcheries could act as an insurance policy, safeguarding the salmon and the ways of life the salmon have created.

“Miramichi's got all the same stories, fishing and baseball players, whatever. And like, I think people want to protect that and they want to ensure it continues. And they view hatcheries as a way of doing that, right. Like a hatchery is almost a defense against losing a way of life.” -Participant 0016

“Sort of the way I see it is that this is a safety net so that if things really do get dire, we can certainly you know, gene bank, but we also have the capacity to kind of bring the river back and jumpstart it.” -Participant 0064

Participants expressed their views that hatchery facilities and stocking programs acted as a source of hope in contrast to the decline of Atlantic salmon populations in the Maritimes. These facilities appeared to provide hope (misguided or otherwise) that through human intervention, humans can slow or even reverse the declines they have caused in Atlantic salmon populations. These facilities offered participants a way to engage in conservation efforts and contribute to salmon recovery, reflecting a sense of responsibility toward supporting natural ecosystems and aiding salmon populations.

“And, and when it comes to living in the wild survival of the fittest, Mother Nature will do her natural selection. And so, I think by doing this, we need to enhance populations, support them. Because when you get big weather events and situations, where perhaps because of human interference, fish can't do their natural process for reproducing that. We owe it to them to help them.” - Participant 006

Further, participants explained how stocking provided a sense of purpose to the staff and volunteers who dedicate their time and effort to raise salmon at these facilities, as they feel they contributed towards the future and conservation of Atlantic salmon. As one participant described:

“The Margaree hatchery we were looking at and that's been established for so long, and members of the Margaree Salmon Association volunteer time there and they have that feeling of like they're doing something it's a feeling of purpose.” -Participant 0059

These examples demonstrate what could be understood as a connection and deep care for salmon and a negative emotional experience in witnessing their decline. For stocking advocates, hatcheries were seen as a safeguard from the loss of salmon and the ways of life salmon have given rise to, which provided hope and a sense of purpose for those actively involved in the hatcheries. This could be summarized as a feeling of not wanting to sit idly by as salmon disappear, there was a wanting to do something, and hatcheries offered an avenue of doing something. One participant summarized this feeling well:

“I always feel like we need to, we need, and we can do something. So we should do something, right?” -Participant 0064

## **Chapter 6. Discussion**

The results of this study highlight numerous social outcomes produced by four Maritime hatcheries that fall outside their stated goal of producing fish, which can be summarized as hatcheries furthering Atlantic salmon science and conservation, nurturing the human-salmon relationship, being a repository for local salmon-rearing knowledge, and providing a source of hope for the future of salmon. These results also emphasize perspectives and frustrations in the current management regime.

The use of hatcheries for conservation is a contested management tool. The literature surrounding stocking points to it often being a detrimental practice, that when aimed at conservation outcomes, does not achieve its goals (Araki & Schmid, 2010; Levin et al., 2001; McMillan et al., 2023); yet stocking persists. Some have tried to explain this persistence by citing human ignorance in believing any problem can be fixed with human ingenuity (Meffe, 1992) or the 7 H's (habit, high, hubris, honor, hope, heresy, h-index) as to why hatcheries remain open as offered by Young (2017). However, as seen in the results of this study, this persistence of stocking could be a result of implicit, yet desirable social outcomes derived from stocking that fall outside the stated objectives of fish production. These outcomes include hatcheries furthering Atlantic salmon science

and conservation, nurturing the human-salmon relationship, being a repository for local salmon-rearing knowledge, and providing a source of hope for the future of salmon.

Regardless of the value of these social outcomes, fisheries managers must still account for and balance the negative ecological, biological, and genetic outcomes of stocking. The challenge then becomes how and whether to also balance the additional positive social outcomes hatchery operations confer. This leaves fisheries managers in a difficult position of trying to figure out how to best utilize this contested management tool, for which no comprehensive framework that engages both social and ecological aspects exists (Aas et al., 2018).

In this management gap, the findings of this study offer insights into how social aspects of these contested management tools butt up against their more deleterious qualities. Here, these findings are discussed in greater depth and context across case studies and hatchery debate literature, and are framed in a social-ecological systems lens in order to contextualize their position in the debate. In that, this paper offers insights into how the findings of this work contribute to the human dimensions literature on stocking and to understanding hatcheries and stocking in socio-ecological systems approaches more broadly. Finally, the ramifications of these findings are discussed in the context of the current management climate, specifically as it relates to DFO's "what we heard report" (Fisheries and Oceans Canada, 2023) and the current policy gap around enhancement in wild Atlantic salmon conservation.

## 6.1. Discussion of Findings and Insights from Case Studies

### *6.1.1. Hatcheries as a Place for Science and Conservation*

The results of this study highlight a belief that hatcheries are places where science and conservation goals are furthered, as hatcheries and community groups engage in more holistic river restoration activities and advocacy in addition to their primary goal of stocking fish. This theme of hatcheries giving rise to broader conservation initiatives has been documented in hatchery facilities throughout Norway, Wales, and Germany (Harrison et al., 2018).

When viewed in the context of feelings of DFO falling short in meeting obligations and perceptions of their lack of urgency in this issue, these hatchery facilities and associated organizations being hubs for Atlantic salmon science, monitoring, advocacy, and conservation work could be seen as the local community taking the fate of Atlantic salmon into their own hands. DFO are seen to not give these salmon the attention they deserve, so these groups stepped up.

Considering these social outcomes provided by hatcheries, the Margaree, Frasers Mills, and Miramichi facilities can be seen as a form of community-based conservation. While these facilities have differing governing bodies and funding structures, their close ties to the community and their focus on local issues align with descriptions of community-based conservation movements (Berkes, 2021). Notably, the Coldbrook facility does engage with community groups and contributes to science and conservation but differs in how these outcomes come about. The Margaree, Frasers Mills, and Miramichi facilities more closely align with bottom-up conservation that is spurred by community action, whereas the Coldbrook facility, represents more top-down conservation as it is federally owned and tasked with stocking a wider geographic area. Due to these differences, the Coldbrook facility is differentiated from the other three facilities when it comes to community-based management.

In contrast to strict protectionism, community-based conservation efforts aim to integrate local ecological, economic, and social objectives through the incorporation and promotion of local interests (Brooks et al., 2013; Otto et al., 2013). Looking at it through this lens, there are other examples of communities taking their natural resources into their own hand following a perceived failure to successfully manage them by government (Charles & Berkes, 2021; SSHRC, 2012). Examples can be seen from community-based lobster research in Atlantic Canada following the cod collapse as communities didn't want to experience another loss (Charles, 1995), and in the fishing industry in Koh Pitak Island in Thailand where local action aimed to rehabilitate what overfishing and pollution did to the industry (Charles & Berkes, 2021; SSHRC, 2012). The work that these hatcheries do in conducting science and conservation can be seen as a

form of community-based conservation in that they fill a perceived gap left by more formal authorities in salmon conservation. This theme of hatcheries giving rise to science and broader conservation initiatives provides further verification of this phenomenon observed by Harrison et al. (2018), highlights this theme's prevalence in the Maritimes, and showcases that these hatcheries are beneficial in providing agency to members of the community in conservation initiatives.

From the opposite point of view, an argument could be made that these conservation groups are being built around and thus protecting a harmful practice to wild salmon populations. As outlined in the introduction, the natural science literature generally views hatchery facilities as having adverse effects on wild salmon populations (McMillan et al., 2023). The growth of conservation efforts centered around these hatcheries might inhibit critical examination of hatchery and stocking practices (Dalby and Harrison, *in review*). As seen in the Miramichi case study, the hatchery and stocking activities were closely tied to their more holistic conservation programs, as the hatchery and conservation organization is housed and run out of the same facility. This has the potential to make it difficult to challenge hatchery activities as they are seen to give rise to additional ecological and social benefits.

#### *6.1.2. Hatcheries as a Repository of Knowledge*

Hatcheries were seen to be repositories for local knowledge. Local ecological knowledge (LEK) is a term that describes place-specific, non-scientific informal knowledge that is passed down through generations (Dyrset et al., 2022). In these case studies, LEK was seen to be passed down from hatchery manager to hatchery manager over generations on numerous relevant topics including how to effectively utilize and run the hatchery to rear Atlantic salmon, where and how to catch Atlantic salmon for broodstock, and how to effectively conduct many of the programs done in addition to fish rearing and release. This theme arose across all case study hatcheries, but was particularly apparent at the Margaree, Frasers Mills, and Miramichi facilities due to the established presence and history of these hatcheries in the communities. This is of

importance as in recent years, there has been an increased emphasis being placed on the value of this knowledge gathered by local people and organizations and its importance to knowledge synthesis and decision-making (Wheeler & Root-Bernstein, 2020). If the common belief held by participants that hatcheries will become increasingly important as salmon continue to decline holds, then the knowledge held at these hatchery facilities by employees will become increasingly valuable as that shift takes place. These findings build on observed similar phenomena of knowledge hybridization between LEK and western science as identified in Welsh and Norwegian salmon hatchery programs (Harrison et al., 2018), demonstrating the role of interactions between knowledge holders and younger generations (Ruddle, 1991).

However, a concern is that this passing down of local knowledge may be outdated or incomplete compared to recent scientific advances. While rearing techniques have been passed down from hatchery manager to hatchery manager over the history of the hatchery, hatchery technology, and rearing practices have advanced tremendously in more recent decades due to scientific improvements. As such, a worry can be raised that these passed-down practices may be ineffective and outdated compared to more modern practices (Beckford & Barker, 2007). Further, debates around the usefulness of local knowledge outside the limited scope of its given context case have been raised (Bicker et al., 2003; Wheeler & Root-Bernstein, 2020).

### *6.1.3. The Human-Salmon Relationship*

Across all case studies, participants agreed that there was something special about Atlantic salmon. Often referred to as “the king of fish”, participants valued Atlantic salmon for various reasons, including ecological, economic, and more intangible social reasons. The value provided to participants in these case studies could be looked at through an ecosystem services lens and a relational lens.

Ecosystem services refer to the ‘benefits’ that people obtain from ecosystems, including provisioning services, such as food and water; cultural services that provide non-material benefits, such as places for recreation; and regulating services that provide

benefits due to the regulation of ecosystem processes, such as flood control and climate regulation (E. M. Bennett et al., 2009; Millennium Ecosystem Assessment, 2005). Ecologically, Atlantic salmon were valued due to the benefits they provide to ecosystems such as the transportation of marine-derived nutrients inland (Samways & Cunjak, 2015), and in what the presence of salmon indicated about the ecosystem state (Hyatt & Godbout, 2000). Participants perceived a positive feedback loop, where the presence of salmon indicates a healthy ecosystem, and the marine-derived nutrients they bring upriver further contributes to making the ecosystem healthier. Economically, salmon were valued for the income they generated through the recreational fishing industry. Many communities were established due to the access to salmon they provided. Salmon shaped the way of life in these communities (Autti, 2017). Participants expressed that these communities relied on the influx of people, income, and jobs that the recreational salmon industry brought. Under the ecosystem services framework, Atlantic salmon produce benefits for the participants of this study through their regulation of ecosystem processes, through their non-material benefits of creating more pristine ecosystems, and through direct economic contributions to the communities that established around them.

However, another avenue of valuing salmon was frequently discussed, though participants often found it challenging to articulate. This could be described as a deep, inherent value that transcends their ecological and economic roles and that extends beyond the socio-cultural shortcomings of the ecosystem service frameworks (Bull et al., 2016; Schröter et al., 2014). This difficult-to-explain relationship between salmon and humans can be seen as the human-salmon relationship. As Lejano (2019) explains, in socio-ecological systems, connections or relationships can form between objects within the system-in this case between humans and salmon. These relationships are often difficult to explain by rational decision but are felt strongly (Lejano, 2019). These human-salmon relationships were present across all case studies.

This human connection to salmon was seen as integral to the species' persistence. Participants expressed a belief that the connections and care humans have

for a species translates to conservation efforts for the species (A. M. Smith & Sutton, 2008). This is frequently seen in the flagship species literature, where popular and charismatic species are used as triggers for conservation movement (Smith & Sutton, 2008). Regarding salmon, personal connection were seen to foster care and responsibility, motivating action such as conservation and advocacy work as the resource declines. This was reflected in the study participants, as many of them were involved in Atlantic salmon conservation due to themselves having a connection or relationship to the fish. With the declines in salmon seen in the Maritimes, many participants expressed a fear over the impacts of losing this human-salmon relationship. As many participants outlined, the loss of salmon results in a positive feedback loop, where the salmon decline causes a decrease in salmon stewardship as people are no longer connected to salmon and thus don't see the value in their preservation. This lack of stewardship results in the further loss of salmon, which furthers the loss of stewardship. This cycle continues until there is a physical loss of salmon and a generational loss of the knowledge of salmon. The presence of a human-salmon relationship was seen as integral to ensuring the continued support and persistence of salmon in the Maritimes, and thus the maintenance of the human-salmon relationship.

Hatcheries were seen as an integral component in facilitating the human-salmon relationship (Harrison et al., 2018), amidst declining salmon populations in the Maritimes. This was accomplished by strengthening pre-established connections to salmon through increasing recreational angling opportunities and nurturing new connections to salmon through programs and activities like hatchery visits or Fish Friends.

Likely as a result of the sampling strategy employed in this study, fishing was a frequently mentioned avenue of connection to salmon. Many participants outlined that their reason for being involved in salmon conservation stemmed from the relationship they had with salmon through angling. Numerous participants held a strong belief that hatcheries improved salmon populations in their local rivers and could continue to do so into the future. The increased abundance of salmon in the rivers theoretically leads to

higher angling participation and success, which in turn strengthens the human-salmon relationship by allowing for increased interactions between humans and salmon. Some hatchery critics may argue that stocking fish to increase angling opportunities is a self-interested act, however, this argument places judgments of 'goodness' on different forms of connection to salmon, citing angling as exploitative and thus less good. Does the form of relationship or motivation matter if positive outcomes such as stewardship are produced?

Hatcheries and their associated stocking activities were also seen as an avenue of fostering new connections between salmon and people, particularly youth. The cultivation of salmon presents an opportunity to view and interact with the species at life stages that would be effectively invisible to most observers in the wild. A primary example of this is the Fish Friends program. In this program, classrooms in various schools throughout the Maritimes got a mini-hatchery that allows the students to watch the salmon from the egg to fry stage, all while learning a curriculum about Atlantic salmon (Atlantic Salmon Federation, 2001). The goal of this program is to promote the education of these students about Atlantic salmon and their issues, as this knowledge is fundamental to caring for them (Atlantic Salmon Federation, 2001). Hatcheries support the connection of these students to salmon as they are required for the collection of broodstock, fertilization of the eggs, distribution of the eggs, and expertise on how to raise the juvenile salmon. Similarly, the hatcheries being open access for visiting provides a similar avenue of connection, as members of the public have the opportunity to view salmon at all life stages, offering an inclusive, non-extractive method of viewing and connecting to Atlantic salmon for any interested individuals. In both examples, hatcheries facilitate the connection of people to salmon in non-traditional but equally meaningful ways, fostering the human-salmon relationship.

Looking forward, the role of angling and hatcheries as forms of connection is less certain. As angling opportunities become increasingly scarce due to declining populations (Sweet, 2024), and closures due to warm water protocols (Farley, 2024), what role will hatcheries play? They may offer an avenue of supporting these traditional

methods of connection and opening the door for new avenues of connection to be made, thus supporting the human-salmon relationship in the stead of now unsuitable salmon environments, though this study does not conclude one direction or another.

Overall, the connection between humans and salmon was seen as integral to ensuring salmon persist both now and into the future, and hatcheries were seen to support this human-salmon relationship in many ways. These hatcheries thus could be seen as a counteractive force halting the salmon-stewardship positive feedback loop as highlighted earlier, ensuring salmon have advocates now and into the future. This outcome of “halting” the generational loss of salmon and salmon knowledge could extend Young’s (2017) framework, adding an eighth “H” to the existing seven reasons why humans continue stocking practices.

Within this discourse on the value of hatcheries in the human-salmon relationship, several critiques reveal themselves and are worth discussing. First, with the documented harm hatcheries and stocking efforts cause to wild populations of salmon (McMillan et al., 2023), an argument could be made that these salmon and thus the human-salmon relationship persists in spite of these efforts, not because of them. Second, while hatcheries appear to facilitate aspects of the human-salmon relationship in the Maritimes, especially in regions with declining or extirpated populations, these connections to salmon should be viewed as a temporary method of ensuring the generational knowledge and care for salmon remains while addressing the more systemic issues afflicting Atlantic salmon populations. In this study, the maxim that ‘a hatchery manager’s goal should be to put themselves out of business’ was frequently repeated, highlighting that, for many, the ultimate goal of any stocking program should be to return populations to a self-sustaining state. The previous section then necessitates the caution that while the relationships to salmon facilitated by hatcheries are important, the ultimate goal should be to not have a need for hatcheries - having wild self-sustaining populations. However, as highlighted in the introduction, the stressors impacting Atlantic salmon populations are extensive (Dadswell et al., 2022; Thorstad et al., 2021). Additionally, the oceanic portion of the salmon lifecycle, often

referred to as a “black box” remains poorly understood as to why mortality is so high at this stage (Burke et al., 2016; Crozier et al., 2018). Compounding this, climate change continues to impede various aspects of the Atlantic salmon lifecycle (Jonsson & Jonsson, 2009). These facts elicit two questions: can/will humans intervene in time to address these issues and prevent the loss of salmon in the Maritimes? If the answer is no, are Atlantic salmon valued enough to warrant perpetual human intervention - even if through ‘artificial’ means?

#### *6.1.4. Salmon Futures*

Almost unanimously across all case studies, participants expressed feelings of fear and concern regarding the future of Atlantic salmon in the Maritimes. These concerns were frequently expressed as sadness that future generations would not get to experience the resource in the ways that participants did - often drawing examples of their grandchildren. These concerns had perhaps particular tenacity in 2024, as that year saw record-low returns to numerous Maritime rivers including the Miramichi and the St. John (Sweet, 2024). While official salmon returns numbers from DFO had not yet been published at the time of this writing, counts from fish ladders and counting fences on the Miramichi and St. John rivers show returns barely breaking the 100 mark in rivers that used to support thousands of fish (Sweet, 2024). The extirpation of salmon from many Maritime rivers appears to be happening now, and fast (figure 3).

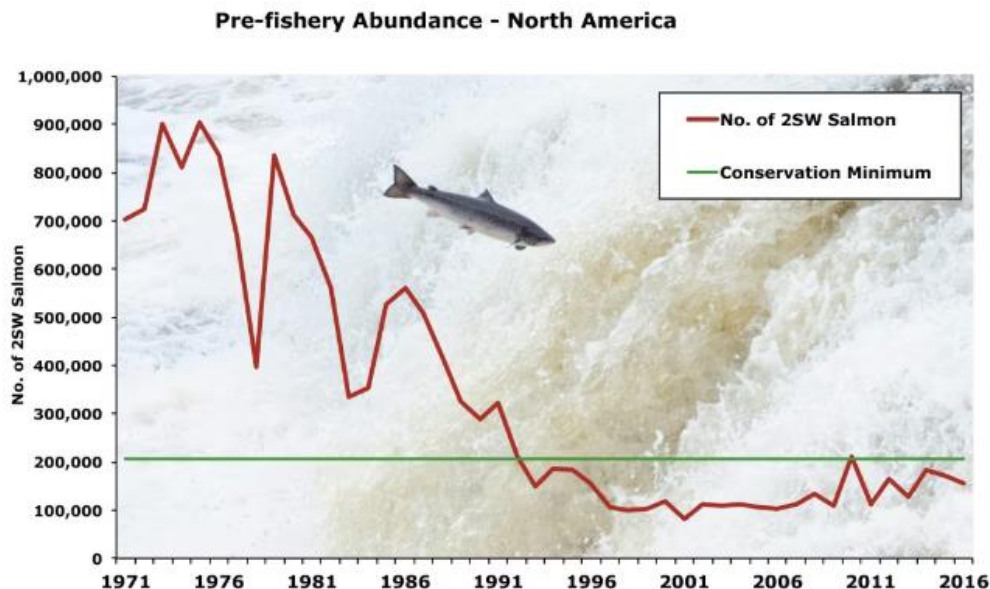


Figure 3. Decline in returns of Atlantic salmon to rivers in North America. Adapted from Atlantic Salmon Federation

These feelings of fear and concern regarding the future of Atlantic salmon can be understood as ecological anxiety. Ecological anxiety (or ecoanxiety, also known as ecological grief or climate anxiety) can be described as “intense feelings of grief as people suffer climate-related losses to valued species, ecosystems, and landscapes” which can impact mental health through numerous pathways (Cunsolo & Ellis, 2018). The SES literature discusses how systems have heterogeneous scales (Berkes et al., 2014; Zurlini et al., 2006). In these case study systems, Atlantic salmon are being lost at various scales both on the ecological and social side of this SES. At the individual level, genetic sub-populations of salmon are being lost due to anthropogenic pressures, and individual anglers are experiencing loss in their inability to catch salmon or see their grandchildren catch salmon due to declines. These individual losses may also be within individuals, as connection to salmon is often seen as a form of identity, evident through the case studies and literature (Harrison, 2013). As such, the loss of salmon could translate to a loss of identity. At the community level, losses in individual salmon populations are being seen as more than the loss of a species of fish, but the degradation of entire ecosystems, as the presence of Atlantic salmon in these systems is seen as a bellwether for ecosystem health. Similarly, on the human side, Atlantic salmon provided significant

economic input into towns along major salmon rivers and socially, brought communities of people together. The loss of these salmon may not simply be the loss of a species of fish, but a loss in the ways of life they gave rise to, and the loss of entire locations and communities that relied on their presence.

Intertwined in the expressions of ecological anxiety were also expressions of hope, particularly in how hatcheries and stocking programs of various kinds provide ecological and social 'insurance' against loss. For example: facilities like Coldbrook use live gene banking to ensure the persistence of the distinct genetic makeup of salmon populations, ensuring that these genetics are preserved into the future. Facilities like the Miramichi, Margaree, and Frasers Mills offer insurance that if these populations were to be wiped out by some climate-induced event, there is capacity to bring them back through stocking. Collectively and in different ways, these facilities seem to provide hope and a feeling of purpose that through human efforts, Atlantic salmon populations and the ways of life they afforded may persist into the future. Participants expressed feelings of wanting to give back to Atlantic salmon and help them along, and hatcheries offered a way to do so. These feelings can be summarized by the sentiment of not wanting to sit idly by while the salmon they care for disappear. As previously discussed, many feel that DFO is not doing enough to conserve Atlantic salmon, and these hatcheries offer a way of doing something rather than nothing to protect a species they care for. These findings align with phenomena observed in western European hatchery programs (Harrison et al., 2018), and in examples from Indigenous hatchery programs (Braun, 2022; Herz, 2023).

While ecological anxiety is a legitimate form of grief and coping with this phenomenon appears to be a beneficial social output of hatchery programs, how can managers balance this perceived benefit against the equally legitimate criticisms of hatchery and stocking programmes? Young (2017) highlights how no matter how much evidence accumulates demonstrating stocking hatchery fish compromises the integrity of wild populations, people will hope. People will hope that their rearing practices, broodstock protocols, stocking strategies, and fish are different, and what they do will

help and not harm- blind faith sees no evidence (Young, 2017). This serves as a caution against allowing feelings of hope to be the sole justification for continuing stocking programs.

That said, the findings from these four case studies suggest that hatchery and stocking efforts in the Maritimes are not driven by blind faith but rather by a lack of other feasible options. Harrison & Berseth (2024) discuss how the combination of ecological pressures of rapidly changing environments and scientific debate surrounding the harm caused by hatcheries is forcing community-based, low-resource fisheries managers into immobility. Instead, they argue that these facilities may act as an avenue of doing something to prevent further salmon decline amidst the limited tools at their disposal (Harrison & Berseth, 2024). This sentiment was echoed by many participants in this study.

Finally, with increasing river temperatures due to a warming climate that shows little to no promise of slowing, a question can be raised as to the purpose of having an insurance policy for rivers that may not be able to support salmon in 20 years. Salmon have a physiological limit of 25°C (Clark et al., 2008), a threshold no amount of stocking can overcome. As such, the question of what these hatcheries are insuring for needs to be addressed.

#### *6.1.5. Governance*

Perspectives on governance were expressed across all case studies. One common perspective shared was a lack of trust for DFO, particularly a lack of belief that the agency would take sufficient action to mitigate the extirpation of Atlantic salmon. As highlighted earlier, participants believe that connection to the resource results in advocacy and stewardship for the resource. Thus, the perceived lack of connection to salmon by DFO employees is worrisome to participants. These sentiments align with the type 2 conflict - issues in how the fishery is controlled - as explained by Bennett et al. (2001). This lack of responsibility and ownership over the resource contributed to the feelings of distrust of DFO held by participants and could explain the community-based

conservation movements in many of these case studies (Charles & Berkes, 2021). In other words, perceived complacency by DFO necessitates these communities to take matters into their own hands.

A temporal mismatch between the speed of regulatory change and the changes occurring in the natural environment was also an emergent problem. Centralized government decision-making is inherently slower due to its multi-level and risk-averse nature (Sobel & Leeson, 2006) to help prevent rash or impulsive decisions, ensuring that outcomes are carefully considered and more likely to be beneficial for the public. However, many participants expressed feelings that this speed (or lack thereof) in decision-making surrounding Atlantic salmon and stocking will contribute to their extirpation from the Maritimes, as policy is seen to be unable to keep up with the rapidly changing Atlantic salmon environment and knowledge base, and thus tools such as hatcheries won't be used effectively leading to their decline.

Policy may also be aggravating a disconnect between the values enshrined in federal salmon policy (namely the Wild Atlantic Salmon Conservation Policy (Fisheries and Oceans Canada, 2019b)) and those held by local salmon advocates. DFO's policy have defined and prioritized certain understandings of wildness as superior. DFO follows the definition that to be wild, a fish has to have been born and spent its entire lifecycle in the wild, and come from parents who did the same (Fisheries and Oceans Canada, 2022a). In this study, participants expressed a spectrum of values attached to wildness from seeing no difference between hatchery and wild fish and not caring, to hatchery fish being seen as a hindrance to healthy salmon populations. However, regardless of definition, many participants took a "wildness agnosticism" view, expressing the sentiment that having any fish was preferred to having no fish at all, regardless of origin. These findings demonstrate a disconnect between definitions of 'wildness' held by DFO science and those held by fishery managers and people in the communities in which this study took place. While DFO policy prioritizes aspects of genetic diversity as a significant aspect of salmon management (Fisheries and Oceans Canada, 2019a), these policies

appear to not align well with the values and definitions of wildness held at the local level.

Another way the DFO-practitioner relationship could be understood in these case studies is one of undesired paternalism, where DFO is perceived to be restricting the conservation action of many of these hatcheries in what is believed to be their best interest. Notably, this study only found evidence of this phenomenon in the Miramichi, Fraser's Mills, and Margaree hatcheries, and not the Coldbrook hatchery. The paternalistic approach, as exemplified by limiting brood pairs in the Nova Scotia cases, and disregarding any research conducted externally to DFO, has led to frustration among hatchery practitioners and the broader Atlantic salmon conservation community. Literature on fisheries management approaches discusses two primary approaches: paternalistic and participatory (Mikalsen & Jentoft, 2008; Siegmund-Schultze et al., 2015). One reason for the popularity of hatcheries that was frequently discussed among participants was the participatory nature. As highlighted earlier, the openness of these facilities to members of communities was valued. In Nova Scotia, hatcheries also provided a space for community members to engage with (provincial) public servants. These interactions fostered a sense of involvement and ownership within communities, reinforcing the hatcheries' importance to the community. Adopting a similar participatory management style in the broader Atlantic salmon management realm could not only rebuild trust between DFO and local communities but also enhance the resilience of salmon populations by fostering stronger human-salmon relationships within a balanced SES framework.

In DFO's "What We Heard" report regarding the development of the new Strategy for Atlantic salmon conservation (Fisheries and Oceans Canada, 2023), objective 3.3 proposes a goal to enhance transparency, accountability, and coordination to better support relationships and conservation outcomes (Fisheries and Oceans Canada, 2023). This indicates that DFO is aware of many of these criticisms but now it is a matter of listening to and incorporating this feedback in the development of the new Strategy for Atlantic salmon conservation. The transition from paternalistic to participatory

management approaches could help in achieving objective 3.3 and help transition DFO from a divisive to a unifying force within the Atlantic salmon conservation community.

## 6.2. Social Dimensions of Atlantic Salmon Stocking in the Maritimes and Policy Opportunities

Socio-ecological systems thinking proposes that systems are comprised of complex interactions between social and biophysical agents interacting at heterogeneous spatial and temporal scales (Janssen & Ostrom, 2006; Ostrom, 2009). Due to the interconnected nature of the social and biophysical components of the SES, the consideration and understanding of both aspects is critical to gaining a full understanding of the system. In the context of conservation planning, Ban et al. (2013) explains that a common difficulty is a fixation on the ecological side of the SES while neglecting the social components of the system, resulting in a failure to meet objectives (Ban et al., 2013; Knight et al., 2008; Wilson et al., 2007). An example of this can be seen in Van Helden (2004) where an attempt at implementing a marine protected area was delayed and ultimately had to be drastically altered due to a focus on the ecological components and a failure to consider the human-based uses of the area in the planning process. Ban et al. emphasize that effective conservation requires the consideration of both halves of the SES to maximize the likelihood of obtaining a favourable outcome (2013). Trade-offs are inherent to conservation planning, however through fully understanding the ecological and social opportunities and consequences of specific conservation decisions and providing honesty and clarity in the decision-making process, it can allow for more effective and readily accepted conservation initiatives (Ban et al., 2013).

Looking specifically at the Maritimes and the management of the Atlantic salmon hatchery facilities, there is a bias towards the ecological (in particular, genetic) portion of the SES. That becomes apparent when looking at the applications of the current documents guiding the decision-making process on whether to permit or deny stocking initiatives. As previously discussed, the Fisheries Act (*Fisheries Act (R.S.C., 1985, c. F-14)*) and the National Code on Introductions and Transfers of Aquatic Organisms (Fisheries

and Oceans Canada, 2017) serve as the primary reference documents when dealing with hatcheries and stocking matters. These documents are concerned with protecting aquatic ecosystems and maintaining the genetic integrity of these populations while maintaining human use benefits from these resources (Aas et al., 2018). However, the science focussed applications of these documents in decision making around Atlantic salmon has led to numerous calls for the incorporation of other perspectives such as social, economic, and Indigenous views (Claxton, 2019; Denny & Fanning, 2016; Steel et al., 2021). As a result of the ecological bias of these guiding documents application, the social portion of the SES is missing from the decision-making process. Resulting from these management decisions, the hatchery debate persists in the Maritimes, as scientists continue to uncover and emphasize the genetic and ecological risk the stocking of hatchery-raised fish poses to wild populations, and local resource managers continue to face limited alternatives to sustain their salmon runs amid a host of anthropogenic stressors.

The difficulties in Atlantic salmon hatchery management in the Maritimes as seen through the hatchery debate indicate that the current management approaches are ineffective, likely due to an overemphasis on the ecological side of the SES. This paper highlights some of the social outcomes produced by four Maritime hatchery facilities. Looking at these outcomes from an SES lens, many of the concepts discussed in this study draw parallels to concepts discussed in the SES literature. The outcome of community-based conservation groups can be looked at as a form of collective action (Berkes et al., 2014), as social capital derived from the hatcheries fuels groups to work towards common goals (Dalby & Harrison, *in press*). The outcome of local knowledge can be seen as 'knowledge flows' being a form of interaction between actors within the SES (Sievers et al., 2024). The loss of salmon can be seen to be occurring at multiple scales, both at the individual and community levels (Berkes et al., 2014), and the view of hatcheries as insurance policies can be tied to the concept of resilience in maintaining the SES despite anthropogenic disturbances to the system (Berkes et al., 2014). Finally, the salmon-stewardship positive feedback loop aligns with similar feedback loops seen

in other SES studies (Berkes et al., 2014; Sendzimir et al., 2011), and the close connection between human and salmon seen in this SES aligns with the concept of relationality as described by Lejano (2019).

The findings from this study emphasize that the human-salmon relationship is deeply interwoven with cultural, emotional, psychological, and ecological attributes that are often overlooked in management approaches. Recognizing the social benefits of hatcheries—such as the sense of hope, purpose, and community engagement they provide—can help create a more holistic view of the hatchery’s role within the SES. While focusing on social outcomes is not an endorsement for stocking, it does suggest that an approach that incorporates all aspects of the SES, that values both ecological and social objectives, is crucial.

As highlighted in a DFO’s “Engaging on a strategy to restore and rebuild Atlantic salmon - What we heard” report, there is a growing sentiment from the public regarding the importance of the social aspects of Atlantic salmon (Section 5.1) and a recognition that hatcheries need to be better managed (Section 5.4). This document discusses how from the perspective of the public, the overarching goal should be to take a balanced approach to enhancement- using stocking as a management tool when appropriate, improve in its management by providing more guidance, opportunities for collaboration, and improvement in practices, while also recognizing the utility of hatcheries and stocking in maintaining social, cultural, and ecological connections to salmon for Indigenous communities (Fisheries and Oceans Canada, 2023). The social outcomes outlined in this paper highlight many of these same perspectives and provide opportunities to address much of this public feedback. Notably, while DFO only reported on Indigenous perspectives regarding the utility of stocking in maintaining social, cultural, and ecological connections to salmon, this paper showcases that hatcheries may have broader applications in providing these same benefits to settler populations.

DFO could increase opportunities for collaboration by engaging and working alongside these community-based conservation movements that have been established around these hatcheries. This recommendation could also help with the aforementioned

transition from paternalistic to participatory management approaches. DFO could work to improve stocking practices by engaging with and considering the local knowledge stored within these hatchery communities and incorporating it into scientific advancements to ensure the guidelines for best practices are feasible to given hatcheries and consider local contexts while also incorporating recent scientific findings. DFO could improve its management approaches by considering many of the discussed criticisms of their perceived lack of care, slow speed, and misalignment with the views of the public. Finally, DFO could better recognize the utility of stocking in maintaining social, cultural, and ecological connections to salmon by considering the hatchery's roles in acting as coping mechanisms for ecological anxiety and providing hope for the future of salmon, and in their facilitation of the human-salmon relationship.

The consideration of the recommendations of this paper and others like it (Denny & Fanning, 2016; Harrison et al., 2018) offer a key opportunity to effectively address many of the public's comments emphasized in the "What We Heard" report. Ultimately, if taking a balanced approach to stocking is truly the goal, then the consideration of the social and ecological sides of the SES is essential to achieving this objective.

## **Chapter 7. Management Recommendations**

- *Foster collaboration: Actively engage with and support community-based conservation movements that have developed around hatcheries.*

Regional DFO offices should identify and engage with these groups as part of their efforts to pilot more place-based collaborative management approaches (Fisheries and Oceans Canada, 2023). As highlighted in the "What We Heard" report, many believe these groups have the capacity to integrate into more formalized approaches (Fisheries and Oceans Canada, 2023). Tentative funding from the Wild Atlantic salmon Conservation Strategy could be used to support these efforts.

- *Engage local knowledge: Partner with hatchery managers to document the local knowledge they have accumulated and integrate this knowledge with the latest scientific research to refine conservation practices.*

DFO Gulf and Maritime should aim to engage with each of the hatcheries within their jurisdiction to document local knowledge held by hatchery employees. This could be achieved through interviews or shadowing exercises designed to capture insights from day-to-day operations. The gathered information could then be consolidated into a comprehensive review document that evaluates the strengths, weaknesses, opportunities, and threats (SWOT) of each facility's current practices. By integrating this local knowledge with recent scientific advancements, DFO could identify opportunities to improve hatchery operations where appropriate. Tentative funding from the Wild Atlantic salmon Conservation Strategy could be used to support these efforts.

- *Improve management: Address key concerns raised by study participants such as perceived lack of care, slow speed, and misalignment with the views of the public.*

DFO Gulf and Maritime should increase transparency and incorporate all aspects of the SES in decision-making. By fully understanding the ecological and social opportunities and consequences of specific conservation decisions, and providing honesty and clarity in the decision-making process, it can allow for more effective and readily accepted conservation initiatives (Ban et al., 2013). This will help with public opinion over management practices.

- *Acknowledge Social and Cultural Roles: Recognize the utility of hatcheries in maintaining social, cultural, and ecological connections to salmon for non-Indigenous communities by acting as a source of hope for the future of salmon and facilitating the human-salmon relationship.*

As previously highlighted, a comprehensive understanding of both the ecological and social implications of conservation decisions, coupled with transparency in the decision-making process, can lead to more effective and broadly supported conservation outcomes (Ban et al., 2013). To ensure such outcomes, the social dimensions of conservation strategies for Atlantic salmon hatcheries must be given due consideration by all DFO regions that contain Atlantic salmon. One way to achieve this is through the development of a dedicated guiding document specific to Atlantic salmon stocking. This document would replace the broader, less specific documents currently in use, such as

the Fisheries Act and the National Code on Introductions and Transfers. This would be applicable throughout the entire Canadian range of Atlantic salmon. Tentative funding from the Wild Atlantic salmon Conservation Strategy could be used to support this effort.

## **Chapter 8. Conclusion**

The findings of this study indicate that the outcomes produced by hatcheries go far beyond their stated purpose of putting fish into water. This paper outlines some of the outcomes four Maritimes hatcheries provide for ecosystems, individuals, and the community at large. These outcomes include hatcheries furthering Atlantic salmon science and conservation, nurturing the human-salmon relationship, being a repository for local salmon-rearing knowledge, and providing a source of hope for the future of salmon. The ultimate goal of this paper is not to promote the continued use of hatcheries. Rather it is to urge regulators to consider both the social and ecological sides of the SES in their decision-making process. By considering these interconnected elements of this SES, management decisions around Atlantic salmon conservation can become more informed, transparent, and relatable to the public, ultimately leading to more effective and widely accepted conservation initiatives.

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## Appendix A: Interview guide

### Introductory questions/building rapport

1. Ask for participant to say name (spell it out loud), state the location of the interview (community), and verbal consent if not given via signature.

2. Background building: Getting to know the participant's role

(For angling groups): Can you tell us about your angling group/your angling activity?

What activities do your group participate in? What is the purpose of the group? Why do you choose to take part in the group?

Maybe ask about their personal relationship with salmon and how it came to be

(For government/policy-makers): Can you tell us about your role, and the division or agency you're part of? What are your/your group's primary responsibilities?

(For hatchery managers): Can you give us a high-level idea of the goals of your hatchery program, and how it operates? (What do you grow, when, collection and release practices) What other groups/organizations/decision-makers are involved in the work of this hatchery/stocking program?

3. Purpose of hatchery: What are the goals of the hatchery/stocking program in question? How did the program get started? Do you think the program is achieving those goals? (sensitive: does the program have a planned end point?)

4. Relationship to hatcheries/stocking: can you tell us about your work with hatcheries/stocking? What activities do you participate in, and how did you get started? How much time do you spend on these activities? Why do you participate (trying to understand value of activities)?

5. For you/your community/agency, are hatcheries/stocking work important? In your view, are you aware of any criticisms or critiques of your hatchery program/hatchery programs in general? Are there any conflicts around your hatchery/stocking activities?

(For agencies): Is there any interest/plan to expand your hatchery program to other areas of your agency (i.e., to other national parks, etc.)?

6. How do you think hatcheries/programs impact wild Atlantic salmon stocks and/or fisheries in your area?

7. If hatchery/stocking programs were to cease, how do you think that would affect wild Atlantic salmon stocks and/or fisheries in your area? Do you have any concerns about potential barriers to continuing this work?

What do you see as the role of hatcheries in Climate Change

Hatchery vs wild fish

If relevant: ask about fish friends

8. Which groups, if any, participate in hatchery work in your area/community? To the best of your knowledge, why do they participate in this work?

9. What type of knowledge systems/information do you use to carry out your work?  
How did you learn to do this work?

10. How do you communicate with the public or other interest groups (if at all) about hatchery/stocking activities ?

11. Anything else we should know?

12. Is there anyone else we should speak to in order to better understand hatcheries/stocking in this area/your field?

13. (during field visits): Is there anywhere we should visit that may help us understand what we've talked about today?