Overview: Climate Change in Canada

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Canada's climate is changing at an alarming rate. Temperatures are rising twice as fast as the global average, and three times faster in the North. Higher temperatures are, in turn, driving more frequent and intense weather events that affect our physical environment, and pose real and increasing risks to Canada's biodiversity, including wild Atlantic salmon. Canada' ecosystems are already experiencing significant impacts from climate change. For example, in September 2022, Hurricane Fiona battered the Atlantic Provinces and Eastern Quebec with high winds and heavy rainfall, causing widespread damage to infrastructure and ecosystem, including those relied upon by Atlantic salmon. The scale and impact of this storm was unprecedented in Atlantic Canada. However, Hurricane Fiona is only one of many recent examples of an increasing number of catastrophic climate events that are impacting coastal and riparian zones, and ultimately Atlantic salmon. Climate change is also driving gradual, but more pervasive, impacts, such as permafrost thaw in the North, sea level rise and coastal erosion, invasive species, the spread of diseases and pathogens like sea lice, and shifting habitats and seasonal patterns of productivity (Government of Canada Adaptation Action Plan 2022).

Canada's National Adaptation Strategy was released in November 2022 to provide a roadmap for whole-of-society action on adaptation. It establishes a shared vision of Canada's path for a more climate resilient future. The foundation of the Strategy is its four guiding principles:

1. Respect jurisdictions and uphold Indigenous rights
2. Advance equity and environmental justice
3. Take proactive, risk-based measures to reduce climate impacts before they occur
4. Maximize benefits and avoid maladaptation

These principles guide Canada's climate change actions, including those for Atlantic salmon.

Climate change impacts on Atlantic salmon

Climate change has dramatically affected the fresh, estuarine, and marine ecosystems inhabited by Atlantic salmon in Canada. These impacts can be profound; for example atypical spring weather in 2018 caused more than 4,000 tonnes of debris into the Chéticamp River in Cape Breton Highlands National Park, completely blocking upstream fish passage. To restore fish passage in time for migrating Atlantic salmon, Parks Canada reacted quickly removing the debris and stabilizing the bank, also supporting the climate change resiliency of this important salmon river.

Understanding how these activities impact the abundance and diversity of Canada's Atlantic salmon populations requires large scale collaboration. The Atlantic Salmon Research Joint Venture (ASRJV) was established to forge the partnerships and collaboration sufficient to address urgent and unresolved scientific questions, including climate change impacts, that might otherwise not be undertake. The ASRJV recently held a workshop to address the effects of climate change on freshwater habitats of Atlantic salmon and to identify research gaps and priorities. Their findings are summarized here, to describe the most important climate change impacts on Atlantic salmon in Canada (C-A Gillis *et al*. 2023):

(1) Effects of climate change on in-river habitat conditions: with temperature and water discharge being recognized as the most important factors for Atlantic salmon to complete their freshwater life cycle;

(2) Physiological and behavioral responses of salmon to temperature: recognizing that Atlantic salmon are cold water, obligate ectotherms with a narrow range of thermal preference, from 16° -18° C; and,

(3) Population-level responses of salmon to climate change: considering the potential for Atlantic salmon to adapt to changing climate in light of the genetic diversity, life history characteristics, physiological and behavioral plasticity at the individual-level required for adaptation.

Canada's climate adaptive management measures for Atlantic salmon

Wild Atlantic salmon is an important icon for the people of Atlantic Canada and Québec. People care about and benefit from salmon for many different reasons. For instance, it is fished for food, social, and ceremonial purposes by more than forty First Nations and many Indigenous communities in eastern Canada. In central and coastal Labrador it is relied on for local community food fisheries. Moreover, salmon angling is a valued recreational activity by both local residents and non-residents. Salmon are considered an indicator of environmental quality, an animal of respect, an attraction for eco-tourism and have an importance beyond economic returns.

In order to protect these values, Canada takes action under three main categories to support adaptive management of this important species in the context of climate change:

i. Fisheries management activities

ii. Habitat restoration, management & activities

iii. Monitoring, modelling & research to support adaptive management

i. Fisheries management activities

On a river-by-river basis, catch and release mortality is highly variable, both in terms of region, and the times fish are caught and released during the angling season. Adaptive fisheries management activities are underway across the Canadian range of Atlantic salmon to reduce mortality in consideration of warming waters. These management approaches consider the best available science on the impacts of recreational fishing for salmon under different temperature scenarios. It is now understood that river warming can increase mortality in Atlantic salmon that are caught and released. For example, in Newfoundland, catch and release mortalities for Atlantic salmon are predicted to be low (<0.05) river temperatures that are less than 12°C. As river temperatures warm (between 18° and 20°C), mortality predictions increase and range from 0.07 to 0.33 (Van Leeuwen *et al.* 2020). Angler education is an important component of successfully implementing any fisheries management activity; in Québec for example, Fédération Québécoise pour le Saumon atlantique has undertaken specific actions to assess the challenges, concerns, impacts and solutions of adaptive management actions undertaken in relation to climate change. In light of Canada's understanding of incidental mortality of Atlantic salmon that are caught and released in warm water, several management measures are undertaken:

Adaptive environmental protocols (a.k.a. warm water protocols): result in recreational fishery closures when water exceeds a warm water threshold. The threshold varies within and between provinces, but generally fall between 18ºC and 20ºC. For example, in Newfoundland, protocols vary by river class and can be triggered when water temperatures exceed threshold

after 2-3 days. Secondary parameters such as water levels and weather forecast may also be considered. River temperatures over the salmon season in some regions have increased over time, leading to a greater number of days closed to angling over the past decade.

Seasonal variation orders: can be used to restrict a season to specific times of year, to protect Atlantic salmon when they are most vulnerable to stress imposed by warming waters. For example, salmon angling in Eastern Cape Breton is limited to a fall season: October 1 – 31st, when waters are cool.

Gear restrictions: are intended to further reduce harm caused by catch and release angling. For example in New Brunswick, Atlantic salmon angling is limited to barbless hook with artificial fly.

ii. Habitat restoration, management & protection activities

In Canada, the responsibility for mitigating against climate change is shared between federal and provincial jurisdictions. Activities that support climate change mitigation through habitat restoration, management and protection, are undertaken by many different government departments, Indigenous communities, and non-government organizations. These activities benefit Atlantic salmon, whether or not the action was specifically undertaken in support of Atlantic salmon, or to more broadly support healthy, resilient ecosystems in the context of climate change. Examples include:

- **National** goal to conserve 30% of Canada's land and water by 2030 to fight climate change, reverse declines in biodiversity and maintain strong sustainable economy;
- **Provincial** climate change action plans outline how provincial governments will help to address climate change by establishing their own targets relating to (e.g., land protection, carbon emissions, and other provincial priorities).
- **Local** habitat restoration activities that support resiliency. Specifically related to Atlantic salmon, these include but are not limited to: the identification and protection cold water refugia; restoring connectivity within freshwater environments and between freshwater and marine environments; riparian planning and regulation of development in riparian zones, including salmon fishing lodges, and; river and pool restoration activities.

iii. Monitoring, modelling & research to support adaptive management

Canada has a robust and diverse science and research sector that includes scientists working within government, non-government, academic, and Indigenous organizations. This research supports adaptive management actions. Examples of recent areas of focus include:

- **Thermal refugia:** studying the importance of, inventorying and protecting these areas in Atlantic salmon rivers.
- **Temperature effects on catch and release fishing:** understanding how warming waters can impact stress, survival, and reproductive success of Atlantic salmon.
- **Linking environmental changes to changes in biology and ecology of Atlantic salmon:** for example, how warming waters affect distribution, abundance, physiology, growth, stress, etc.
- **Modelling climate vulnerability & risk assessments,** through both quantitative and qualitative techniques, to better understand where climate change will have the greatest impact.
- **Tracking salmon migration patterns of Atlantic salmon in relation to changing environmental conditions at-sea .** Using both conventional satellite and acoustic

technology deployed through large-scale partnership (e.g., case study on Atlantic salmon tagging), as well as research and development initiatives to support technological advances in tagging technology.

Best practices from the most effective climate actions in Canada

For the purpose of this report, Canada will summarize four best practices with supporting case studies, that explore how to effectively support climate resiliency for Atlantic salmon:

1. Supporting Indigenous data, knowledge and leadership
2. Innovation and use of emerging technologies
3. Supporting Atlantic salmon conservation through dedicated funds
4. Partnership and collaboration

Best practice: Supporting Indigenous data, knowledge, and leadership

Case Study: Unama'ki Institute of Natural Resources

Unama'ki Institute of Natural Resources (UINR) is Unama'ki's Mi'kmaq voice on natural resources and the environment. By integrating Netukulimk (traditional Mi'kmaq management) with traditional and conventional ways of understanding, known as Etuaptmumk (Two-Eyed Seeing), UINR takes the lead on best-management practices in Unama'ki. UINR is responsible for aquatic research and stewardship, species management, traditional Mi'kmaq knowledge, conserved and protected areas, water quality monitoring and environmental partnerships. All of this work in conducted in the context of climate change, noting that Indigenous communities are particularly affected by climate change impacts due to their limited infrastructure funding and land base (Davies et al, 2016).

Best practice: Innovation and use of emerging technologies

Case study: University of New Brunswick

Under current and future climate change scenarios, Canada's Atlantic salmon rivers are warming. Rising river temperatures will negatively impact Atlantic salmon, especially in summer months, which often correspond to recreational angling seasons. The University of New Brunswick has been testing various remote sensing techniques to map the frequency, distribution and utility of thermal refuges at the river-scale. This research includes innovative application of drone-based infrared and topobathy sensors, as well as publicly accessible, free data available on Google Earth. Understanding the effectiveness of different tools that are accessible and feasible for potential practitioners is top-of-mind for UNB researchers, who envision this research being used to support comprehensive GIS-based aquatic monitoring plans for Atlantic salmon. For example, data on the Miramichi has already been used by the North Shore Micmac District Council, to enhance cold-water habitats on Canada's most prolific Atlantic salmon river (O Sullivan et al. 2019; O Sullivan et al. 2020; O Sullivan et al. 2021a; O Sullivan et al. 2021b)

Best practice: Supporting Atlantic salmon conservation through dedicated funds

Case study: Atlantic Salmon Conservation Foundation

In 2007, The Atlantic Salmon Conservation Foundation (ASCF) was awarded $30 million by the Government of Canada to create a trust fund intended to support wild Atlantic salmon conservation projects, in perpetuity. The Foundation funds its project grants from income earned on the trust fund, in support of its overall mission: *To promote enhanced community partnerships in the conservation of wild Atlantic salmon and its habitat in Atlantic Canada and Quebec.* Given that Atlantic salmon are under increasing pressure from climate change, the

Foundation has funded an increasing number of climate change related projects over time. Over 70 Atlantic salmon projects have been funded by the ASCF that relate directly to climate change, including (but not limited to): climate change impact and vulnerability assessments, habitat restoration and impact mitigation projects, Indigenous traditional knowledge studies, and the identification, restoration and protection of thermal refuges.

Best practice: Partnership and collaboration

Case study: Atlantic salmon migration at-sea research , an Environmental Studies Research Fund project

Of the Atlantic Canadian fish species, Atlantic salmon has one of the most complex life histories and migration patterns. Post-spawned adult (kelt) and juvenile (post-molt) salmon migrate from their native freshwater river to the Atlantic ocean to feed, sometimes even as far as the Labrador Sea. This project uses acoustic and satellite telemetry to better understand the migratory behaviour (location and habitat use) of salmon while at sea. The objective of this project is to determine when, where and for how long Atlantic salmon from different life stages (juvenile post-smolt, post-spawned kelt and multi-sea winter adults) are in the Eastern Canadian offshore regions. Achieving this objective requires collaboration across the entire Canadian range of Atlantic salmon; over 20 project partners contribute to tagging efforts and research on their local rivers, including Indigenous communities, Indigenous organizations, non-government organizations and several provincial and federal government departments. The results will support regulatory decision making in Canada's areas of offshore oil and gas activity.

Lessons learned from Canada's climate change management actions to improve our effectiveness

Atlantic salmon are already experiencing the effects of climate change, and these effects will continue to grow well into the next century. Canada's adaptive management measurements to date are helping us understand how our climate is changing, the impacts and risks to Atlantic salmon, and the opportunities to take action for this iconic species. Below are some lessons learned through Canada's ongoing efforts:

Low populations & continued declines hinder the resiliency of Atlantic salmon in Canada: To ensure the survival of Atlantic salmon into the future, we must rebuild and protect the biological foundations of wild Atlantic salmon today.

Managing competing interests: Atlantic salmon are of social, cultural, ecological and economic value in Canada. Protecting these values in the context of continued development of coastal and riparian zones will continue to be a challenge, especially if social and cultural connections to Atlantic salmon are lost.

Facilitating & including Indigenous data, knowledge, & leadership for better outcomes: The Government of Canada has passed legislation (e.g., Fisheries Act) that require Indigenous Knowledge to be considered in project reviews and regulatory decisions. This represents a significant and positive change to how fish and fish habitat is managed; it requires Canada to move from decisions made solely based on Western science and perspectives, to decisions that incorporate a broader body of Indigenous knowledge and values.

Translating climate change science into management action: There exists a wealth of research and scientific evidence to support climate resilient management actions; How we apply and translate what we are learning into actions on the ground needs further consideration.

Coordination, tracking & reporting: In a large country with shared jurisdictions for climate change, the environment, and Atlantic salmon, how we track, monitor, and adapt our actions

requires consideration.

Conclusions from Canada

Climate action requires a whole-of-government approach and buy-in from all Canadians, including Indigenous peoples, partners and stakeholders within the Atlantic salmon community. Given their iconic status and reliance on clean, cool, healthy freshwater and oceans, Atlantic salmon are a useful lens through which we can motivate climate action. Hope and action are symbiotic elements of seeing salmon persists for many human generations to come. Finally, Canada recognizes that hope and action are symbiotic elements of seeing salmon persists for many human generations to come**.**

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