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Governing for transboundary environmental justice: a scientific and policy analysis of fish consumption advisory programs in the Upper St Lawrence River

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Abstract

This paper examines fish consumption advisories (FCAs) as a site of transboundary governance in the Upper St Lawrence River with the aim of identifying opportunities for enhanced coordination and power sharing to address environmental injustices. The Upper St Lawrence River is part of the Great Lakes watershed of North America and the traditional territory of multiple Indigenous Nations, as well as the present-day jurisdictions of Ontario (Canada), Quebec (Canada), and New York State (USA). Through an analysis of publicly available information on FCA programs, we examine similarities and differences in these programs across jurisdictions. We find an overall lack of coordination in fish monitoring and differences in consumption advice for a waterway in which fish may easily move between transboundary areas. We offer recommendations for improving FCAs in this transboundary waterway from the lens of environmental justice, focusing on (1) a shared and transparent approach to monitoring contaminant levels and fish species; (2) integration of cultural food practices; (3) enhanced outreach to angler populations; and (4) upholding the self-determination of Indigenous communities. We also underscore that FCAs should not be seen as a permanent solution. Preventing and reducing contaminants, including associated harm reduction in communities affected by FCAs, need to be priorities.

Key words: fisheries governance, St Lawrence River area of concern, Laurentian Great Lakes, recreational fisheries, Indigenous fisheries, Akwesasne

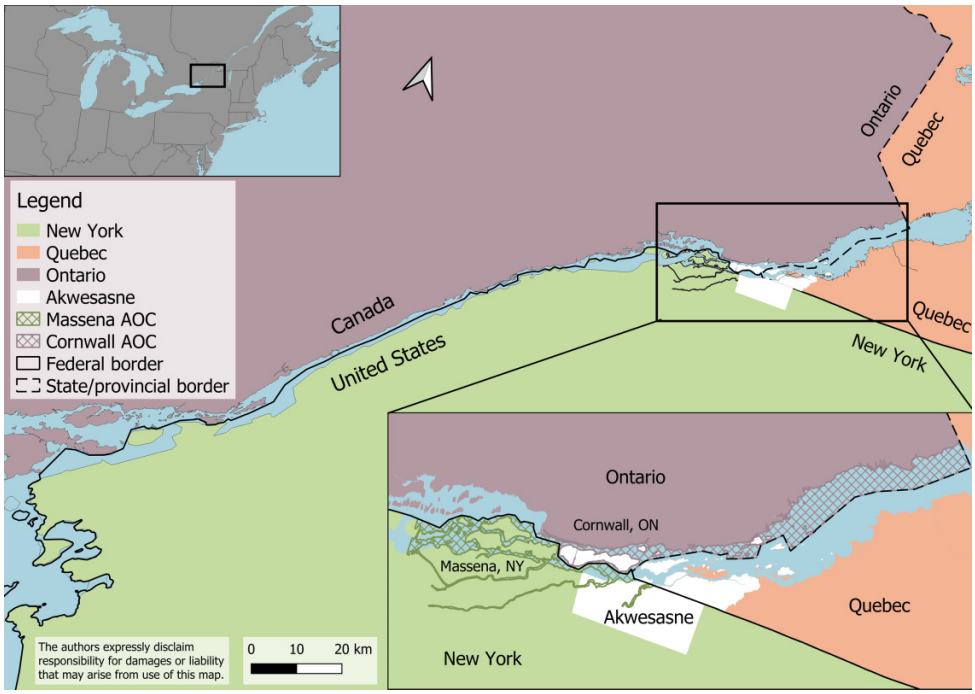
1. Introduction

The St Lawrence River is a sensitive and complex large body of water and the only natural outlet for the Great Lakes, the world's biggest freshwater surface system (LaPan et al. 2002). Over the last two centuries, the St Lawrence River has experienced significant environmental stress related to overfishing, habitat alteration, non-native aquatic species, pollution, shipping, and industrial development (Marty et al. 2010; Taylor 2016; Beauchesne et al. 2020). The resulting changes to water quality and fish populations have led to fish consumption advisories (FCAs) being issued by regulatory agencies to guide the safe consumption of freshwater fish that people catch.

This paper examines FCAs as a site of transboundary governance, focusing on the Upper St Lawrence River (see Fig. 1). The Upper St Lawrence River spans from the river's headwaters at Lake Ontario to around the modern-day Ontario/Quebec border. It is the traditional territory of the Mohawk communities of Tyendinaga, Akwesasne, and Kahnawake and is part of the Dish With One Spoon Wampum, a treaty among the Anishinabek and Haudenosaunee to share and protect the resources around the Great Lakes (Jacobs and Lytwyn 2020). These Indigenous Nations have long-standing networks of governance and diplomacy preceding the recent establishment of colonial borders (Hele 2008, p. xv). Present-day colonial jurisdictions on the Upper St Lawrence River include New York (USA), Ontario (Canada), and Quebec (Canada). As such, there are Indigenous, federal, state, and provincial authorities with vested interests and responsibilities in these waters (Gaden et al. 2012).

It is well documented that transboundary watersheds experience resource management policies that are not well integrated and often conflict (Leonard et al. 2004; Bakker and Cook 2011). In the Upper St Lawrence River and broader Great Lakes watershed, key challenges to transboundary gov-

Fig. 1. Map of the Upper St Lawrence River region, coordinate reference system (CRS) WGS 84/UTM zone 18 N, with data from the Commission for Environmental Cooperation (2022), Indigenous Services Canada (2022), Natural Resources Canada (2011), and the United States Environmental Protection Agency (2022).



ernance include different languages, worldviews, knowledge systems, legal and regulatory frameworks, and unresolved implementation of Aboriginal and Treaty rights (Norman 2015; Medema et al. 2016; Reid et al. 2020). The International Joint Commission (IJC) and the Great Lakes Fishery Commission (GFLC) were formed to promote interjurisdictional cooperation on water quality and fisheries management, respectively (Grover and Krantzberg 2015; Clamen and Macfarlane 2018). While these institutions have achieved some successes, building capacity to respond to the social and ecological diversity of the watershed and supporting the full participation of Indigenous Nations in these forums remain ongoing processes (Henquinet and Dobson 2006; Krantzberg and Manno 2010; Norman 2015; Orr 2022).

FCAs operate in this transboundary context, with Indigenous, state, and provincial government authorities along the Upper St Lawrence River each developing and issuing FCAs. However, the fish, contaminants, and people that these advisories consider all move across this waterway and its political boundaries. What happens in one part of the river and upstream in the entire Great Lakes system can affect fish populations and consumption elsewhere. Recognizing FCAs as a site of transboundary governance, this paper presents an analysis of publicly available information on FCA programs in the Upper St Lawrence River to examine similarities and differences in these programs across jurisdictions and offer recommendations for enhancing FCAs in this shared waterway.

In what follows, we begin by providing an overview of FCAs and their history in the Upper St Lawrence River and introduce environmental justice as our analytical lens. We then present the methods for our study and share our results and recommendations for FCAs, focusing on the key categories of fish monitoring, consumption guidance, and development and communication.

1.1. Overview of fish consumption advisories

FCAs are guidlines to avoid or limit the consumption of certain species of fish because of contamination. They are generally issued due to concerns about the health impacts of eating fish contaminated with mercury and persistent bioaccumulative toxins (PBTs), such as polychlorinated biphenyls (PCBs), PCB-like dioxins and furans, as well as some insecticides (e.g., dichlorodiphenyltrichloroethane (DDT), Mirex, Chlordane). As Cleary et al. (2021, p. 72) explained, FCAs present a "critical dilemma" for fish eaters, especially pronounced for communities with a strong culture of fish consumption (Duhaime et al. 2004; Lee et al. 2019; Lowitt et al. 2019). On the one hand, fish is a nutritious food source high in omega-3 polyunsaturated fatty acids with benefits for cardiovascular health, brain development, and a reduced risk of some cancers (Cleary et al. 2021). However, contaminants that bioaccumulate in fish tissue can present health risks to certain segments of the population—typically denoted as "sensitive" populations and considered as children <15 years of age and women of child-bearing age (<50 years)—especially vulnerable (Cleary et al. 2021).

FCAs use a traditional risk-based approach that attempts to measure exposure and make recommendations for public health (Cleary et al. 2021). Levels of contaminants that may harm human health are estimated by collecting fish and monitoring their tissue loadings (King et al. 2021). The methods

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needed to achieve this require substantial investment and presume that seasonal sampling can effectively and reliably catch fish to represent the broad array of species and size ranges needed for this purpose. The understanding of the risks underlying FCAs has also been critiqued by Arquette (2004) for only capturing biological and physical data and overlooking the risks to the social, cultural, and spiritual practices closely tied to fish consumption in many Indigenous communities. Similarly, Dawson et al. (2008) point out that FCAs often ignore the social and cultural contexts in which risk is understood among fish eaters (Dawson et al. 2008). These critiques have led to some efforts to develop more holistic approaches to risk assessment and decision-making (Arquette et al. 2002; Arquette 2004; Aven and Kristensen 2005).

1.2. The Upper St Lawrence River: history of fish consumption advisories and environmental justice

The first FCAs for the Upper St Lawrence River were issued in the early 1970s. They were meant to be temporary until contamination sources could be eliminated, although various FCAs have remained in place ever since. In 1985, the St Lawrence River at Cornwall, Ontario, was designated an AOC[1] under the Great Lakes Water Quality Agreement due to high levels of discharges over many decades from industrial facilities, including auto manufacturers and pulp and paper companies, located along the river in Cornwall, Ontario and Massena, New York (Neff et al. 2013). This AOC includes the jurisdictions of the Mohawk community of Akwesasne (comprised of the Mohawk Council of Akwesasne on the north side of the river and the St Regis Mohawk Tribe on the south), Canada, and the United States (Ritcey et al. 2011). The impacts of environmental contamination on the health and well-being of Akwesasne, located just downstream from these industrial sites, are well documented in the environmental justice literature (see Hoover 2018). Along the St Lawrence River, studies have associated higher concentrations of methylmercury with neurobehavioural deficits among fish eaters (Mergler 2002; Morrissette et al. 2004). Previous environmental health research has also linked development deficits, neurological problems, and disruptions in reproductive parameters to fish consumption throughout the Great Lakes watershed (Johnson et al. 1999).

Recent decades have seen progress in addressing contamination in the AOC and the Upper St Lawrence River. Overall, mercury and PCBs are trending downward, due to government and community efforts to remediate the river and a reduction in industrial discharges (Neff et al. 2013; St Lawrence Action Plan 2016, 2019). However, levels of mercury and PCBs remain higher in certain sections of the river and in older, and generally larger, specimens of fish (St Lawrence Action Plan 2016). Alongside these legacy contaminants, contaminants of emerging concern (CECs) have been detected in the river (Elliott et al. 2017; Baker et al. 2022; Ren et al. 2022). CECs are a group of chemicals, such as pharmaceuticals, personal care products, and per- and polyfluoroalkyl substances (PFAS), that are suspected of causing harm to human or ecological health, especially as they interact in aquatic ecosystems (Baker et al. 2022).

Presently, there are active multi-million dollar recreational fisheries throughout the Upper St Lawrence River, with millions of anglers each year fishing in the larger Great Lakes watershed (Ontario Ministry of Natural Resources and Forestry 2015; Responsive Management National Office 2019). Smallmouth bass (*Micropterus dolomieu*), walleye (*Sander vitreus*), northern pike (*Esox lucius*), and yellow perch (*Perca flavescens*) are among the most popular angling species along the upper part of the river (New York State Department of Environmental Conservation 2015; Responsive Management National Office 2019). Anglers often keep a portion of the fish they catch, with over 50% of respondents in a recent survey of Ontario anglers reporting keeping and/or consuming fish (Howarth et al. 2021). Studies have also indicated that consumption of recreationally caught fish is especially important for anglers that are less financially secure and among certain ethnic groups (Nordenstam and Darkwa 2010; Lauber et al. 2017; Hunt et al. in press).

In the Mohawk community of Akwesasne, a range of fish, including perch, bullhead, and sturgeon, have traditionally been eaten (Hoover 2013). Fish consumption patterns have significantly changed because of FCAs introduced since the 1970s, with Hoover (2013) describing the emergence of "generational divides" in fish consumption, with those beyond their childbearing years more likely to eat fish. Cook (2003) similarly documented the pronounced impacts of FCAs on Mohawk women, understood as the "first environment" within Mohawk cultural philosophy and whose life-sustaining roles are threatened due to contaminants. Indigenous peoples' cultures reflect the water and landscapes they emerged from and formed over thousands of years of relationship-building. In this biocultural context, the Haudenosaunee connection to creation demonstrates an interwoven knowledge system and kinship network that "inform their values, teachings, knowledge, practices, and identity" (Francis et al. 2023). Therefore, damage to the water and fisheries has cascading effects beyond just direct impacts on human health. The Ohenton Karihwatehkwen ("Words Before All Else") articulates this relationality in which fish carry the responsibility to offer themselves as sustenance and clean the waters. Fish consumption is about reinforcing a relationship between the community and relatives, which ensures cultural integrity and continuity.

As demonstrated in this overview, the impacts of contamination and FCAs are unevenly distributed, with women of childbearing age, children, anglers who rely on recreationally caught fish for food security, and Indigenous communities disproportionately affected. Therefore, in our following analysis, we pay attention to the environmental justice implications of FCA programs in terms of the principle that everyone is entitled to equal protection of environmental and public health regulations and has the right to participate in decision-making affecting their health and local en-

[1] Forty three areas of concern (AOCs) exist throughout the Great Lakes watershed, identified as areas experiencing high levels of environmental harm (Environment and Climate Change Canada 2023).

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vironment (Mohai et al. 2009, p. 407). Recent revisions to the Canadian Environmental Protection Act recognize Canadians' rights to a healthy environment (Environment and Climate Change Canada 2022). Environmental justice takes on added significance in Indigenous contexts, as seen in documents such as the United Nations Declaration on the Rights of Indigenous Peoples (UNDRIP), the Missing and Murdered Indigenous Women and Girls (MMIWG) 231 Calls for Justice, and the Truth and Reconciliation Commission's (TRC) 94 Calls to Action. These documents are expressions of Indigenous voices in Canada and globally that call for addressing discrimination and upholding Indigenous rights based on traditional governance systems. Of central importance to this study, these documents underscore shared governance for Indigenous Nations as a right in the transboundary waterway of the Upper St Lawrence River.

2. Methods

This study is based on a content analysis of publicly available information on FCA programs for the Upper St Lawrence River. We identified FCAs publicly available by the Ministry of the Environment, Conservation and Parks (Ontario), the Ministère de l'Environnement et de la Lutte Contre les Changements Climatiques (Quebec), the State Department of Health (New York State), and the Environment Division of the Saint Regis Mohawk Tribe (SRMT), located in present-day New York State. Notably, the SRMT advisory emerged from an extensive community-driven process to identify the fish species that community members consumed and the way information should be conveyed for safe consumption as part of a traditional diet Saint Regis Mohawk Tribe Environment Division (2013).

Information consulted included the FCAs themselves (i.e., the public-facing guidance) as well as the associated public data sets on which FCAs are based. FCAs issued by Ontario, Quebec, and New York State cover numerous sampling sites. Sampling efforts rely on individual analyses of samples from representative locations, e.g., areas of easy access, areas of higher contamination risk from known point sources, or from places of community importance, to represent all sites within their respective zones. We focus our analysis on zones 14 and 15 in the Ontario Guide to Eating Fish, the St Lawrence River advisories within the St Lawrence Valley Region Advisories in New York State, and the Lac St-Francois sites in the Guide to Eating Freshwater Game Fish in Quebec. While not technically a FCA and thus not included in the analysis, the Mohawk Council of Akwesasne, representing the present-day northern portion of Akwesasne in Ontario and Quebec, maintains a do not consume fish resolution from the 1970s.

The content analysis coded the available information on FCA programs for the following categories: monitoring requirements, fish species and contaminants, standards for consumption advice (including portion sizes, populations considered, eating, and preparation instructions), and communication of information (including language, use of images, and digital/print formats). The content analysis was led by Madison, Lowitt, Kaur, and St-Pierre and emerging findings were shared with the full author team for discussion and interpretation.

The content analysis was supported by a review of policy documents and legislation governing FCAs in the region, with materials identified through a scan of state, provincial, federal, and Indigenous authority websites and reading literature.

3. Results and recommendations

A summary of the results from the content analysis is presented in Table 1. We now describe these results in detail and present our recommendations, focusing on the categories of fish monitoring, consumption guidance, and communication and development of FCAs.

3.1. Fish monitoring

As shown in Table 1, various fish species and contaminants are monitored in FCAs for the Upper St Lawrence River. Notable fish species with specific advice across all four, or three out of four jurisdictions, include brown bullhead (BB), smallmouth (SMB) and largemouth bass (LMB), channel catfish (ChC), common carp (CC), northern pike (NP), yellow perch (YP), walleye (WLYE), and white sucker (WS). Advice for the region varies for species and is dependent on the jurisdiction. This ranges from seven or eight fish species with specific advice to over 21 different species covered by the SRMT advisory. For example, species like sturgeon are on the SRMT advisory as connected to their inherent rights and responsibilities (i.e., sturgeon is a species of concern and illegal for non-Indigenous fishers to harvest). Additional nuance surrounding the target species was also identified. For example, Quebec's FCA provides advice for "bass" without species-level advice, while others typically provide separate advice for both largemouth and smallmouth bass.

Thresholds for establishing species-specific size thresholds also vary by jurisdiction. For example, Ontario considers increments of 5 cm within a certain species size range, while Quebec uses two thresholds to delineate which fish are considered one of three small, medium, and large sizes for that species. The New York State and SRMT FCAs use a single size threshold to note either less or greater than an established size. The central difference between New York State and SRMT is that New York State uses a species-specific size for this threshold, while SRMT uses a similar size threshold for many different species of fish. It is of note that the single threshold sizes generally align with the medium- to large-sized fish in Quebec's advice but do not relate to a similar type of advice in the Ontario FCA.

The dominant chemical contaminants triggering FCAs in the Upper St Lawrence River are mercury and PCBs (and related dioxins, furans, and dioxin-like compounds). These priority contaminants are monitored by Ontario, Quebec, and New York State and are also considered in all four of the FCAs, including the SRMT FCA, which is largely based on fish sampled from the surrounding regions in international monitoring programs and with specific coordination between New York State and the SRMT Environment Division (see Skinner et al. 2018). Advice bodies using single-size

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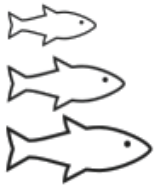
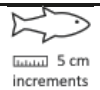
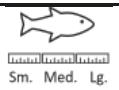
Table 1. Overview of FCA programs in the Upper St Lawrence River, including Ontario (CAN-ON), Quebec (CAN-QC), New York State (US-NYS), and Mohawk Council of Akwesasne (AKWE) and the Saint Regis Mohawk Tribe (SRMT).

		CAN-ON	CAN-QC	US-NYS	AKWE-SRMT
Advisory 	Jurisdictional Entities	Health Canada; Ontario Ministry of the Environment, Conservation and Parks	Health Canada; Québec Ministry of the Environment, Conservation and Parks / Québec Ministère de l'Environnement et de la Lutte contre les changements climatiques	New York State Department of Health; New York State Department of Environmental Conservation	Akwesasne; St Regis Mohawk Tribe Environment Division
	Source Information	*Guide to Eating Ontario Fish* https://www.ontario.ca/page/eating-ontario-fish-2017-18	*Guide to Eating Freshwater Game Fish* https://www.environnement.gouv.qc.ca/eau/guide/localisation.asp	*St. Lawrence Valley Region Fish Advisories* https://www.health.ny.gov/environmental/outdoors/fish/health_advisories/regional/st_lawrence.htm	*Akwesasne Family Guide to Eating Locally-Caught Fish* https://www.epa.gov/sites/default/files/2016-09/documents/srmt_fishadvisory_webfinal.pdf
Fish 	Species with Advice	(8) BB, LMB, NP, SMB, WLYE, WP, WS, YP	(7) BB, BS, (LMB+SMB)*, NP, WLYE, YP (**no differentiation of species*)	(7) BT, ChC, CCp, LT, SMB, WP, WS; (*all other fish*)	(21) AE, BB, BC, BG, BkT, BT, CCp, ChC, ChS, CoS, LMB, LS, MKL, NP, PS, RB, RT, SMB, WLYE, WS, YP
	Size Thresholds	Many 5 cm bins For each species  5 cm increments	Three size bins For each species  Sm. Med. Lg.	One size threshold for each species 	One size threshold for many species 
	Contaminants Considered	*Across Transboundary Advisories*			• Mercury • PCBs; Dioxin-like PCBs, Dioxins & Furans (*not directly monitored*)
		Priority Drivers	*Monitored*	*Exceptions (*NYS only)*	
		• Mercury • PCBs; Dioxin-like PCBs, Dioxins & Furans	• Metals (various) • PAHs • PBDEs • PCNs • PFAS	• Aldrin* • BHCs (hexachlorocyclohexane)* • Chlordane* • DDT & Metabolites* • Heptachlor* • Mirex • Toxaphene	
Consumption 	Demographic Considerations	*Sensitive Populations:* Women < 50; Children < 15	*Sensitive Populations:* Women pregnant, planning to conceive, or breast feeding; Children 5-11	*Sensitive Populations:* Women < 50; Children < 15	*Whole Family Advice:* All ages considered
	Portion Sizes	• 227 g / 8 oz	• 230 g	• 8 oz / 227 g	• 4 oz / 114 g
	Meal Frequency Restrictions	• Do Not Eat (0 meals per month) • 1, 2, 4, 8, 12, 16 mpm • 32 mpm (unrestricted)	• Do Not Eat (0 meals per month) • 1, 2, 4, 8 meals per month		

Note: AE, American eel; BC, black crappie; BG, bluegill; BkT, brook trout; BB, brown bullhead; BS, black sucker; BT, brown trout; ChC, channel catfish; ChS, chinook salmon; CoS, coho salmon; CCp, common carp; LS, lake sturgeon; LT, lake trout; LMB, largemouth bass; MKL, muskellunge; NP, northern pike; PS, pumpkinseed; RT, rainbow trout; RB, rock bass; SMB, smallmouth bass; WLYE, walleye; WP, white perch; WS, white sucker; YP, yellow perch; BHCs, benzene hexachlorides; DDT, dichlorodiphenyltrichloroethane; PAHs, polycyclic aromatic hydrocarbons; PBDEs, polybrominated diphenyl ethers; PCNs, polychlorinated naphthalenes; PCBs, polychlorinated biphenyls; PFAS, per- and polyfluoroalkyl substances.

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threshold triggers for FCAs are typically dominated by mercury (Ontario, Quebec) and PCBs (New York State, SRMT) as the result of historical and present-day industry in the area, but also dioxin-like PCBs, dioxins, and furans make up a large proportion of PCB-related priority contaminants in fish that have been identified at levels considered a risk to human health (Pinheiro et al. 2020; Richter and Skinner 2020). Additionally, concentrations of PFAS in the tissues of fish, mainly perfluoro-octane sulfonic acid (PFOS) and perfluorooctanoic acid (PFOA), indicate that these are a rising concern throughout the Great Lakes with respect to their ubiquity and increasing presence in the aquatic environment (Christensen et al. 2019; Valsecchi et al. 2021). As with some PCBs and dioxins, PAHs and CECs, including PFOS and PFOAs, and PBDEs, are inconsistently monitored within FCA jurisdictions and contain discrepancies between the specific analytes and congeners of these compounds (e.g., Mirex; Photomirex) across contaminant monitoring programs. A small number of certain pesticides are also monitored in some incongruency across the four FCAs. For example, Aldrin, Chlordane, DDT, and Heptachlor are predominantly monitored in New York State, while Mirex and Toxaphene are monitored in New York State, Ontario, and Quebec. The SRMT FCA provides a similar approach, but using only historical priority contaminants, mercury and PCBs, and their tissue loads in local fishes, and provides no specific advice for CECs, such as PFAS.

Within the public-facing FCAs, the presentation of this information also varies considerably by jurisdiction. FCAs in Ontario and New York both indicate the specific contaminants of concern in fish within public guidance documents. In Ontario, detailed information on contaminant levels is available in a separate datafile accessible through a web link in the FCA. No information on specific contaminant levels is provided in the New York State FCA, nor is a web link to associated datasets provided. In Quebec, levels of mercury are provided for all fish that are monitored, whether these levels are high enough or not to warrant restrictive meal advice due to health risks. Other contaminants of concern that may be contributing to local restrictions are not indicated in the FCAs in Quebec. These public-facing FCAs also provide varying levels of detail about how contaminant levels are set. For example, the New York State FCA indicates using federal fish marketing standards to set mercury guidelines in FCAs; in Ontario and Quebec, it is not clear from public-facing guidance if the mercury threshold used in FCAs is the same or different than that set federally by Health Canada for mercury in retail fish.

The differences in monitoring that we have documented can be attributed to a lack of coordinated mechanisms for developing and harmonizing FCAs, which leaves it to individual jurisdictions to put in place monitoring frameworks. King et al. (2021) previously pointed out the lack of a comprehensive approach to fish monitoring across Canada and the United States, and these differences are particularly apparent in the transboundary waterway of the Upper St Lawrence River. In Canada, there is no federal legislation that requires fish monitoring. As such, individual provinces, territories, and First Nations can decide if, when, and how often to conduct fish monitoring. In the US, states are required to monitor for mercury in fish in all waters designated for fishing, according to the federal Clean Water Act (King et al. 2021). There is no legislative basis for other contaminants (King et al. 2021). Federally recognized tribes can also set their own rules outside of state laws.

Collaboration on a shared and transparent approach to monitoring contaminant levels and fish species with requirements in the Upper St Lawrence River would be a significant improvement to the present patchwork approach that our research has documented and would help provide more consistent protections for environmental justice across the waterway. With a coordinated mechanism, differences in monitoring across jurisdictions—for example, to recognize local areas of concern, ecologically unique species, or to incorporate fish species that are locally preferred for eating—could then be accommodated. Capacity building with Indigenous Nations to implement their own monitoring frameworks and standards in unison with surrounding settler government agencies will be key to a more just and coordinated approach within the transboundary setting of the Upper St Lawrence River. In this region, a community-driven science initiative (Great River Rapport—see www.riverrapport.ca) was initiated in 2018 in response to concerns regarding the health of the river. Community engagement identified fish contamination as a priority. A collaborative effort among the Mohawk Council of Akwesasne and the River Institute, a local non-governmental agency with government funding support, has since facilitated fish contaminant sampling in 2021 and 2022 for assessment in the traditional territory of Akwesasne. The results of this project will provide much-needed information to address data gaps in the status of fish contaminant loads and provide the opportunity for capacity building within the local community.

3.2. Consumption guidance

FCAs provide consumption advice based on the levels of contaminants found in representative fish sampled according to their location, species, and length. However, we observed some differences in the existing transboundary FCAs that could be in conflict and, at best, confusing for fish eaters (see Table 1). This includes some variation in how the population demographics are considered in the advice provided, the sizes of portions considered “meals”, and the level of detail behind the restrictions in frequency for consuming fish.

Notably, FCAs issued by Ontario, Quebec, and New York State provide guidance for the general population and sensitive populations, including children and women of childbearing age. Quebec provides some additional breakdown of the age of children considered, while the SRMT FCA offers broad advice for the whole family (i.e., men and women of all ages, young, and elderly). The latter is the result of rigorous community engagement with Akwesasronon, reflecting Indigenous kinship networks compared to the nuclear family or the individual eaters to whom FCAs are typically targeted. What remains is that the act of fish consumption at the community level may not reflect the Western linearity seen in the other FCAs, as one portion may not be eaten as a single meal or the portion may not be made up of a single fish or single

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species. Thus, to effectively estimate a safe number of meal portions that can be eaten, the Akwesasronon would need to know the species, capture location, and size of all fish contributing to a meal and consider each restriction per portion individually to estimate daily allotments of safe fish intake.

There is also variation across the FCAs with respect to the standard size of fish fillet, as a portion or meal, and its consumption frequency as a meal. The recommended meal or portion sizes range from 227 to 230 g for Ontario, Quebec, and New York State and half this amount in the SRMT FCA (114 g), reflecting whole-family advice. While a 3 g variation in portion size may have a minimal increase in risk for occasional fish eaters, it approximates an additional portion per month for those who eat fish daily, considering the SRMT advice.

Broadly, the levels of meal restriction are similar, with restrictions of 0 or "Do Not Eat" advice up to 1, 2, 4, and 8 meals per month provided across all FCAs except Ontario. Further, Quebec, New York State, and SRMT advise up to a maximal allotment of eight meals per month of any species of fish; however, it is not clearly indicated how many fish of a particular size contribute to this maximum, adding to the confusion. In FCAs employing one or two size thresholds, no specific concessions are made for the exact sizes of fish that make up the meal amount considered in the restrictive advice or the number of fish meals consumed per month (e.g., eating two medium-sized fish may range between 30 and 40 cm, while one large fish could be over 65 cm). Ontario advice is unique in that it provides an additional level of detail within the consumption advice that considers 5 cm intervals. This considers contaminant loads for those eating fish daily up to a maximum allotment of 32 meals per month (Do Not Eat (0), 1, 2, 4, 8, 12, 16, and 32 mpm), where consumption advice is functionally unrestricted. However, there are also instances in which unrestricted consumption of specific species is misaligned. For example, for yellow perch from the St. Lawrence River (zone 14) in Ontario, the general population is advised to consume up to eight to 32 meals per month (depending on the size of the fish), and children/women of childbearing age are advised to consume up to four to 16 meals. However, in New York State, across the river at Massena, the general population is advised to eat only up to four meals per month, and children/women of childbearing age are advised "Do Not Eat" due to the concern of PCBs.

Differing guidance can be confusing for the public and fishing communities to understand and can also make it difficult for individuals and communities to engage in decision-making that affects their health. For example, the Mohawk community of Akwesasne, which spans the Canada/US border, has long had to deal with varying FCAs in their traditional waters (Boehme 2020). Recognizing this, in 2020, the International Joint Commission (IJC) initiated a project to develop more consistent and culturally appropriate FCAs in this multi-jurisdictional setting (Boehme 2020). At the time of writing this article, there is no publicly available information about the status of this initiative.

Alongside these differences, we also identified some consistent gaps in consumption guidance. First, we found minimal consideration of cultural food practices across the FCAs. The SRMT guide and its whole family advice are exceptions. Previous research has pointed out that FCAs are weak in this respect, instead providing universal dietary advice (Dellinger et al. 2018, 2019). However, this universal advice overlooks the risks or benefits associated with different eating practices. For example, studies in the Great Lakes watershed have suggested that ethnic groups are more likely to keep the fish they catch for consumption (Nordenstam and Darkwa 2010; Lauber et al. 2017; Hunt et al. in press); however, race and ethnic differences in recreational angling harvesting and consumption practices remain understudied (see Hunt et al. 2007) and are generally not reflected in consumption guidance. Indigenous communities have also traditionally eaten a greater range of parts of the fish that may have a different contaminant load than the flesh. Even within the community-based SRMT FCA, beyond general guidance in the FCAs to trim fat off the flesh of fish, we found no guidance about consuming or preparing different parts of the fish (e.g., livers, gonads, eyes, etc.). Greater engagement with the cultural eating practices of communities may be a step toward the more holistic risk assessment called for by Arquette (2004).

Lastly, we note that the FCAs issued by Ontario, Quebec, and New York State do not consider fishing management regulations, including how many fish are legally allowed to be caught by recreational anglers. This siloed approach to policy could potentially contribute to the advice to eat fish low in contaminants but whose catch is limited. Consumption guidance could be better aligned with harvesting regulations. However, doing so would require working through categories such as meal and portion sizes that are not yet appropriately and consistently defined for all fish eaters, as well as collecting more information on fish that is eaten versus caught and released by recreational anglers.

3.3. Development and communication of FCAs

How FCAs are developed and communicated is crucial to their uptake, awareness, and potential impact on anglers and fishing communities. There have been calls for more outreach to angling populations in the Great Lakes watershed to increase adherence to consumption recommendations (Connelly et al. 2017). For example, over one-third of recreational fishers surveyed in Ontario in 2020 reported no awareness of FCAs (Hunt et al. 2022). King et al. (2021) have noted a need for more public engagement on FCAs so that technical information on fish contamination can be better communicated and blended with individual and community perceptions of risk. The US Environmental Protection Agency provides recommendations for states on how to develop FCAs, including risk communication programs, identifying partners, and developing outreach plans (Environmental Protection Agency 2022). We found no similar guidance in Canada.

Awareness of cultural practices may be an important means of developing effective transboundary FCAs. In the FCAs we analyzed, only the SRMT FCA provides images of the fish contained in their advisories. The use of photos of fish species is an example of implementing culturally-based science and risk communication by changing the presenta-

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tion style to make it more engaging among Akwesasronon (Medin and Bang 2014). The Ontario, Quebec, and New York State FCAs rely heavily on numerical information presented in tables. Previous studies have suggested that the highly technical information contained in FCAs is often not readily understood among the public (King et al. 2021) and that the use of plain language writing, graphics, and qualitative information can enhance appeal and communication (Connelly and Knuth 1998). As well, engagement with cultural eating practices, as discussed in the previous section, might help in developing more culturally appropriate risk assessment communication. For example, Dellinger et al. (2018) in collaboration with the Chippewa Ottawa Resource Authority on Lake Michigan, developed a fish consumption application that incorporated the nutritional and cultural benefits of eating fish alongside the risk of exposure to PBTs. Their messaging, starting with an understanding of the positive place of fish in the Ojibwe culture, was broadly desired by the community and well received.

Another key consideration for environmental justice is access to information. The FCAs we analyzed are available only in English in Ontario and New York State, and English and French in Quebec. The SRMT FCA is likewise published in English only. This may limit outreach to socio-culturally diverse populations, including ethnic groups that may be more likely to eat recreationally caught fish. FCAs in all jurisdictions are provided online. Print copies can be ordered online in Ontario and New York. A reliance on the internet as a key form of communication raises concerns about internet access and the needed technological literacy to navigate these advisories. This may be particularly important in the context of an aging demographic of recreational anglers across the Great Lakes watershed as well as the still predominantly rural geography of anglers, where high-speed internet options may be more limited (Hunt et al. in press).

Lastly, the development and communication of FCAs in ways that uphold self-determination are of central importance for Indigenous environmental justice. Within the Haudenosaunee biocultural context, fish are kin, and thus rights and public health cannot be separated from their relationality with the fish. When FCAs are not developed by or implemented in partnership with Indigenous communities, they may lead to further social, nutritional, and economic disruptions and cultural loss (Duhaime et al. 2004; McAuley and Knopper 2011; Hoover 2013). Hoover (2013) demonstrated how FCAs, starting in the 1970s, contributed to environmental violence among Akwesasne community members, including disruption of language and knowledge systems and the inability to fulfill community roles and responsibilities tied to fishing and fish consumption.

With respect to the contemporary legal context, Gagnon et al. (2018) argued that FCAs can undermine Treaty rights to fish in traditional territories. In Canada and the US, there is a lack of guidance in legislation or policy about how FCAs interface with constitutionally protected Aboriginal and Treaty rights in Canada and Treaty rights in the United States. In Canada, the Crown has a "Duty to Consult" as part of the recognition and affirmation of Aboriginal and Treaty rights in Section 35(1) of the Constitution Act, 1982, and this should be upheld in any implementation of FCAs in Indigenous territories. Foundationally, Indigenous consent and self-governance, as reinforced in the United Nations Declaration of Rights on Indigenous Peoples (UNDRIP), need to be key principles for transboundary governance in the Upper St Lawrence River, including the development of FCAs.

4. Conclusion

In conclusion, this study has examined FCAs as a site of transboundary governance in the Upper St Lawrence River. Examining FCAs as a site of transboundary governance requires attending to social, political, and geographical differences across jurisdictions as well as opportunities for enhanced collaboration and power-sharing. We found that monitoring of contaminants and fish species as well as consumption advice varies across jurisdictions, despite fish and contaminants in these waters not respecting political boundaries. People also travel across different parts of the Upper St Lawrence River, where they must contend with varying consumption guidance and monitoring standards. We have offered several recommendations for enhancing FCAs in support of environmental justice in this transboundary setting, considering the need for (1) a shared and transparent approach to monitoring contaminant levels and fish species; (2) integration of cultural food practices; (3) enhanced outreach to angler populations; and (4) upholding the self-determination of Indigenous communities.

We believe these recommendations offer a first step towards improving FCAs in the transboundary Upper St Lawrence River. However, it is important to underscore that we do not believe FCAs should be a permanent solution. Ultimately, efforts toward minimizing and preventing contaminants, including both legacy contaminants and emerging chemicals of concern, need to be a priority so that FCAs in the future will no longer be necessary (Gagnon et al. 2018). We are hopeful about the progress that is being made towards environmental revitalization in the Upper St Lawrence River, driven by community and grassroots efforts in tandem with Indigenous, government, and non-profit partners (McGaughey et al. 2022). McGaughey et al. (2022) highlight opportunities for a collective impact approach, embedded in adaptive management strategies and coalition building, to scale up environmental revitalization efforts. Moving forward, from an environmental justice lens, efforts to improve ecological health need to be paired with harm reduction in affected communities to address the health, social, and cultural losses associated with contamination of fish and to restore sustainable consumption of fish as ecological health improves.

Acknowledgements

We would like to thank John Jackson for his helpful feedback on previous versions of this manuscript. We also sincerely thank Erin Smith for creating the map used in this paper. Lastly, we acknowledge funding support from the Social Sciences and Humanities Research Council of Canada (grant number 430-2019-00128).

Article information

Editor
Irene Gregory-Eaves

History dates
Received: 5 May 2023
Accepted: 8 October 2023
Version of record online: 25 January 2024

Notes
This article was originally published with minor errors (formatting in Table 1 and author's address) that have now been corrected.

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Data availability
Data generated or analyzed during this study are provided in full within the published article and its supplementary materials.

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Competing interests
The authors declare there are no competing interests.

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