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## Review

## Two-Eyed Seeing: Developing perspective and wisdom on sea lamprey in the Laurentian Great Lakes

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## ABSTRACT

Bridging knowledge systems is a potential means of equitably and collaboratively working towards improved conservation and management of aquatic ecosystems, such as the management of invasive species. *Etuaptmumk* (Two-Eyed Seeing) is a Mi'kmaw framework that encourages the bridging of Indigenous and Western knowledge systems to work together in parallel on a shared issue or problem. Invasive species pose a significant threat to aquatic ecosystems, and they are disrupting fisheries and entire lake ecosystems within the Laurentian Great Lakes. Sea lamprey (*Petromyzon marinus*) are one example of an invasive species in these Great Lakes with an established control program. Sea lamprey management faces many challenges including possible declining social acceptance of control programs, especially amongst Indigenous communities in the region. Such challenges illustrate the need for sea lamprey management to be resilient, sustainable, and reflective of the knowledges and needs of the people across the Laurentian Great Lakes. We argue that applying the guidance offered by Two-Eyed Seeing to sea lamprey management could help uphold Indigenous rights and knowledges in resource management and be an important step towards remedying the historical and contemporary exclusion of Indigenous Nations in decision-making concerning the Laurentian Great Lakes fisheries. Specifically, we explore why Two-Eyed Seeing should be applied and how it can guide non-Indigenous government agencies and fisheries organizations across the Laurentian Great Lakes region to expand and deepen their partnerships with Indigenous Nations for more equitable decision-making while enhancing the collective state of knowledge in the interests of re-envisioning and enhancing sea lamprey control.

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**Positionality statement**

*“We could not be without being in relationship with everything that surrounds us and is within us. Our reality, our ontology is the relationships... Our systems of knowledge are built by and around and also form these relationships.”* –Shawn Wilson (Wilson, 2008, p. 81).

As a Canadian graduate student with a settler-European background, I (Charity Nonkes/first author) come to this work with a set of biases and relationships shaped by settler colonialism. My co-authors and many other Indigenous thinkers introduced me to Two-Eyed Seeing and Indigenous research methodologies, which continually challenge me to reflect on how my privilege and Euro-centric background impacts my approach to this research. The author team’s (Charity Nonkes, Alexander T. Duncan, Ryan Lauzon, Kathleen Ryan, Dr. Andrea Reid, Dr. Steven J. Cooke, and Dr. Nathan Young) relationships with each other and sea lamprey stewardship have likewise shaped this article. The team is made up of Indigenous and non-Indigenous fisheries scientists, biologists, aquatic ecologists, and social scientists; many of whom are brought together in this collaboration through a Great Lakes research project entitled *Sea Lamprey Research and Management - Indigenous Input and Inclusion*. As well, in the context of my graduate studies at the University of Ottawa, I partnered with the Saugueen Ojibway Nation (SON), in collaboration with co-authors, on a research project about sea lamprey stewardship with a focus on the rehabilitation of Denny’s Dam, which serves as a barrier to sea lamprey movement and dispersal. It is with this set of experiences that we welcome the reader to this article and present our collective reimagining of sea lamprey stewardship.

**Introduction**

Sea lamprey (*Petromyzon marinus*, bimiziiz or ginebigomeg in Anishinaabemowin) are an aquatic invasive species in the Laurentian Great Lakes (hereafter the Great Lakes) that have caused significant ecological and economic damage over the past century (reviewed in Brant, 2019). Due to the scale of impacts, sea lamprey control has been a major priority for the governments of Canada and the United States (U.S.) and a major reason why the bilateral Great Lakes Fishery Commission (GLFC) was founded as per the *Convention on Great Lakes Fisheries (1954)* treaty (Gaden et al., 2021b). The sea lamprey control management system has been undertaking research and operations for more than 70 years and has demonstrated success in reducing sea lamprey population size by 90 % from peak population (Brant, 2019). However, various methods of control are under scrutiny due to potential negative impacts which could be leading to shifts in social acceptance (Gaden et al., 2021a; Mattes and Kitson, 2021). As well, there is pressure to better consult and build partnerships with Indigenous Nations which is connected with the growing recognition of Indigenous rights exemplified by the United Nations Declaration on the Rights of Indigenous Peoples (UNDRIP) (United Nations General Assembly, 2007). Sea lamprey control programs occur within (and across) Indigenous territories throughout the Great Lakes basin, but not all Indigenous Nations, fishery leaders, and

organizations are meaningfully involved in these programs, especially in the current Canadian context (Gaden et al., 2021a; Mattes and Kitson, 2021; Steeves and Barber, 2020). Exclusion from sea lamprey control (and fisheries management at large) decision-making spaces may contribute to diminishing support and social acceptance of sea lamprey control methods amongst some Indigenous communities (Gaden et al., 2021a). A re-assessment and re-envisioning of sea lamprey management may be needed to ensure the program’s viability and acceptability in the future while embracing opportunities for program enhancement.

The challenges facing sea lamprey management are a microcosm of broader social and ecological issues in the Great Lakes, and perhaps beyond. The sustainability of these Great Lakes for present and future generations depends on a reimagining of fisheries management that bridges knowledge systems and upholds Indigenous communities’ relationships, rights, and responsibilities to their lands and waters (Tribes and First Nations of the Great Lakes Basin, 2004). A framework for bridging knowledge systems in fisheries management, including sea lamprey control, is offered by Two-Eyed Seeing. Two-Eyed Seeing (*Etuaptmumk* in Mi’kmaw) is a teaching carried by Mi’kmaw Elders Dr. Albert Marshall and Murdena Marshall, and is defined as, “learning to see from one eye with the strengths of Indigenous knowledges and ways of knowing, and from the other eye with the strengths of Western knowledges and ways of knowing, and to use both these eyes together, for the benefit of all” (Bartlett et al., 2012, p. 335). In this framework, knowledges are not combined, integrated, or tested against one another. Instead, different perspectives are brought together in parallel, while remaining distinct, for consideration in decision-making and advancing understanding. Two-Eyed Seeing imparts a responsibility on participants to not only listen but take action (Reid et al., 2021). This teaching can ultimately be a new approach for the GLFC, government partners, and others to re-envision their relationships with Indigenous Peoples and communities and address some of the most pressing social and ecological issues in the Great Lakes. These relationships must be collaborative and be long-term commitments to meet the needs for both Indigenous and non-Indigenous Peoples throughout the Great Lakes Basin.

In this article, we argue that the GLFC, Indigenous Nations, and U.S. and Canadian federal, state, and provincial governments would benefit from implementing a Two-Eyed Seeing framework in their policy, practical, and research approaches to sea lamprey management. This article focuses on why Two-Eyed Seeing should be applied to sea lamprey management and how this process may be started. While the focus is on sea lamprey management, ideas shared can be extended to other invasive species and fisheries management programs.

There is a need for Two-Eyed Seeing in invasive species management and recognition of Indigenous leadership in this domain. As one of the most extensive and longstanding invasive species management programs on the planet, the sea lamprey control program should set an example by adopting principles of Two-Eyed Seeing to create more adaptive and inclusive solutions. This is especially crucial in light of the historical and continued exclusion of some Indigenous groups and knowledge systems in decision-making, and Indigenous opposition to control methods - which

highlights concerns about the impacts from barriers and lampicides on water quality and fish passage (Hume et al., 2021; Mattes and Kitson, 2021;). Adopting a Two-Eyed Seeing approach would require sea lamprey stewardship decision-making spaces to create an ethical space (Ermine, 2007) that welcomes more Indigenous representatives and knowledges to ensure Indigenous Peoples have power in the processes that impact their lives. The organizations in sea lamprey control already have varying degrees of experience in partnering with Indigenous Nations in sea lamprey management and, thus, have a foundation to work more closely together to equitably engage Nations impacted by sea lamprey management. Here, we provide guidance for movement towards a more adaptive and holistic sea lamprey management system centered on Two-Eyed Seeing. However, there is a need for more in-depth and directed research into Two-Eyed Seeing and Indigenous partnerships in sea lamprey management in the Great Lakes; this effort is but one first step in this direction.

In the spirit of Two-Eyed Seeing, the use and meaning of the term *management* is approached with a critical lens in this article as it reflects a Western paradigm without an equivalent in many Indigenous contexts. For instance, within the Anishinaabe language (Anishinaabemowin) there is no direct translation of the word *management* (Lauzon and Ryan, 2019). Therefore, the terms *fisheries management*, *sea lamprey management*, and *sea lamprey control* are incongruous with an Anishinaabe (Indigenous cultural group, traditionally in the Great Lakes region) worldview, specifically with respect to spiritual connections and human-environment reciprocity, relationship, and responsibility (Vernon Roote, personal communication, May 26, 2021). Words such as *understanding*, *stewardship*, *responsibility*, *relationship*, *care-taking*, and *decision-making* better reflect aspects of such worldviews, but none alone fully encompass them. For the purposes of this article, the term *stewardship* will henceforth replace the term *management* when referring to fisheries or sea lamprey management (e.g., fisheries stewardship, sea lamprey stewardship). We recognize that the term *stewardship* also carries its own connotations related to 'ownership' over the planet, enforcement of a hierarchy with humans above all other species, and religious understandings of humans borrowing the Earth and being held accountable by God (Foster, 2005; Worrell and Appleby, 2000). However, there is no "right" term in English that fully reflects the relationship and responsibilities between humans, other beings, and the environment. Similarly, the term *control* also carries its own connotations of human superiority and dominion; therefore, its use is limited and mainly used when referring to 'control methods' or for clarity reasons.

In the remainder of this article, we explain why Two-Eyed Seeing is needed in sea lamprey stewardship and potential ways it could be applied. First, we discuss the history of sea lamprey stewardship and Indigenous involvement in sea lamprey stewardship decisions. This is followed by a discussion of UNDRIP, and the legal and political imperatives to equitably engage Indigenous Nations in projects that are on their lands and/or impact their lives. This section demonstrates challenges and opportunities for applying Two-Eyed Seeing to sea lamprey stewardship on a systematic level, and how it can fulfill obligations to uphold Indigenous rights. Second, we consider Indigenous concerns about control methods and how these may be intertwined with environmental (in)justice, thus demonstrating the need for Two-Eyed Seeing. Third, we provide background on Indigenous agency in the invasive species field using as an example an Anishinaabe way of thinking about invasive species in North America that directly applies to Two-Eyed Seeing in fisheries stewardship. This example illustrates how Two-Eyed Seeing presents a framework for partnerships and knowledge coexistence with Indigenous communities for enhanced sea lamprey stewardship. The fourth and final section explores Two-Eyed

Seeing as a knowledge coexistence framework and its potential in sea lamprey and fisheries stewardship.

## Re-envisioning sea lamprey stewardship

### *Sea lamprey stewardship history and legacy*

Sea lamprey are a parasitic fish originating from the Atlantic Ocean, now considered invasive to the Laurentian Great Lakes (Siefkes et al., 2012). Sea lamprey begin their life cycle as non-parasitic larvae that inhabit tributaries until they undergo metamorphosis and begin to migrate into lake systems (Siefkes et al., 2012). This metamorphosis transforms the larvae into parasitic young adults that continue to grow and feed on living host fish for 12 to 18 months, after which they enter their spawning life stage and find tributaries to reproduce in and then die (Siefkes et al., 2012). The sea lamprey stewardship program, introduced above, is considered highly successful at reducing sea lamprey population sizes throughout the Great Lakes and is respected for its long-standing operation of aquatic invasive species control (Gaden et al., 2021a; Siefkes et al., 2012). However, there is little peer reviewed literature specifically focusing on Indigenous partnerships and experiences in this program (Gaden et al., 2021a; see Mattes and Kitson, 2021). The following section provides a broad overview of sea lamprey stewardship history and current operation with a focus on the involvement of Indigenous Peoples. This provides context for the opportunities and challenges for implementing Two-Eyed Seeing on a systematic level to sea lamprey stewardship.

There is some debate as to whether sea lamprey are native to Lake Ontario (Eshenroder 2009; Sturtevant et al., 2019; Waldman et al. 2004); nevertheless, Niagara Falls acted as a sea lamprey barrier barring sea lamprey movement into the rest of the Great Lakes (Brant, 2019; Siefkes et al., 2012). After the construction of the Welland Canal (which bypassed the falls to enable ship passage between Lakes Ontario and Erie) in the mid-1800s and its subsequent widening in the 1910s, sea lamprey began to swim their way into Lake Erie and the rest of the Great Lakes (Hubbs and Pope 1937; Brant, 2019). Demands from the industrial revolution and World War I fueled the construction and expansion of the Welland Canal as it sought to meet the needs of growing North American industries by allowing ships to transport resources to and from the Great Lakes area (Brant, 2019). This growth in industry, and the belief amongst settlers that fish in the Great Lakes were limitless, put significant pressure on the Great Lakes ecosystems (Brant, 2019). As well, this quest for connectivity opened the Great Lakes to international shipping vessels and a plethora of aquatic invasive species including sea lamprey (Brant, 2019; Ricciardi, 2006; Sturtevant et al., 2019). This short-sightedness was repeated with the opening of the St. Lawrence Seaway in 1959 which further exacerbated the spread of aquatic invasive species as they were released into the Great Lakes through ocean freighter ballast water (Alexander, 2009).

Throughout the first half of the 20th century, there was a steady increase of sea lamprey in the Great Lakes that led to an overabundance by the 1940s and 1950s (Brant, 2019). This, along with commercial overfishing, habitat alterations, and other factors, led to the decimation of the Great Lakes' fisheries, particularly lake trout (*Salvelinus namaycush*) and lake whitefish (*Coregonus clupeaformis*) (Brant, 2019; Fetterolf Jr., 1980; Gaden et al., 2012; Hudson and Ziegler, 2014; Siefkes et al., 2012). In response to political pressures and calls from scientists, fishers, and others for uniform fishery regulations and a coordinated response to the growing sea lamprey issue, a treaty called the *Convention on Great Lakes Fisheries (1954)* was created and signed by Canada and the U.S.

which prompted the establishment of the GLFC in 1955 (Brant, 2019; Christie and Goddard, 2003; Gaden et al., 2012; Miehl et al., 2020).

Between the 1940s and 1960s, several sea lamprey control methods were put in place, including mechanical weirs, traps, barriers, and lampricides. These lampricides included TFM (3-trifluoromethyl-4-nitrophenol) starting in 1957 and Bayluscide (2', 5-dichloro-4'-nitrosalicylanilide) in 1963 (Applegate and Smith 1951 as seen in Miehl et al., 2020; Brant, 2019; Siefkes et al., 2012; Smith and Tibbles, 1980). With the advent of lampricides, the populations of sea lamprey have been reduced by 90 % from peak levels throughout the Great Lakes by the 1980s (Christie and Goddard, 2003; Cornelius et al., 1995; Pearce et al., 1980; Siefkes et al., 2012; Smith and Tibbles, 1980). Due to their success and effectiveness at reducing sea lamprey populations, lampricides are now the primary sea lamprey control method employed by the GLFC (McDonald and Kolar, 2007). However, due to the high costs and public perceptions of pesticides, barriers were often used as an alternative to lampricides from the late 1960s onwards (Christie and Goddard, 2003; Lavis et al., 2003).

Throughout this time, Indigenous involvement and voices were excluded from deliberations for the *Convention on Great Lakes Fisheries* and early sea lamprey stewardship because Indigenous Nations surrounding the Great Lakes were subjected to state/provincial/federal authority over their fisheries (in Canada driven by the *Fisheries Act* and the *British North America Act* of 1867 for example) (Gaden et al., 2012; 2021b). In the U.S. this lasted until the 1980s when intertribal organizations began exercising management authority as affirmed by the 1979 *U.S. v. Michigan* court decision which asserted tribal management authority in Lakes Superior, Michigan, and Huron (see Gaden et al., 2012). However, courts in Canada ruled (*R. v. Sparrow*, 1990) that federal and provincial management do not deny First Nation access to fish; therefore, federal and provincial governments can manage fisheries on behalf of First Nations (many First Nations disagree with this) given there is proper consultation and no infringement of First Nation fishing rights (see Gaden et al., 2012; Harris and Millerd, 2010). This influences the level of involvement Tribes in the U.S. and First Nations in Canada have in decisions concerning fisheries stewardship in the Great Lakes. In order to apply-Two-Eyed Seeing to sea lamprey stewardship on a systematic level it is important to understand how different Indigenous Nations interact with sea lamprey/fisheries stewardship on a governance level. Gaps in representation could indicate opportunities to make space for First Nation representatives and Indigenous knowledge systems.

The GLFC under the *Convention on Great Lakes Fisheries* holds the ultimate authority for sea lamprey stewardship in the Great Lakes, but this is facilitated in partnership with U.S. Fish and Wildlife Service (FWS), U.S. Army Corps of Engineers (USACE), and Fisheries and Oceans Canada (DFO) (Steeves and Barber, 2022). These organizations often work with Tribal, First Nation, and state/provincial governments to implement control methods such as applications of lampricides and construction of physical barriers onto specific tributaries. Many other organizations are involved in implementing the sea lamprey control methods and research including state, provincial, and tribal authorities as well as the U.S. Geological Survey and universities (GLFC, 2022). The Sea Lamprey Research Board (composed of academics, GLFC, and governmental representatives) sets priorities and themes to address the research needs of sea lamprey stewardship. The priorities and themes center around Western scientific research concerning current and supplementary control methods, assessment, and other related topics with less focus on human-ecological relationships. Other actors in sea lamprey stewardship are the Sea Lamprey Control Board (SLCB) and task forces which help to set strategies for sea lamprey steward-

ship with the GLFC, and it is composed of non-governmental experts and state/federal/tribal representatives (GLFC, 2022).

In 1964, exercising its treaty obligation to create cross-border stewardship, the GLFC created a “lake committee” for each lake as a place for the state and provincial fishery agencies to share information and cooperate. U.S. tribes joined the process starting in the mid-1980s. The goals and targets for sea lamprey stewardship are directed by fish community objectives set by each of the lake committees, a process established by the 1981 Joint Strategic Plan for Management of Great Lakes Fisheries (JSP) (Steeves and Barber, 2022; see Gaden et al., 2012). It is a requirement for an organization to have clear fishery management jurisdictional responsibility to be a member of a lake committee and at the time the lake committees and the JSP were formed, Indigenous organizations like First Nations were not considered to possess fishery management jurisdiction. Therefore, the inclusion of Indigenous representatives from Canada on the lake committees or the JSP was thought to be beyond the GLFC's authority. Therefore, First Nations do not hold official seats and decision-making power in these spaces (but may hold observational seats) because of *R. v. Sparrow* 1990, but several Tribal organizations (*U.S. v. Michigan* 1979) have seats on lake committees and are signatories of JSP (e.g., Chippewa-Ottawa Resource Authority, Great Lakes Indian Fish and Wildlife Commission, the 1954 Treaty Authority). This is an issue because the lake committees directly influence the goals of sea lamprey stewardship through fish community objectives. This means that many First Nation and Tribal perspectives and worldviews were not represented in the crafting of these objectives that continue to shape GLFC fisheries and sea lamprey stewardship decisions, goals, and actions across Indigenous territories.

As well, First Nations like the Saugeen Ojibway Nation (SON) have been left out of the process, even though SON has had a series of commercial fisheries agreements with the Ontario government since 2000 that demonstrate SON jurisdiction and co-management of the fishery within their Traditional Territory (which covers a large portion of Lake Huron and Georgian Bay) (Morence, 2013; *Substantive Commercial Fishing Agreement*, 2011). Discussions could take place involving the GLFC, SON, and the Province of Ontario to consider the SON's fishery management jurisdictional responsibility and the potential of SON representatives holding seats in the Lake Huron Committee. It is important to have a range of Indigenous representation because Indigenous communities hold established rights to the waters and fish, and different Nations have distinct experiences and knowledges about sea lamprey and sea lamprey stewardship. However, inclusion is the bare minimum, and it is vital to reduce barriers to participation so that diverse experiences, knowledge, and pathways, regardless of formal education, are respected and provided opportunities to make meaningful contributions.

In general, the organizations that make high-level decisions and goals for sea lamprey stewardship are primarily made of representatives of the JSP. The GLFC and other sea lamprey stewardship actors already have decades of experience working with some Tribal organizations in fisheries sea lamprey management. Consultation and partnerships with First Nations may occur for the implementation of specific control methods projects (e.g., Denny's Dam rehabilitation with the Saugeen Ojibway Nation and the GLFC), but First Nations' access to higher levels of sea lamprey stewardship decision-making spaces is limited. While the GLFC does not have the authority to allow First Nations without affirmed management authority to become signatories of the JSP and subsequently lake committees, more should be done to explicitly identify the pathways/mechanisms for inclusion of First Nation representatives and knowledges in the boards and task forces that influence the sea lamprey stewardship program (especially since their perspectives may differ from Tribal representatives). This,



with the inclusion of Tribes, could, if done with intention, help shift sea lamprey research, goals, and strategies from being solely Western scientifically based to a Two-Eyed Seeing approach.

#### *Imperatives for Indigenous inclusion*

A part of Two-Eyed Seeing is the upholding of Indigenous rights as established constitutionally, through international legal norms, and/or in treaties (Reid et al., 2021). Two-Eyed Seeing is built on equitable relationships which necessitates the upholding of Indigenous rights. Thus, implementing a Two-Eyed Seeing approach can help organizations conform to requirements in treaties and international legal norms.

The promise of shared decision-making relative to Great Lakes fisheries spans back to the agreements made in the Treaties (e.g., Upper Canada Treaties: 1781–1862; Treaty of Washington: 1836; Treaty of St. Peters: 1837; Robinson-Superior: 1850, Robinson-Huron: 1850; Treaty of La Pointe: 1842 and 1854; and Williams Treaties: 1923) that promised to share rather than exploit the lands and waters of the Great Lakes. Engagement with Indigenous Peoples and knowledges must begin with a rights-based approach built on trust and respect (Bawa et al., 2011) that ensures equity in decision-making, and Indigenous control over the ownership, interpretation, and application of Indigenous knowledges. This adds to the mounting imperatives in legal and political spheres to equitably engage Indigenous groups and Indigenous knowledges in resource management (Ogar et al., 2020; Reid et al., 2021).

Some of the legislative imperatives for Indigenous inclusion come from UNDRIP. UNDRIP is an international resolution adopted by the United Nations to establish a framework of minimum standards, “for the survival, dignity and well-being of the Indigenous Peoples of the world” (United Nations General Assembly, 2007). UNDRIP lays the foundation for Indigenous knowledge holders to have a rightful place at the decision-making table, and to oversee how Indigenous knowledges/Traditional Ecological Knowledge (TEK) is used, owned, and applied. Indigenous rights, as enshrined by UNDRIP, assert that fisheries stewardship and decision-making require the free, prior, and informed consent of Indigenous Peoples (Articles 19/25/26), and for Indigenous Peoples to participate meaningfully in decision-making, with full determination as to how (their) knowledges are interpreted and applied.

For the GLFC and federal/state/provincial governments active in sea lamprey stewardship this necessitates consent and shared decision-making from Indigenous Nations in control methods within their Territories. Despite the GLFC’s mandate to implement sea lamprey stewardship, Indigenous sovereignty must be respected and their rights to deny the use of control methods on their lands and waters upheld (Mattes and Kitson, 2021). UNDRIP Article 31 affirms Indigenous Peoples’ right to maintain, control, protect, and develop their knowledges and sciences (United Nations General Assembly, 2007). This reflects McGregor’s (2002) calls that Indigenous knowledge holders must be involved when Indigenous knowledges are applied to environmental stewardship, because the two are inextricably linked since “TEK is something one does” and cannot be acquired or learned without experience (McGregor, 2002, p. 8). Actors in sea lamprey stewardship could implement this UNDRIP Article by creating space for Indigenous knowledge systems in sea lamprey research, decision-making, and the implementation of control methods. This must follow the principles of OCAP™ (The First Nations principles of ownership, control, access, and possession), ensure data sovereignty, and be rooted in trust-based relationships with Indigenous knowledge holders.

Moreover, Indigenous knowledge is directly tied to land and language and cannot be taken out of this context. Colonialism sought to break Indigenous Peoples connections from land and language. Any actions to bridge knowledge systems must acknowl-

edge this and work toward decolonizing the process by protecting Indigenous knowledge holders’ connections to land and language. Inclusion of Indigenous knowledge systems in sea lamprey research and stewardship is the bare minimum. This process necessitates the breaking down of barriers that prevent Indigenous knowledge holders from participating. This is a long-term process which will not adhere to rigid project management norms (e.g., schedules, deadlines, contracts) that Western organizations traditionally implement.

UNDRIP Article 18 affirms the rights for Indigenous Peoples to participate in decision-making in matters that would affect their rights. Based on this it could be argued that federal, state, and provincial regulators should affirm more Indigenous Nations’ jurisdictional management authority in the Great Lakes and by extension their rightful place at the decision-making table, and not just in an advisory capacity. Implementing the principles of UNDRIP is especially important for Canadian sea lamprey actors because Canada (by having legislated UNDRIP into law in 2021) is required to reform its approach to Indigenous relations in fisheries and all other spaces. Moreover, the GLFC as a bi-national body, is free to work with Indigenous Nations to implement the Articles of UNDRIP into their policy, practical, and research actions. The process of Two-Eyed Seeing creates relationships that would inherently fulfill the principles of UNDRIP and the implementation of UNDRIP creates an environment where Two-Eyed Seeing can be practiced.

In light of these imperatives, a re-assessment of the sea lamprey stewardship program should be conducted to examine how Indigenous knowledge systems can help guide stewardship decisions and how to provide more decision-making power to Indigenous Peoples that are active in Great Lakes fisheries and sea lamprey stewardship. This is particularly relevant in light of UNDRIP and First Nations assertion of their jurisdiction and individual and collective (Nation) rights to sustain their ways of life and relationships (Lauzon and Ryan, 2019).

It should be noted that the GLFC and other sea lamprey stewardship actors are already moving towards more collaborative engagement with Indigenous Peoples and knowledge systems. Much of the GLFC’s work with Indigenous Peoples goes beyond mere consultation and seeks to build relationships based on trust and respect. The GLFC is built upon a principle of collaboration that is evident in many of its relationships with the Indigenous organizations (especially signatories of the Joint Strategic Plan) they partner with to deliver sea lamprey stewardship. As well, the GLFC has recently supported *Sea Lamprey Research and Management – Indigenous Input and Inclusion* (3I Project) which is a multi-year research project that seeks to work with Indigenous Peoples across the Great Lakes Basin to understand the range of experiences and knowledges on sea lamprey and sea lamprey control methods which may differ from one community or context to the next.

Other examples of the GLFC recognizing the importance of Indigenous knowledges in their work includes its support of the *Bridging knowledge systems between Indigenous and non-Indigenous communities* session at the International Association for Great Lakes Research’s (IAGLR) 2021 Conference on Great Lakes Research (chaired by co-authors A. Duncan and Dr. A. Reid, with colleagues Kaitlin Almack and Nicholas Boucher) and subsequently this special issue of the Journal of Great Lakes Research. The GLFC has committed to better engage with Indigenous Peoples. We argue that this commitment should involve openness to new frameworks and wise practices to guide partnerships with Indigenous Peoples to ensure the upholding of Indigenous rights and knowledges, and the equitable distribution of decision-making power. Specifically, the GLFC should consider examining stewardship and research processes that restrict Indigenous involvement (e.g., using lake committees to set fish community objectives)

and develop new methods and take direct action to bridge knowledge systems in its decision-making processes, even if states and provinces do not.

#### *Environmental injustice and opposition to control methods*

It is essential to understand the history and reality of environmental injustice and colonization around the Great Lakes as it creates context for sea lamprey stewardship and the relationships that are a part of the process today. There remains much skepticism from the Western science community concerning the validity of Indigenous knowledge systems (Reid et al., 2021), and likewise distrust from Indigenous Peoples concerning scientific practices and claims to expertise (Berkes, 2018).

A factor in this distrust is the numerous examples of environmental injustice where the rights of Indigenous Peoples have been repeatedly infringed upon by authorities leading to subsequent environmental degradation (e.g., James Bay hydroelectricity project; Sydney Tar Ponds, Grassy Narrows, Enbridge Line 5) (Haluza-DeLay et al., 2009). Whyte's (2011) concept of technoppression also helps explain Indigenous distrust. Technoppression is a form of environmental injustice that involves the deployment of 'risky' technologies (e.g., uranium mining) in or near Indigenous communities without regard for their sovereignty or how it will impact their lives, ceremonies, values, relationships, or land. Indigenous Peoples have been and still are largely excluded from decision-making processes that impact their livelihoods and lands, thus creating power imbalances, historical and ongoing traumas, and environmental/racial injustices (Gilio-Whitaker, 2020). Indigenous Peoples have been ignored, misled, and disproportionately burdened from environmental degradation with governments less likely to step in with corrective action (Haluza-DeLay et al., 2009). This history is valuable for understanding current challenges with sea lamprey stewardship.

At present, the continued public acceptance of the sea lamprey control methods is not guaranteed. Gaden et al. (2021a) explore how the GLFC cannot take its social license to operate sea lamprey control methods for granted and argue that shifting baseline syndrome (when successive generations become accustomed to changes that would have once seemed extreme; Pauly, 1995) means that the general public, fishery managers, and politicians may not remember the devastation wrought by sea lamprey in the mid-20th century. Future sea lamprey stewardship may therefore be a victim of its past success, as the public does not see the immediate need for lampricide and barrier construction or maintenance, which carry their own environmental risks and costs (Gaden et al., 2021a).

For example, there are impacts on non-target species mortality by both barriers and lampricides. Macroinvertebrates, teleosts, amphibians, and native lamprey species have shown a range of sensitivity to TFM and Bayluscide lampricide. However, the scheduling of lampricide application every-three to five years has shown that there has been minimal long-term effects, except for native lamprey species (Siefkes et al., 2012). Western research and the GLFC have deemed the non-target impacts of the lampricides minimal compared to the potential impacts of reducing sea lampricide application (Siefkes et al., 2012); Indigenous perspectives and knowledge on this are an important missing piece of the discussion. Barriers block fish passage through waterways as most native fish populations have limited jumping abilities and cannot get over the fixed-crest barriers often used in sea lamprey stewardship (McDonald and Kolar, 2007; Zielinski and Freiburger, 2021). As well, degradation of existing infrastructure (barriers) is an issue as it creates safety concerns and weakens the structures' ability to block sea lamprey (Miehls et al., 2020). For some Indigenous communities, barriers pose issues for fish passage by disrupt-

ing native species (e.g., lake sturgeon *Acipenser fulvescens*) ranges and preventing them from reaching Indigenous Territories (Hume et al., 2021; Mattes and Kitson, 2021). In general, social trends might not be in favour of barriers and chemical introductions into the environment, nor newer control methods such as genetic manipulation (Gaden et al., 2021a).

There is some evidence of opposition and skepticism from some Indigenous communities to lampricides and barriers which poses serious challenges to the continuation of these efforts in the short and long terms (Mattes and Kitson, 2021). The legacy of environmental injustice may be influencing some Indigenous Peoples' perceptions of sea lamprey control methods and the government agencies implementing the control methods – particularly lampricides and their impacts on non-target organisms. There are concerns about the effects of pesticides on water quality and the continued safety of the rivers and lakes for use by Indigenous Peoples (Hume et al., 2021). In Ontario, lampricide applications to the Root River, Garden River, Echo River, and Mississagi River were deferred throughout the 2010's due to lack of support from the Garden River and Mississauga First Nations (Barber and Steeves, 2019, 2021; Dobiesz and Bence, 2018; Steeves and Barber, 2020). Dobiesz and Bence (2018) conducted modeling to determine the possible effects of delaying these lampricide applications on the Echo, Root, Garden, and Mississagi Rivers. The model predicted that stopping lampricide applications on the Mississagi River would result in the doubling of spawning lamprey in Lake Huron and without control methods, this would likely lead to a doubling of attacks and fish mortalities in Lake Huron from sea lamprey (Dobiesz and Bence, 2018). It was not until 2019 and 2020 that applications of lampricide were applied to the Mississagi River and Garden River, respectively (Barber and Steeves, 2021). These applications went forward because relationships were built with the First Nations. These relationships created an ethical space where community concerns, knowledge, and experience could be listened to and addressed.

More research is needed to understand the range of Indigenous perspectives and knowledges on sea lamprey stewardship because Indigenous views may differ considerably from other communities and agencies (Gaden et al., 2021a; Mattes and Kitson, 2021). For example, many Tribes in the U.S. have a different experience with sea lamprey stewardship than First Nations in Canada because of different levels of involvement in decisions and interactions with governments implementing the control methods. Moreover, amongst Tribes there is a range of perspectives on what sea lamprey stewardship should look like (Mattes and Kitson, 2021). This can range from aspirations for eradication, better fish passage, no intervention, to non-chemical control (Mattes and Kitson, 2021). Similarly, the 2018 Chiefs of Lake Huron Fisheries Forum remarked on the need for holistic invasive species stewardship methods (Lauzon and Ryan, 2019). Using substances such as lampricides was seen as an 'easy way' out and that does not respect or account for Indigenous teachings in certain contexts or larger ecological implications (Lauzon and Ryan, 2019).

Gaden et al. (2021a) highlight the need for research on the range of Indigenous perspectives on sea lamprey and sea lamprey stewardship because the control methods program's social license to operate may be in jeopardy. While this is an important motivator for the GLFC and others to facilitate this research, it does not clearly express considerations of Indigenous sovereignty to determine what happens on Indigenous lands and waters, but rather focus is placed on how Indigenous knowledges and experience can be used to maintain the GLFC's social license to operate. Indigenous knowledge systems cannot be separated from Indigenous Peoples, their engagement requires active participation from knowledge holders and carriers (McGregor, 2002). If an ethic of knowledge coexistence and equal partnership (that addresses

power dynamics and decision-making power imbalances) is not built into sea lamprey stewardship practices with Indigenous Peoples, then such efforts may act as a form of assimilation and continue environmental injustices.

We argue that Two-Eyed Seeing can be a mechanism to understand Indigenous knowledge systems while respecting Indigenous sovereignty in decision making. The GLFC and other non-Indigenous actors in sea lamprey stewardship (e.g., DFO, FWS) already have good working relationships with many Indigenous Nations. These relationships should be further supported to create spaces where Two-Eyed seeing can be applied, and new relationships with other Indigenous Nations should be invested in. As well, these organizations should facilitate, fund, and encourage research with Indigenous Peoples to understand their knowledges and experiences with sea lamprey and sea lamprey stewardship. These relationships could act as a foundation for ongoing research and feedback that uses a Two-Eyed Seeing approach. However, before Two-Eyed Seeing and its potential in sea lamprey stewardship can be further discussed, we provide background on Indigenous Peoples' agency in the specific context of invasive species stewardship and examine some of the differences between Indigenous and Western scientific understandings of invasive species and environmental stewardship. These differences in understanding highlight the need for a knowledge coexistence approach in order to achieve a shared goal.

#### *Indigenous leadership in invasive species stewardship*

Many Indigenous Nations across North America are actively working in the area of invasive species stewardship by bridging Western science and Indigenous knowledge systems. However, this work is not well represented in academic literature (Reo et al., 2017). Discourse around the human dimensions of invasive species largely neglects Indigenous Peoples or focuses on vulnerability and sociocultural impacts without mention of Indigenous agency in the invasive species field (Reo et al., 2017).

Reo et al. (2017) conducted a survey of Indigenous Nations' staff in Canada and the U.S. (n = 106) and found ample examples of Indigenous Nations developing invasive species policies within their Nations and forming partnerships with non-Indigenous organizations and governments to co-determine invasive species policies (81 % of respondents). This research reveals that many Indigenous Nations are leveraging Indigenous knowledge systems and resource management tools in addition to Western science to actively prepare and respond to invasive and introduced species while protecting culturally significant plants and animals. Indigenous Nations are leading invasive species mitigation and adaptation programs within their territories and bridging knowledge systems through these projects. However, Reo et al., (2017) do not specify how the Nations approach and bridge different knowledge systems. This raises the question as to how differing knowledge systems can coexist in invasive species stewardship.

A knowledge coexistence approach to invasive and introduced species stewardship needs to consider the varying epistemologies and concepts of invasive species between Indigenous and Western sciences. From a Western science understanding, introduced species have slightly different connotations than invasive species as both are non-native but introduced species integrate into the environment while invasive species spread rapidly and/or are considered 'pests' (Ricciardi, 2015). In Anishinaabe teachings, plants and animals are seen as persons that are assembled into Nations (Kimmerer, 2013; Reo and Ogden, 2018). Invasive species are seen as migrations of non-human Nations, the arrival of new plants and animals are natural processes (Reo and Ogden, 2018). Therefore, the term 'invasive' may not be appropriate to describe these beings

as it also has nationalistic and militaristic implications (Bach and Larson, 2017).

Reo and Ogden (2018) found, through interviews with Anishinaabe tradition-bearers (n = 22) from Michigan, that many, "*feel strongly that nature finds its own balance, and people should not intervene using chemicals or other drastic management techniques*" (p. 1448). There was more concern over the 'invasive land ethic' (as a product of settler colonialism) than the risks associated with invasive species. The invasive land ethic imposes colonial property ownership regimes, command and control environmental stewardship, and an ideology that separates people from nature (Reo and Ogden, 2018). Therefore, some Indigenous Nations and Peoples may have less of a concern about invasive species and more of a concern about how governments and others interact or steward an ecosystem. Differing understandings of what the 'problem' truly is will impact collaboration in invasive species projects between Indigenous and non-Indigenous parties. This highlights the need for open dialogue where all parties can come together to understand each other's perspectives such as in Two-Eyed Seeing.

Another example of differing understandings between Western scientific and Indigenous knowledge systems is encompassed by a report from the 2018 *Chiefs of Lake Huron Fisheries Forum*. It explains that it is human actions that need to be governed, "*Fish do not need governing – fish (and all non-human beings) have their own governance systems – and have always governed themselves without human interference*" (Lauzon and Ryan, 2019, p. 7). This is a different paradigm of interacting with the Great Lakes ecology; it is a shift from being managers of the Great Lakes fisheries to being in relationship with the Great Lakes ecology. It puts more emphasis on managing human behaviours in relation to the fisheries or invasive species rather than the non-human beings themselves (or ecologies). This seeks to address the root causes of issues that the Great Lakes are facing rather than the symptoms. In fact, invasive species may have something to offer the ecosystem, and there may be an opportunity to build a positive relationship with these species (Lauzon and Ryan, 2019). There are varying perspectives on the correct course of action to take regarding human-introduced invasive species. Indeed, invasive species can be a threat to Indigenous Peoples' relationships with their lands and waters, ceremony, commerce, and the harvesting of foods (food sovereignty). Actions to limit the spread of invasive species can therefore be warranted in certain contexts, but they must be holistic and consider how to work with and see what these beings offer to the ecosystem (Lauzon and Ryan, 2019).

Within sea lamprey stewardship, the differences between knowledge systems translates into how the impact of sea lamprey on native fish populations in the Great Lakes is understood. Brant (2019) argues that if there were no sea lamprey control methods, then the Great Lakes fisheries would once again collapse. Brant focused largely on the impacts of sea lamprey on commercial fisheries, recreational fisheries, and commonly stocked recreationally valued fish species such as non-native coho (*Oncorhynchus kisutch*) or Chinook salmon (*Oncorhynchus tshawytscha*). Stocked fish, whether native to the ecosystem or not, are not valued or understood in the same ways in every knowledge system (Rypel et al., 2021).

For example, some Indigenous communities oppose non-native fish stocking due to the impacts observed on native-fish-based Indigenous fisheries (amongst other reasons: culture, relationships with waters, food sovereignty, ceremony, economy, etc.) (Akiwenzie and Roote, 2004; Gobin et al., this issue). While sea lamprey have also impacted native fish species, including those essential to Indigenous fisheries (e.g., lake whitefish), some Indigenous communities have called for focusing on the health and resilience of the ecosystem as a whole instead of at the species level



(Lauzon, and Ryan, 2019). There is, however, limited information available regarding how Indigenous knowledge systems across the Great Lakes understand and interpret the impacts of sea lamprey or perceive the impacts of sea lamprey control methods (past and current) and potential alternatives (Gaden et al. 2021a). However, Two-Eyed Seeing provides a framework to understand the range of perspectives on invasive species, the impacts of stewardship practices (e.g., stocking, sea lamprey control methods), and co-develop better solutions for the future.

### *Two-Eyed Seeing in fisheries stewardship*

As mentioned earlier, Two-Eyed Seeing is a knowledge system that enables the pairing of Indigenous and Western scientific knowledges for mutual understanding and equitable partnerships that generate actions to resolve problems, including prolonged fisheries stewardship issues (Reid et al., 2021). Two-Eyed Seeing is a potentially transformative approach to fisheries issues that ensures Western scientific approaches do not assimilate Indigenous knowledge systems but pair with them to build a sustainable future (Reid et al., 2021). When built through collaborative partnerships for long-term engagement, Two-Eyed Seeing can help to create solutions that address the needs of Indigenous and non-Indigenous Peoples. It is a framework that utilizes what Ermine (2007) calls an “ethical third space” where knowledges can be shared, coexist, and move beyond knowledge dichotomies (Martin, 2012). Ermine (2007) explains ethical space as a neutral zone between the worldviews of distinct societies when they come together for engagement, where one society is not better or more correct than the other.

Martin (2012, p. 32) describes Two-Eyed Seeing as a way to create a more complete picture of the world where Indigenous knowledges hold merit and are not ‘greater or lesser’ than Western scientific understandings, but simply different. When different epistemologies, axiologies, and methodologies examine a shared question, a more dynamic understanding can emerge with more nuanced decision making. This is especially vital in light of environmental injustice because Two-Eyed Seeing is positioned to identify and help redress power imbalances that exist between colonizers and the colonized. For example, colonialism sought to sever Indigenous Peoples’ connections with their lands and languages. Relationships applying Two-Eyed Seeing can take actions to protect and work within Indigenous Nations’ lands and languages as a means to rectify these injustices and keep Indigenous knowledges within their contexts.

This emphasizes ‘why’ Two-Eyed Seeing should be used and how it is different from stewardship methods solely based in Western science. By creating ethical space for mutual understanding, partnerships can be formed from a context that pays specific attention to the histories and realities of environmental injustice (and other injustices), rather than by just setting them aside or pretending they do not exist. This attention to the history and current reality of environmental injustice concerning Indigenous communities is vital in the formation of meaningful partnerships that Two-Eyed Seeing is based on. These injustices create barriers for Indigenous partnership as continued effects of colonialism are felt within communities and by knowledge holders (e.g., loss of language/culture, intergenerational trauma, forced removal from Traditional Territories). Learning about and addressing the injustices Indigenous communities currently face is a part of the Two-Eyed Seeing process and works towards addressing power imbalances which prevent Two-Eyed Seeing from being applied.

Within fisheries stewardship, there is recognition of the shortcomings of the current dominant system and calls for a more ecosystem-based approach (Link, 2010) that builds an ethic of knowledge coexistence (Reid et al., 2021). A re-envisioned

approach to research and stewardship needs to treat Indigenous voices and knowledges equitably in discussions, decisions, and solutions that affect Indigenous Peoples (Martin, 2012).

Two-Eyed Seeing does not come without challenges. It is difficult reconciling differences in perspectives of Western science (based on reductionism and objectivism) and Indigenous knowledges (derived from highly divergent socio-cultural contexts; more reflexive and agency-driven) which can lead to uncertainty (lack of confidence in results/estimates) (Mantyka-Pringle et al., 2017). This uncertainty is itself an opportunity to practice Two-Eyed Seeing, as its goal is not reconciling knowledges, but holding both perspectives in tandem consideration (Bartlett et al., 2012). Disconnections between results in Western science and Indigenous knowledge can be opportunities for further dialogue to gain a greater understanding of why there is a difference, what that reveals about a system, and the best way to navigate such differences when making decisions (Reid et al., 2021).

Social science has revealed that although Indigenous knowledge can be valued by environmental managers, it is rarely brought into decision-making (Kadykalo et al., 2021). Two-Eyed Seeing is a practical framework to overcome that disconnect. Other challenges include the coloniality/Eurocentricity of Western science, Western science experts’ misconceptions about Indigenous Peoples and knowledges, communication across different languages/worldviews, and practical applications of Two-Eyed Seeing outside of knowledge dialogue in research is argued to remain vague (Broadhead and Howard, 2021; Wright et al., 2019). As well, Reid et al. (2021) raised questions of whether equitable inclusion of Indigenous knowledge systems into policy decision-making is prevented by colonial sentiments (explicit or implicit) held by governments and officials, asking whether they are only valued when they are supported by or congruent with Western science (Nadasdy, 1999). There are also concerns about Two-Eyed Seeing’s impact if the mutual understanding generated does not impact policy decision-making which ultimately translates in how the fishery is stewarded. Two-Eyed Seeing is more than just listening - it requires action so that decision-making is a part of the process (Reid et al., 2021). Needless to say, commitment to Two-Eyed Seeing is a long-term (ongoing) process if done in a respectful and meaningful way.

There are also other Indigenous coexistence frameworks similar to Two-Eyed Seeing that could be implemented and use ethical space (Reid et al., 2021). The Kaswentha (Two-Row Wampum) offers another model for parallel processes where Indigenous and non-Indigenous “*undertakings exist separately, yet side-by-side and in partnership with each other*” (McGregor, 2002, p. 9). There are also other coexistence frameworks such as the Māori concept of Waka-Taurua (Double-Canoe) in Aotearoa/New Zealand and the Yolngu concept of Ganma (Two Ways) in the Northern Territory of Australia (Reid et al., 2021). These knowledge coexistence frameworks are not exclusive to Western science and Indigenous knowledge systems; rather they (and others) can promote knowledge coexistence across contexts with distinct ways of knowing such as two separate Indigenous knowledge systems. Two-Eyed Seeing is being suggested as the knowledge coexistence approach to be applied to sea lamprey stewardship because of its increasing traction in theoretical and practical domains of fisheries stewardship. As well, Two-Eyed Seeing explicitly calls for actions to come out of the bridging of knowledge systems (Reid et al., 2021). The other frameworks have principles of action-taking, but Two-Eyed Seeing is a means to build relationships and bridge knowledge systems in order to compel shared decision-making and action (Reid et al., 2021).

Each of these frameworks provides lessons on how to work across knowledge systems. For example, Buell et al. (2020) conducted a case study with SON on risk assessments for contami-



nated sediments in the Owen Sound Harbour (in the SON Traditional Territory) which used a knowledge coexistence approach. A risk assessment was originally completed by a private consulting group using a solely Western scientific approach without attention to how impacts would affect SON's fishery or rights. This raised concerns amongst the SON, so a new risk assessment was performed which deconstructed current processes for risk assessments and rebuilt them through partnership using both Western science and Indigenous knowledge systems and tools. The conventional Western scientific approach to risk assessments is embedded with the reliance on scientists to apply their 'best professional judgment' to design, conduct, and interpret the study and potential impacts (Buell et al., 2020). This is influenced by a Western science value base which will differ from an Indigenous knowledge value base for the design and implementation of the risk assessment. For example, Western science would use quantitative observations to identify potential stressors while Indigenous knowledge would use on-the-land experience and oral history which encompass extended temporal observations and experiences (e.g., 50 years of an individual's experience to generational time periods (hundreds of years) of a family or Nation's experience).

The case study showed how creating frameworks for knowledge coexistence requires equal partnership and extensive deconstruction of the 'norm' of colonial approaches for environmental research and policy development. This resulted in the SON communities' relationships, rights, and responsibilities to the water and fishery to be included in the risk assessment (which altered the outcome and actions taken as a result of the assessment) as well as using a Western scientific approach to determine impacts. Similar lessons could be applied to sea lamprey stewardship. This process must be collaborative, establish mutual learning, and be a long-term process of relationship-building. When knowledge is co-generated, it can facilitate a decision-making process that meets the needs of the Indigenous and non-Indigenous Peoples alike (Buell et al., 2020).

#### *Applying Two-Eyed Seeing to sea lamprey stewardship*

One such instance where knowledge coexistence could provide insight into the application of Two-Eyed Seeing to sea lamprey stewardship is the Denny's Dam rehabilitation project near the eastern shores of Lake Huron within SON Territory. Denny's Dam (Fig. 1) is a sea lamprey barrier that was in a state of disrepair for many years and needed to be reconstructed to ensure it would continue to block sea lamprey. Originally, a plan was developed to rehabilitate the dam in the late 2000 s, but the SON were not consulted, nor their rights properly considered on the project. This led to the rehabilitation being put on hold indefinitely until proper consultation took place and SON's knowledge, experience, and concerns were taken into account.

In 2015, a partnership between the SON and GLFC was formed and from this relationship a knowledge coexistence approach was used to inform and make recommendations for the rehabilitation project (Ryan, 2017). This knowledge coexistence approach involved shared decision-making power between the SON and GLFC. As well, both Western scientific studies (e.g., fish community assessment) and Indigenous knowledge studies (e.g., land use and occupancy study) were conducted, not to verify another, but to hold both in parallel and use them to make decisions together. This ensured the inclusion of SON derived knowledge, prioritizing and minimizing impacts to the local environment as well as community use and access to the area. This partnership and knowledge coexistence approach was only possible through years of diligent work by several individuals who faced many challenges along the way. Yet, it shows the GLFC's and other organizations' ability and desire to meaningfully engage and incorporate a knowledge coexistence approach with First Nations communities to implement sea lamprey stewardship.

A Two-Eyed Seeing approach to specific projects in sea lamprey stewardship could emulate the Denny's Dam experience by first forming a meaningful partnership between Indigenous and non-Indigenous parties. From this relationship, trust and respect can be built and shared decision-making power established. Studies



**Fig. 1.** The rehabilitated sea lamprey barrier named Denny's Dam on the Saugeen River in Saugeen Ojibway Nation Territory, photo taken in 2021.

**Table 1**  
Recommendations to Support Applying Two-Eyed Seeing to Sea Lamprey Stewardship.

Target Group(s)	Recommendation
GLFC, Sea Lamprey Research Board	Establish formal policies that fairly assess research funding proposals that are written by Indigenous Peoples, contain Indigenous knowledges and methodologies, or propose engagement with Indigenous Communities <u>because Western scientific metrics and methodologies may not be appropriate and lead to the exclusion of important research.</u>
GLFC, Sea Lamprey Research Board	Create funding calls targeting Indigenous knowledge research and Indigenous research methodologies, <u>to consider and treat them of equal value to research generated from Western scientific framings.</u>
GLFC, Sea Lamprey Control Board, Sea Lamprey Research Board	Create space for more Indigenous representation – particularly First Nation – on groups that inform and advice sea lamprey stewardship strategies, <u>to ensure a range of Indigenous knowledges, experiences, and perspectives are being considered and addressed.</u>
GLFC, provincial/state/federal government agencies	Ensure all staff have appropriate training on respectful Indigenous engagement, <u>to minimize risk of potential harms to Indigenous Peoples through engagement processes.</u>
GLFC, provincial/state/federal government agencies	Adopt UNDRIP into policy and practical activities, applying the Declaration’s Articles to all stewardship decisions, <u>to ensure the protection of Indigenous Peoples’ rights and knowledge systems.</u>
Provincial/state/federal government agencies	Officially recognize the jurisdictional fisheries authority of interested Indigenous Nations in the Great Lakes <u>as this is enshrined in UNDRIP, and this is a requirement for Indigenous Nations to be signatories of the 1997 A Joint Strategic Plan for Management of Great Lakes Fisheries and thus hold official seats on Lake Committees and other GLFC decision-making bodies.</u>
GLFC	Explore actions to create space for Indigenous Nations, specifically First Nations, in sea lamprey stewardship and research decision-making committees, boards, and other groups. When possible, create opportunities for interested Indigenous Nations to be official signatories of the 1997 A Joint Strategic Plan for Management of Great Lakes Fisheries and appoint official members to Lake and Technical Committees, <u>to co-create Fish-Community Objectives and fisheries/sea lamprey stewardship decisions in the Great Lakes.</u>
All parties	Implement Two-Eyed Seeing as a framework for knowledge coexistence when working on sea lamprey stewardship projects, <u>to bridge knowledge systems and guide partnerships with equal decision-making power.</u>

could be conducted from both Western scientific and Indigenous knowledge perspectives and used together to develop understanding and inform decisions. Throughout this all, Indigenous rights should be upheld. However, the application of Two-Eyed Seeing may look different for each partnership it is used with. These practices provide direction, but each partnership needs to determine for themselves how best to apply-Two-Eyed Seeing and what the process will look like exactly.

In a similar vein, [Mattes and Kitson \(2021\)](#) suggest that proper consultation is needed with Indigenous Peoples on sea lamprey stewardship, and that these consultation practices need to begin early and include going to communities for meetings, for example, and working with individual Indigenous communities on a government-to-government and nation-to-nation level. This underlines the need for free, prior, and informed consent as enshrined in UNDRIP. Two-Eyed Seeing is consistent with UNDRIP’s Articles and can be a mechanism to meet and exceed these requirements because sea lamprey stewardship needs to go beyond just consultation. Two-Eyed Seeing promotes collaboration at a grassroots level that builds community into the entire process. Therefore, the process becomes a practice of partnership or co-development from the beginning and is not just a consultation or check-box process. Implementing a Two-Eyed Seeing approach can fulfill (and go beyond) the basic duty to consult obligations and creates a co-developed system built through meaningful dialogue, mutual understanding, mutual benefit, and shared decision-making. The application of Two-Eyed Seeing can build upon the GLFC’s and other fisheries agencies’ already established best practices for partnering with Indigenous communities, and act as a way to improve the process to make it more ethical and equitable.

The GLFC has set a goal to engage more closely with publics and Indigenous Peoples around the Great Lakes in sea lamprey stewardship ([Gaden et al., 2021a](#)). There are many examples of the GLFC partnering with Indigenous Peoples in the assessment, indexing, monitoring, and implementation of control methods, with varying levels of collaboration. However, there are also examples of skepticism to sea lamprey control methods from Indigenous communi-

ties ([Dobiesz and Bence, 2018](#); [Gaden et al., 2021a](#)). This presents an opportunity for the GLFC and state, provincial, and federal departments to begin and reinforce relationships with Indigenous communities grounded in the Two-Eyed Seeing framework. As these organizations work towards equitably engaging Indigenous communities, these aspirations for partnerships need to value Indigenous knowledge systems, allow co-decision making, and recognize/rectify the impacts of colonial management systems on the Great Lakes while upholding Indigenous rights. Partnerships that are not approached in a respectful way will continue to uphold power disparities and enact knowledge extraction rather than exchange reciprocity ([Blair, 2015](#)).

Two-Eyed Seeing can build on the GLFC’s experience working with Indigenous Peoples to create more sustainable and equitable relationship-building practices. This may serve to help lessen issues associated with shifting baseline syndrome, social license, and waning public support. Two-Eyed Seeing is an opportunity to guide partnerships and create a coordinated, holistic, and whole-ecosystem approach to sea lamprey and other invasive species stewardship while adhering to the rights and values of Indigenous Peoples. [Table 1](#) shows a list of specific opportunities that could be embraced by the GLFC and other fisheries agencies to improve sea lamprey stewardship.

**Conclusion**

We have argued that Two-Eyed Seeing is essential for the future success of sea lamprey stewardship in the Laurentian Great Lakes. While there has been much improvement to include Indigenous Peoples, there are still many Indigenous Nations that are not a part of fisheries or sea lamprey stewardship decision-making, even though the UNDRIP requires it. Presently, sea lamprey control methods are faced with challenges that threaten their social acceptance and therefore jeopardize native fish populations in the Great Lakes. As well, Indigenous opposition to control methods (as influenced by environmental injustices) underlines the need for the GLFC and other agencies to re-imagine sea lamprey stewardship.

Knowledge coexistence and equitable partnerships that share decision-making power lie at the center of these issues (similar with many other invasive species stewardship issues). The traditional method of solely using Western science to address these complex issues has not been effective at maintaining public support for the control methods program, leading us to argue that a more holistic approach is needed. These challenges, however, present opportunities for the re-envisioning of sea lamprey stewardship whereby the GLFC, Indigenous Nations, and federal, provincial, and state governments implement a Two-Eyed Seeing framework to guide their policy, practical, and research approaches. The full extent of change needed to adopt a Two-Eyed Seeing framework remains unclear, but efforts in this direction could lead to major social and political transformations or reforms. As well, for Two-Eyed Seeing to become a reality in sea lamprey stewardship, there should be more co-produced (Cooke et al. 2021), co-evolved (Chapman and Schott, 2020), and co-assessed (Sutherland et al. 2017) research on Indigenous knowledges of sea lamprey and control methods. This research needs to happen in an ethical space where colonial systems (e.g., academic institutions, state/provincial departments) and thinking are deconstructed and where knowledge holders are not brought away from their communities and lands in order to participate. We provided a list of recommendations to apply Two-Eyed Seeing and knowledge coexistence to the sea lamprey stewardship program which will require significant training and conscientious action to make meaningful progress towards.

We close by emphasizing that the benefits of Two-Eyed Seeing extend beyond the knowledge sphere. Two-Eyed Seeing is bolstered by the creation of an ethical space (Ermine 2007) where Indigenous Peoples, the GLFC, and other actors in the system can come together and collectively act on sea lamprey projects to the satisfaction of all parties while offering diverse solutions to new and existing issues. It is therefore integral that actions (e.g., shared decision-making) be part of the Two-Eyed Seeing approach, and the framework is not used to just extract knowledge. In this way, new ideas, approaches, and solutions can be developed together. This can serve as an example of relationship building and knowledge coexistence for other invasive species programs while recognizing and enabling Indigenous rights and agency. Creating an environment in which Indigenous and Western knowledge systems can coexist in sea lamprey, fisheries, and invasive species stewardship is paramount for future work in the Great Lakes.

### Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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