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Inclusivity of Indigenous Knowledge Systems in Fisheries Management

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ABSTRACT

Indigenous Peoples have developed knowledge systems that foster respectful and reciprocal relations between humans and other-than-human beings, supporting resilient ecosystems and societies. Despite the impacts of colonisation, Indigenous Knowledge Systems (IKS) endure in many parts of the world, and there is growing recognition that IKS can strongly improve fisheries management. During the last 5 years, Fisheries and Oceans Canada (DFO), the federal institution responsible for managing Canada's fisheries, released policies and strategies intended to make fisheries management more inclusive of IKS. To measure progress in their implementation, we applied 13 semiquantitative indicators and qualitative analyses of IKS inclusivity to a sample of 78 public documents produced or co-produced by DFO to advise management decisions. Of these documents, ≈87% reported cases that did not meaningfully include Indigenous Peoples and their IKS, 9.0% reported cases in which Indigenous Peoples were included in some aspects of research but their IKS was not, ≈3% reported cases in which IKS contributed to objectives and elements of research design but the process privileged Western science over IKS, and only one document met a high standard for the pairing of IKS and Western science. The indicators that we developed in a Canadian context can be used, with locally appropriate revisions, to gauge the extent to which state governments in other countries are inclusive of IKS in fisheries management, thereby identifying shortcomings in law, policy, and practice and informing mitigation measures. Strengthening the inclusivity of IKS would enable more holistic approaches to fisheries management and benefit global conservation.

1 | Introduction

1.1 | Positionality Statement

We are a team of three Indigenous Peoples and one immigrant into Canada. KM, JS, and KP were raised amidst the living knowledges of their communities in their respective traditional territories of Ugpi'ganjig, NunatuKavut, and Neqotkuk. AF descends from diaspora Jews, grew up in Mexico, has lived in Western Canada since early adulthood, and has been working collaboratively with coastal First Nations since 2013. Our combined academic and professional backgrounds span the natural and social sciences, with applications to fisheries or wildlife management. The work we present here brought us together because of our shared belief that a plurality of knowledges can lead to a more socially just and ecologically resilient world.

1.2 | Background and Objectives

Indigenous Knowledge Systems (IKS) are ways of living in the world that intertwine governance, ceremony, ethics, values, empirical observations, harvesting practices, and other elements that support and enrich—spiritually, socially, and materially—the peoples who give rise to such knowledge. These systems are place-based, inseparable from the people, landscapes, and seascapes to who they belong, which leads to their diversity across cultures while holding some commonalities (McGregor 2021; Whyte 2013). Among them is an understanding that each species exists in relation to their environments, people, and other species, and that the resilience of ecosystems and human societies is inseparable from these relations (Kimmerer 2002; Reed et al. 2024). Critically, IKS exist in a continuum of time, enduring into the present. They embrace modern technologies and concepts while maintaining traditional principles. This adaptability allows for the pairing of IKS and science: a framework central to how many Indigenous Peoples approach fisheries and marine conservation today (Ban et al. 2018; Reid et al. 2021).

The work we present here examines cases where Fisheries and Oceans Canada (DFO), the federal institution responsible for managing Canada's fisheries and ocean resources, generates knowledge used to inform management decisions.[1] Typically, DFO's decisions have been informed by Western science, largely driven by an economic system that commodifies species and ecosystems—and ultimately determined by Ministerial discretion—with little or no recognition, acceptance, or application of IKS (Frid et al. 2023; Hutchings et al. 2020).

In 2019, however, Canada's *Fisheries Act* (2019) was modernised through multiple amendments, including some that better uphold the rights of Indigenous Peoples and that authorise the Fisheries Minister to "consider" Indigenous knowledge in decision-making. Furthermore, during the last several years, the government of Canada has been unveiling a growing number of laws, policies, and strategies intended to make federal institutions more inclusive of IKS. For instance, the 2018 *Principles respecting the Government of Canada's relationship with Indigenous peoples*[2] specify that Canada is committed to achieving reconciliation with Indigenous Peoples through recognition of rights, respect, co-operation, and partnership as the foundation for transformative change. Specific to fisheries, the 2019 *DFO Reconciliation Strategy*[3] calls for DFO to "Involve Indigenous groups in the development and implementation of new policy, program, and operational initiatives in relation to fish and fish habitat conservation and protection" and to "Increase Indigenous involvement in the prioritising, conduct, and communicating of science and survey activities." Additionally, measure #40 of the 2023 *United Nations Declaration on the Rights of Indigenous Peoples Act Action Plan* (Department of Justice 2023) commits DFO to "Develop and employ mechanisms that respect and incorporate Indigenous Knowledge as a distinct knowledge system in the management of fisheries, fish habitat, conservation, marine safety and protection of the marine environment." Further, regional agreements can increase the potential to advance the inclusivity of IKS in fisheries management. Among them is the 2021 Fisheries Resources Reconciliation Agreement (FRRA 2021), which involves eight First Nations from British Columbia and DFO. The FRRA intends to support the following:

> ...ecosystem-based management frameworks that aim to achieve the coexistence of healthy, fully functioning ecosystems and human communities using all available information including Indigenous Knowledge, scientific information, best practices, and Indigenous laws and principles (including respect for the natural world, balance and intergenerational equity, intergenerational knowledge transfer, and reciprocity).

For fisheries management by DFO to live up to its modernised legal and policy landscape, IKS must become inherent to all components of fishery decision-making—including research, management plans, laws, regulations, and policies. Among these components, research is the root of *evidence-based* decision-making and, therefore, can provide critical insights into the worldviews driving fisheries management (Reid et al. 2021). Thus, an important step for operationalising IKS inclusivity is for research intended to advise management decisions to be co-produced by Indigenous Peoples and DFO. Such research would require IKS and Western science to support mutually agreed goals and objectives without privileging one knowledge system over the other (Strand et al. 2024). As our analyses will show, however, research intended to advise Canadian fisheries management has rarely been inclusive of IKS.

At the same time, fisheries science in many countries has been transitioning from a historic focus on single species management to ecosystem approaches to fisheries management, or EAFM (Link et al. 2020; Pikitch et al. 2004). EAFM overlap conceptually with some aspects of IKS, as both frameworks recognise that marine organisms are embedded in relationships with other species (humans included), habitats, and oceanographic conditions, and that shifts in these relationships may affect the resilience of ecosystems and the fisheries that they support. Yet despite their conceptual overlap, the two frameworks differ philosophically (Figure 1). In the words of Indigenous scholar Robin Wall Kimmerer (2002).

> Unlike SEK [scientific ecological knowledge], traditional knowledge [a term akin to IKS] is woven into and is inseparable from the social and spiritual context of the culture. Traditional knowledge can rival Western science as a body of empirical information, but traditional knowledge may also extend its explanatory power beyond the strictly empirical, where science cannot go. TEK [traditional ecological knowledge: another term akin to IKS] is laden with associated values, while the scientific community prides itself on data that are "value free." TEK includes an ethic of reciprocal respect and obligations between humans and the nonhuman world.

In contrast to IKS's ethic of respect and reciprocity—which encourages two-way benefits for people and the nonhuman world, including management practices that enhance the productivity of ecosystems and diversity of species (Salomon et al. 2023)—the purpose of EAFM is to "plan, develop and manage fisheries in a manner that addresses the multiple

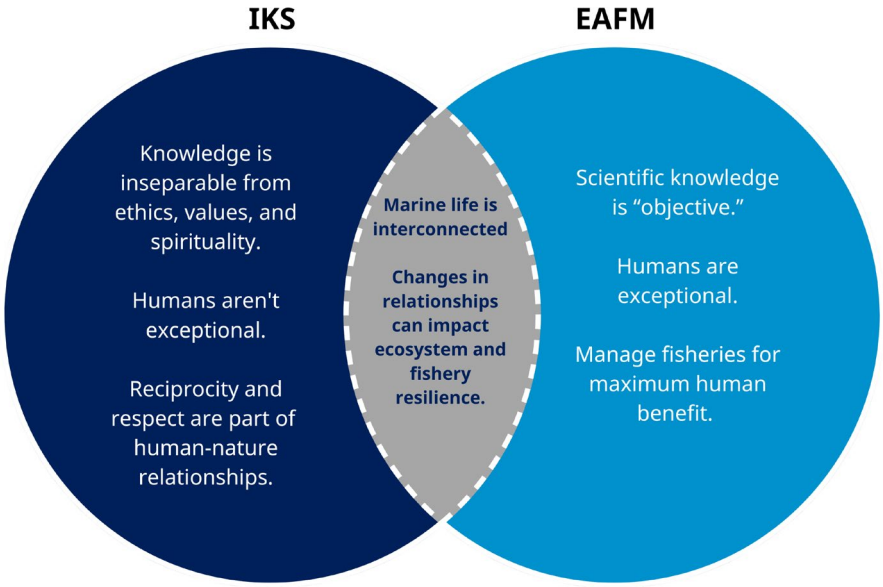

FIGURE 1 | Some key philosophical differences and conceptual overlap between Indigenous Knowledge Systems (IKS) and ecosystem approaches to fisheries management (EAFM) (Ban et al. 2018; Frid et al. 2023; Kimmerer 2002; Muradian and Gómez-Baggethun 2021).

needs and desires of societies, without jeopardising the options for future generations to benefit from the full range of goods and services provided by marine ecosystems (FAO 2003)." In other words, while IKS see humans as an unexceptional species among many others, purely scientific approaches (EAFM included) favour human exceptionalism, focusing on the sustainable exploitation of organisms or other one-way benefits from the ocean to people, which may create blind spots for achieving socio-ecological resilience (Frid et al. 2023; Kimmerer 2002; Muradian and Gómez-Baggethun 2021) (Figure 1). At the same time, science has unique strengths (e.g., statistical methods for making inferences from noisy datasets; satellite imagery and other technologies that extend the observable beyond human senses) that can complement IKS in generating knowledge within a pluralistic framework (Ban et al. 2018).

DFO policies on EAFM date back to 2009 (DFO 2009) and their implementation, though not devoid of challenges, has progressed (Pepin et al. 2023). This progress, combined with policies intended to advance relationships with Indigenous Peoples, alludes to a possible future in which the complementary strengths of IKS and EAFM are paired consistently and equitably to generate new knowledge that improves governance and decision-making for fisheries management in Canada and elsewhere.

To support that possibility, we examined the extent to which Canadian fisheries management—as reflected in public documents produced or co-produced by DFO to communicate research that advises management decisions (for brevity, "advice documents")—has been inclusive of IKS. Our analysis focused on advice documents that pertain to species that are vital to social determinants of Indigenous health (Snook et al. 2022) and that were published in the last 5 years: a period during which progress towards IKS inclusivity is arguably expected. Based on our results, we conclude with recommendations on how to improve the inclusivity of IKS in knowledge co-production and decision-making processes, strengthening the role of Indigenous Peoples in collaborative fisheries management. Lessons from our case study are broadly applicable to many other countries where Indigenous Peoples continue to fish and be guided by their knowledge systems, potentially enabling more holistic and socially just management approaches with better conservation outcomes (Berkes 2018; Strand et al. 2024; von der Porten et al. 2019).

2 | Methods

2.1 | IKS: Implications for Terminology

As substantiated in the writings of Indigenous scholars and in the lived experience of Indigenous members of the author team, IKS are inseparable from the peoples who give rise to such knowledge. In this context, knowledge is not a noun representing something that can be acquired. Rather, knowledge is a verb: something that must be "lived" (McGregor 2021; Reed et al. 2024; Whyte 2013).

The implication is that the concepts expressed by the term "inclusivity *of IKS*" (whether in fisheries advice or other contexts) are inseparable from the concepts expressed by the term "inclusivity *of Indigenous Peoples*," as only Indigenous Peoples have the positionality for contributing elements of their knowledge systems. However, Indigenous Peoples also participate in fisheries advice processes that are driven by state-government priorities and for which their ability to contribute is very limited; Indigenous participation does not equate with IKS inclusivity in these cases.

2.2 | Document Selection

We focused on publicly available Science Advisory Reports (SARs) and rebuilding plans, which are key advice documents used by DFO fisheries managers. SARs are searchable in the

Canadian Science Advisory Secretariat (CSAS) website[4] and apply to a large diversity of species at different management areas, regardless of their status. SAR development under the CSAS process requires a peer review meeting to which Indigenous organisations are routinely invited; in almost all cases to date, these meetings focus on technical review of Western scientific approaches with little or no scope for IKS inclusivity. Rebuilding plans are specific to stocks—which generally correspond to management units (DFO 2023e)—for which abundance has dipped into a "critical zone" where low levels might lead to irreparable harm if appropriate management measures are not taken (DFO 2009, 2023e); they are searchable in DFO's website for Integrated Fisheries Management Plans (IFMPs)[5]. SARs or rebuilding plans were selected if their publication date was between 1 January 2019 and 1 July 2024 and their title included the name of a focal species (or species group, i.e., Pacific salmon) we considered to be vital to social determinants of Indigenous health (Snook et al. 2022) (Table 1). Indigenous members of the author team selected the focal species for the regions where they are culturally rooted: Canada's Arctic and Atlantic coasts. Our choice of focal species for the Pacific coast corresponds to those highlighted by Reid et al. (2022), an Indigenous-led study from that region. We acknowledge that our selection of focal species reflects the positionalities of our author team and that of Reid et al. (2022) and that the list is not all inclusive. [Correction added on 11 June 2025, after first online publication: The text "IFPMs" is replaced as "IFMPs" in this version.]

If more than one document was available for a combination of species and management area, only the most recent one, whether an SAR or rebuilding plan, was analysed (Appendix S1). Cases in which a focal species lacked a document that met publication date criteria were tabulated (Table 1).

The exception to our document selection criteria was the recovery plan for Pacific Herring in Haida Gwaii (CHN et al. 2022), which was co-produced by the Haida Nation, DFO, and Parks Canada. As stated in the most recent Pacific Herring IFMP[6], "The rebuilding plan was *approved and finalised in April 2024* [emphasis ours]." The document, however, was not yet published at DFO's website at the time of writing, and we obtained the publicly available draft from the Council of the Haida Nation's (CHN) website. Differences between the public version at the CHN website (CHN et al. 2022) and that approved by the Minister of Fisheries are "very minor" (Russ Jones, CHN and an author of the rebuilding plan, email to AF on 4 July 2024)[7]. Appendix S2 provide additional justifications for this exception.

2.3 | Process for Developing Indicators of IKS Inclusivity

We used an iterative process of online discussions and written revisions, involving all authors and spanning several weeks, to develop a suite of indicators for IKS inclusivity. These discussions began by (1) examining knowledge co-production frameworks that can potentially lead to the meaningful pairing of IKS and Western science to generate management advice (Almack et al. 2023; Cooke et al. 2021; Reid et al. 2021), and (2) discussing Frid et al.'s (2023) argument that, to be compatible with IKS, fisheries management must aim to restore and/or maintain species abundances to levels above those required to enable harvests at maximum sustainable yield, and include objectives for restoring larger size and older age structures.

Following initial discussions, Indigenous members of the author team brought forth the IKS elements they thought should be represented in the Indicator suite: governance, languages, observations from individual knowledge keepers, principles of respect and reciprocity, sacred locations, intergenerational knowledge transfer, traditional stewardship practices (small-scale spatial management included), ability to harvest traditional foods near the community, and the responsibility to take only what is needed while not impacting other species in the ecosystem.

Additionally, Indigenous members of the author team developed indicators on the extent to which state-governments (1) support management measures that prioritise Indigenous access to fish over other sectors (as a matter of equity and consistency with Canadian case law), (2) financially support the revitalisation of IKS (as partial retribution for past wrongs), and (3) support knowledge co-production processes that create opportunities for knowledge transfer from Indigenous Peoples to state government personnel, and vice versa (as opportunities for learning and moving forward from past wrongs).

For the final stage of indicator development, consensus on the concepts emerging from our discussions was captured in the writing and ordinal scoring criteria that comprise the indicator suite (next section). As noted in the introduction, IKS intertwine governance, ceremony, ethics, values, empirical observations, harvesting practices, and other elements. Our indicator suite captures most of these elements, except "ceremony" and the countless other aspects of IKS encompassed by "other elements." The point being that we recognise that our indicator suite is not the only possible one. We do, however, offer it as a living methodology that can be modified by other Indigenous Peoples wishing to include other aspects of their own IKS.

2.4 | The Indicator Suite

Table 2 details the suite of indicators, their scoring criteria, and whether they apply to all or a subset of taxa. A general description of each indicator is as follows:

Indicator 1 provides a general assessment of the extent to which the process of producing knowledge that advises fisheries management was inclusive of IKS. To score this indicator, documents were initially searched for the following terms (not case specific): (1) *Aboriginal*, (2) *community*, (3) *First Nation*, (4) *food, social, and ceremonial*, (5) *FSC* (the acronym for the previous term), (6) *hunt*, (7) *hunter*, (8) *Indigenous*, (9) *Inuit*, (9) *Nation*, (10) *Tribal*, and (11) *Tribe*. Additionally, for SARs the names of Indigenous groups listed in the participant list for the peer review meeting were searched. Sections containing any of these search terms were read in detail. Scores with values of ≤ 1 signalled that the document did not pass a minimum threshold of IKS inclusivity. In these cases, Indicators 2–13—which gauge the *depth* of IKS inclusivity—were not scored (scores would have equalled zero, by contingency).

TABLE 1 | Focal species included in the study (ordered alphabetically by common name).

Common name[a]	Scientific name	Distribution	Document selection criteria met?
American eel	*Anguilla rostrata*	Atlantic	Yes
American lobster	*Homarus americanus*	Atlantic	Yes
Arctic char	*Salvelinus alpinus*	Arctic, Atlantic, and Pacific	Yes
Arctic cod	*Boreogadus saida*	Arctic and Atlantic	Yes
Atlantic cod	*Gadus morhua*	Arctic and Atlantic	Yes
Atlantic Herring	*Clupea harengus*	Atlantic	Yes
Atlantic mackerel	*Scomber scombrus*	Atlantic	Yes
Atlantic Salmon	*Salmo salar*	Arctic and Atlantic	Yes
Beluga	*Delphinapterus leucas*	Arctic	Yes
Bowhead	*Balaena mysticetus*	Arctic	Yes
Brook trout	*Salvelinus fontinalis*	Atlantic	No. SAR or RP lacking for any year
Capelin	*Mallotus villosus*	Arctic and Atlantic	Yes
Chinook salmon	*Oncorhynchus tshawytscha*	Pacific	Yes
Chum salmon	*Oncorhynchus keta*	Pacific	No. SAR or RP lacking for any year
Coho salmon	*Oncorhynchus kisutch*	Pacific	Yes
Dolly varden	*Salvelinus malma*	Arctic and Pacific	No. Most recent SAR published in 2016
Dungeness crab	*Cancer magister*	Pacific	Yes
Eulachon	*Thaleichthys pacificus*	Pacific	No. Most recent SAR published in 2015
Geoduck	*Panopea generosa*	Pacific	No. Most recent SAR published in 2017
Giant sea cucumber	*Apostichopus californicus*	Pacific	Yes
Greenland halibut	*Reinhardtius hippoglossoides*	Arctic, Atlantic, and Pacific	Yes
Harp seal	*Pagophilus groenlandicus*	Arctic and Atlantic	Yes
Hooded seal	*Cystophora cristata*	Arctic	No. SAR or RP lacking for any year
Narwhal	*Monodon monoceros*	Arctic	Yes.
Northern abalone	*Haliotis kamtschatkana*	Pacific	No. Most recent SAR published in 2016
Northern shrimp	*Pandalus borealis*	Atlantic and Pacific	Yes
Pacific herring	*Clupea pallasii*	Pacific	Yes
Pacific salmon	*Oncorhynchus* spp.	Pacific	Yes
Pink salmon	*Oncorhynchus gorbuscha*	Pacific	No. Most recent SAR published in 2012
River herring	*Alosa aestivalis* and *A. pseudoharengus*	Atlantic	Yes
Quillback rockfish	*Sebastes maliger*	Pacific	Yes
Ringed seal	*Pusa hispida*	Arctic	No. Most recent SAR published in 2011
Snow Crab	*Chionoecetes opilio*	Atlantic	Yes
Sockeye Salmon	*Oncorhynchus nerka*	Pacific	Yes
Spot prawn	*Pandalus platyceros*	Pacific	No. Most recent SAR published in 2011
Striped Bass	*Morone saxatilis*	Atlantic	Yes
Walrus	*Odobenus rosmarus*	Arctic	Yes
Yelloweye rockfish	*Sebastes ruberrimus*	Pacific	Yes

Note: The last column indicates whether advice documents met selection criteria for publication in the last 5 years; if not, the year of the most recent advice document is provided.

Abbreviations: RP, rebuilding plan; SAR, Science Advisory Report.

[a]SAR titles refer to river herring as "Alewife and Blueback Herring" and (in some cases) to Atlantic herring as "herring"; document searches for these species used the term "herring." Similarly, searches for American lobster used the term "lobster."

TABLE 2 | Descriptions and scoring criteria for semiquantitative indicators.

Indicator			Score			
ID	Applicable taxa	Description	0	1	2	3
1	All	Indigenous Peoples and state government personnel co-produced research used to advise fisheries management, such that both IKS and Western science supported mutually agreed goals and objectives. (If score ≤1 then the remaining indicators are not scored.)	(1) The advice document is *based only on Western scientific methods* and data; *and* (2) Indigenous contributions, *if any*, are limited to participation in peer review or advisory roles for state *government-driven* research and management; *and* (3) the document mentions *IKS* or related concepts (e.g., traditional knowledge) *superficially* (outside the context of a knowledge co-production process pairing IKS and Western Science) *or not at all*	*Indigenous Peoples were included* in some aspects of research but *their IKS was not*. i.e., Indigenous participation was *limited* to fieldwork or contributing data or observations to state *government-driven* scientific research conducted outside knowledge co-production processes for pairing IKS and Western science	Indigenous Peoples *contributed some elements* of IKS to a state *government-driven process* that privileged Western science over IKS in the development of goals, objectives, management measures, assumptions, interpretation and communication of results, and other research elements	*The pairing of IKS and Western science had a high standard*. IKS played a significant role in knowledge co-production, including the development of goals, objectives, management measures, assumptions, interpretation and communication of results, and other research elements
2	All	The people and governance structures of the Indigenous community were properly engaged in developing management goals and objectives	*No* indication of *engagement* of the community and their governance structures	The process of knowledge co-production *acknowledged and met obligations of historic and or modern-day treaties or agreements* with the state governments	Additionally, the process of knowledge co-production recognised Indigenous governance and *followed the decision-making structures of the Indigenous community* when developing management goals and objectives	Additionally, *individual knowledge keepers* within the community were *engaged* via processes led from within the community

(Continues)

TABLE 2 | (Continued)

Indicator			Score			
ID	Applicable taxa	Description	0	1	2	3
3	All	The words of Indigenous collaborators were heard, respected, and highlighted	Words from Indigenous collaborators were *not included* in the document	*Either* (1) Indigenous *languages* were used to name key elements of the research and of management goals and objectives (e.g., species, places, ecological or oceanographic features, harvesting practices or protocols), or (2) *quotes* from community members (e.g., Elders, Matriarchs, Hereditary Chiefs, technical staff, youth, knowledge keepers, food harvesters or processors) were used to convey relationships between people and the species	*Both* (1) Indigenous *languages* were used to name key elements of the research and of management goals and objectives (e.g., species, places, ecological or oceanographic features, harvesting practices, protocols), and (2) *quotes* from community members were used to convey relationships between people and the species	
4	All	IKS principles, such as respect for and/or reciprocity towards other species, guided the framework used to generate management advice	*No mention* of IKS principles	*IKS principles guided* the framework used to generate management advice		
5	All	Sacred locations were recognised, and management measures were consistent with Indigenous protocols for those areas	*No mention* of specific locations considered to be sacred	*Locations* considered to be sacred were *specified* (in accordance with confidentiality rules of the Indigenous community)	Additionally, Indigenous *protocols* for allowable uses at those locations were specified	

(Continues)

TABLE 2 | (Continued)

Indicator			Score			
ID	**Applicable taxa**	**Description**	**0**	**1**	**2**	**3**
6	All	The process of knowledge co-production created opportunities for in-person intergenerational knowledge transfer and other forms of knowledge sharing within the Indigenous community	*No mention* of in-person knowledge sharing within the community during the research process	*Community members interviewed knowledge keepers* as part of the research process	Additionally, *in-person knowledge sharing extended to exchanges between knowledge keepers and others in the community* (e.g., youth) while practicing or discussing knowledge about the species	
7	All	The process of knowledge co-production created opportunities for state government-supported capacity sharing with Indigenous Peoples	*No mention* of state government-supported capacity sharing	The research process included state *government-supported capacity sharing* that increased the knowledge repertoire of *Indigenous Peoples* (e.g., the state government supported, financially and in other ways, training, education, and employment opportunities linked to the project)	Additionally, the research processes facilitated *Indigenous-led capacity* sharing that increased the knowledge repertoire of *state government collaborators* (e.g., the state government supported, financially and in other ways, opportunities for government personnel to better understand IKS via in-person engagement with the community and their territory)	
8	All	IKS determined the spatial scales of management examined. (This is not exclusive with additional analyses at larger spatial scales determined by state government personnel.)	*No indication* that IKS determined spatial scales of management	Analyses include *smaller spatial scales* of management determined by IKS	Additionally, an integrative research approach that pairs IKS and science informed *management measures consistent* with the smaller spatial scales determined by *IKS*	

(Continues)

TABLE 2 | (Continued)

Indicator			Score			
ID	Applicable taxa	Description	0	1	2	3
9	All	IKS determined the species abundances that are vital to local Indigenous Peoples, set the goals and objectives for rebuilding and/or maintaining those abundances, and contributed to analyses of potential management measures	*No indication* that IKS determined the goals and objectives for rebuilding and/or maintaining species abundances	*IKS determined* the *goals and objectives* for rebuilding and/or maintaining species abundances	Additionally, an *integrative research approach* that pairs IKS and science *examined change over time, status, and management measures* to rebuild or maintain the desired abundances	
10	All	The continuity or recovery of cultural practices that require higher local abundances of species, such as the ability to harvest traditional foods and run youth education programs near the community, are specified in management goals and objectives	Goals and objectives were *not* explicitly *linked to cultural practice*s	*Cultural practices* requiring higher local abundances of harvested species were identified and *linked* to management goals and objectives	Additionally, an *integrative research* approach that pairs IKS and science determined the *management measures* likely to achieve those goals and objectives	
11	Fish and invertebrates	IKS contributed knowledge of change over time for size and/or age structures of the population, determined the goals and objectives for rebuilding and/or maintaining these structures, and contributed to analyses of potential management measures to achieve those goals and objectives	*IKS did not contribute* insights into changes to size and/or age structures	*IKS contributed* knowledge of change over time for size and/or age structures	Additionally, *IKS determined the goals and objectives* for rebuilding and/or maintaining size and/or age structures	Additionally, an *integrative research* approach that pairs IKS and science further *examined* potential *change over time* relative to a historical baseline, current status, and *management measures* to rebuild or maintain the desired size and/or age structures

(Continues)

TABLE 2 | (Continued)

Indicator			Score			
ID	**Applicable taxa**	**Description**	**0**	**1**	**2**	**3**
12	Fish and invertebrates (Only Indigenous peoples can harvest marine mammals.)	The management measures examined prioritise Indigenous access, over other sectors, to species vital to Indigenous well-being	*Priority access* by Indigenous Peoples is *not explicit* to the management measures examined	*Priority access* by Indigenous Peoples is *explicit* to the management measures examined	An *integrative research* approach that pairs IKS and science *estimated local abundance thresholds* to be exceeded before other sectors can access the same species without compromising Indigenous access	The recommended *management measures allow community members to harvest species in the critical zone (at very low abundance) for cultural purposes*, including inter-generational knowledge transfer. (This score does not apply if the species or population is not in critical zone.)
13	Forage fish and salmon	IKS determined the goals and objectives for balancing human harvests with the food requirements of predators that eat the same species as people, and contributed to analyses of potential management measures	The food requirements of other species were *not considered*	IKS determined the goals and objectives for *balancing human harvests with the food requirements of predators* that eat the same species as people	Additionally, an *integrative research* approach that pairs IKS and science examined *management measures* (i.e., fishery allocations that would not compromise the needs of predators) to support these goals and objectives while prioritising Indigenous harvests for food over commercial and recreational fisheries	

Indicator 2 examines whether Indigenous governance and community-led processes were recognised in setting the goals and objectives of the project. The rationale is that there is a history of scientists having an extractive approach towards IKS (e.g., Whyte 2013), and this indicator aims to differentiate extractive from collaborative approaches that follow Indigenous governance protocols.

Indicators 3–6 examine the extent to which IKS is understood and valued by state governments. The rationale is that there is a history of IKS being misunderstood or diminished as "anecdotal" by state government personnel (McGregor 2021; Snook et al. 2022).

Indicator 7 examines the extent to which state governments have supported capacity sharing with Indigenous communities during knowledge co-production processes. The rationale is that Indigenous communities often are under-resourced and better able to engage in knowledge co-production if external support is available (Cooke et al. 2021).

Indicator 8 examines the extent to which IKS determined the spatial scales of management considered by research used to advise managers. The rationale is that state government institutions, DFO included, have historically delineated management units at large spatial scales that are incompatible with IKS, often failing to support higher local abundances that are vital to Indigenous Peoples (e.g., Ban et al. 2017; Okamoto et al. 2020; Reid et al. 2022).

Indicator 9 examines whether IKS (a) determined goals and objectives for rebuilding or maintaining species abundances and (b) informed the management measures required to achieve them. The rationale is that state government goals and objectives for commercially fished species, including those of DFO, primarily apply reference points which focus on the maximum sustainable exploitation of commercial species (Marentette et al. 2021; Martin et al. 2023), rather than on higher abundances vital to Indigenous Peoples and resilient ecosystems (Frid et al. 2023; Gavenus et al. 2023; Lamb et al. 2023).

Indicator 10 builds on the previous one by linking local species abundances to the continuity of cultural practices and relating these to management goals and objectives (Lamb et al. 2023).

Indicator 11 examines whether (a) IKS determined the goals and objectives for rebuilding and/or maintaining larger body sizes and older ages of fish and invertebrates and (b) informed the management measures required to achieve them. The rationale is that Indigenous Peoples often recognise when size and age structures decline for cultural keystone species (e.g., Eckert et al. 2018; Gauvreau et al. 2017). In turn, size and age declines may reduce population productivity (Hixon et al. 2014; Marshall et al. 2021), disrupt social transmission of learned behaviours (Wilson and Giske 2023), and diminish the ecological roles of species (Olson et al. 2020).

Indicator 12 examines the extent to which the management measures prioritised Indigenous access to the population over other sectors, and whether IKS contributed to those measures. In Canada, Indigenous priority access is consistent with Canadian case law. This indicator does not apply to marine mammals that can be legally hunted only by Indigenous Peoples.

Indicator 13 pertains to forage fish and salmon, which are key prey for diverse predators (Pikitch et al. 2012; Walsh et al. 2020). It examines whether IKS determined the goals and objectives for balancing human harvests with the food requirements of predators that eat the same species as people and informed the management measures required to achieve them. The rationale is that the principles of respect and reciprocity towards other species, as upheld by the IKS of some cultures, require that people "take only what they need and leave lots for the ecosystem" (Adams et al. 2021; Reid et al. 2022).

Indicator scores were based only on the information provided in the advice document, except for a SAR for two Pacific herring populations in southern British Columbia (DFO 2019a). That document identified a collaborative process involving DFO, First Nations, and representatives from the commercial fishing industry (i.e., stakeholders), yet was unclear about the extent to which knowledge co-production reflected First Nation's perspectives. Correspondence with fisheries staff for the Nuu-chah-nulth Tribal Council confirmed the role of First Nations in knowledge co-production (Jim Lane, pers. comm. to AF, 9 July 2024).

The justification for each score was tracked (see Data Availability Statement). Indicator scores were normalised as a proportion of their maximum potential value.

2.5 | Qualitative Analyses of IKS-Inclusive Documents

Documents that met a minimum level of inclusion of Indigenous Peoples (i.e., Indicator 1 score = 1) or their IKS—which is inseparable from the people (i.e., Indicator 1 score ≥ 2)—were annotated with qualitative data analyses software MaxQDA, applying codes based on grounded theory (Bryant and Charmaz 2007). Insights from these analyses are presented descriptively.

3 | Results

Seventy-eight advice documents (5 rebuilding plans and 73 SARs) met selection criteria for analyses (see Data Availability Statement). The selection did not include documents for 10 of the 38 focal species (26.3%) for which advice documents were outdated or altogether lacking (Table 1).

3.1 | Semiquantitative Indicators

Of the 78 documents analysed, 68 (87.2%) showed no meaningful inclusion of Indigenous Peoples and their IKS (Indicator 1 score = 0), and seven documents (9.0%) reported cases in which Indigenous Peoples were included in some aspects of research but their IKS was not (Indicator 1 score = 1), (Table 3). Of the latter documents, six pertained to marine mammals, fish, and invertebrates important to Inuit communities and one pertained

TABLE 3 | Summary of Indicator 1 scores for the 78 advice documents analysed.

Document type	Number of documents			
	Score = 0: ***No meaningful inclusion of Indigenous Peoples and their IKS***	**Score = 1:** ***Indigenous Peoples were included in some aspects of research but their IKS was not***	**Score = 2:** ***IKS contributed to the objectives and research design of a state government-driven process that privileged science***	**Score = 3:** ***The pairing of IKS and Western science had a high standard***
Rebuilding plan	4	0	0	1
SAR	74	7	2	0
Total	78	7	2	1

Note: Indicator 1 provides a general assessment of the extent to which the process of producing knowledge that advises fisheries management was inclusive of IKS.

to Chinook salmon that spawn in the Okanagan River system (Table 4; see Data Availability Statement).

Only three documents were inclusive of IKS, but to different degrees (Table 3). For two documents—a SAR evaluating management procedures for two populations of Pacific herring in southern British Columbia, and a SAR estimating the beluga population in the Eastern Beaufort Sea—IKS contributed to the objectives and elements of research design, yet the process remained DFO-driven, privileging Western science over IKS (Indicator 1 score = 2) (Tables 5 and 6). The third document—the ecosystem-based rebuilding plan for Pacific herring in Haida Gwaii (CHN et al. 2022)—showed a much higher standard for pairing IKS and Western science (Indicator 1 score = 3); its scores for all indicators, individually and on average, were superior to that of the other documents (Table 6; see Data Availability Statement).

3.2 | Qualitative Analysis

3.2.1 | Documents in Which Indigenous Peoples Were Included in Some Aspects of Research but Their IKS Was Not

This section complements Table 4 with qualitative analysis of documents in which Indigenous participation was limited to fieldwork and/or data contributions to DFO-driven scientific research (Indicator 1 score = 1). Patterns present throughout these documents include (1) no indication in the methods of a concerted effort to include IKS in a thoughtful or systematic way; (2) unsubstantiated references to Indigenous Knowledge or data; and (3) peer review advisory meetings, required for the development of SARs under the CSAS process, in which Indigenous representatives were a substantial minority. The following examples illustrate these patterns.

The document on Arctic char in Ikaluit Lake (DFO 2023d) included the following statements: (1) Arctic char are "an important commercial and subsistence resource for Inuit"; (2) "It is understood but not documented that Iqaluit residents rely more heavily on Ikaluit Lake Arctic Char for subsistence compared to residents of Pangnirtung"; and (3) "The subsistence harvest information from the HTO [Hunters and Trappers Organisation] and HTA [Amaruq Hunters and Trappers Association] were used in this assessment." The document, however, provided no formal references nor description for the process by which Inuit knowledge or harvest data were obtained. Of the 16 participants who attended the peer review advisory meeting, only five (including an interpreter) were Indigenous representatives. An Inuktitut translation of the document is available, which increases accessibility to the SAR without improving IKS inclusivity in the development of the document.

The document on beluga in Cumberland Sound (DFO 2022a), which was developed in a co-management context (i.e., joint management responsibility by Indigenous and state government with only the latter having decision-making authority), includes the following statements: (1) "Local traditional and hunter knowledge has raised concerns that beluga from multiple distinct groups summer in Cumberland Sound, and that the current quota does not reflect this dynamic" and (2) "Inuit knowledge from the Pangnirtung community indicated multiple beluga groups are present in Cumberland Sound." The report, however, provides no formal references or descriptions for the process by which Inuit knowledge was obtained. Of the 39 participants who attended the peer review advisory meeting, only two were Indigenous representatives. An Inuktitut translation of the document is available (improving accessibility only).

The assessment of snow crab in Newfoundland and Labrador (DFO 2023a) acknowledges use of the "Torngat Joint Fisheries Board-DFO collaborative trap survey" but provides no formal references nor description of Inuit contributions to that survey (e.g., there is not mention that the Torngat Joint Fisheries Board includes 50% Inuit representation). Further, the document does not specifically mention Indigenous Peoples. Of the 49 participants who attended the peer review advisory meeting, only four were Indigenous representatives.

3.2.2 | Documents With Limited IKS Contributions

This section complements Table 5 with qualitative analysis of the two documents in which IKS contributed to the objectives and elements of research design, yet the process

TABLE 4 | Documents in which Indigenous Peoples were included in some aspects of research (e.g., fieldwork, data contributions) but their IKS was not (i.e., Indicator 1 score = 1).

Document	Species	Management unit	Justification for Indicator 1 score
DFO (2023d)	Arctic char	Ikaluit Lake (Robert Peel Inlet)	The Pangnirtung Hunters and Trappers Organisation (HTO), Amaruq Hunters and Trappers Association (HTA), and Pangnirtung fishers engaged in a 2-day "Regional Advisory Process meeting" in Iqaluit, where they provided information on the influence of tidal cycles on the timing and movement of Arctic Char into different lake systems, and the population discreteness of Ikaluit Lake Arctic Char. The assessment applied subsistence harvest information provided by the HTO and the HTA. These contributions were limited to support of a DFO-driven research process
DFO (2022b)	Beluga	Eastern Hudson Bay and James Bay	Beluga harvests by the Nunavik communities are managed under a multi-year management plan developed by the Nunavik Marine Region Wildlife Board and the Eeyou Marine Region Wildlife Board. Hunters contributed their harvest data (see Figure 2 and Tables 1 and 2) and provided information on the timing of beluga migrations but these contributions were merely supportive of a DFO-driven research process
DFO (2022a)	Beluga	Cumberland Sound	The population is co-managed by DFO and the Nunavut Wildlife Management Board, the local Pangnirtung Hunters and Trappers Association, and the Qikiqtaaluk Wildlife Board. The document references several aspects of Inuit knowledge (see Section 3.2.1) but these contributions were merely supportive of a DFO-driven research process
DFO (2019b)	Chinook salmon	Okanagan River	The Okanagan Nation Alliance (ONA) has engaged in the study and conservation of the population since 2002, including field data collection and habitat enhancement. ONA collaborated with DFO, Columbia River Intertribal Fish Commission, and Summit Environmental to produce an Okanagan Chinook Recovery Potential Assessment (RPA) in 2006, and produced a second RPA in 2016, but the 2019 document does not specify how outputs from these earlier, Indigenous-led initiatives contributed to the most recent RPA. ONA shared escapement data for non-adipose-clipped summer Okanagan Chinook Salmon (2006–2018), which the 2019 RPA depicts in its Figure 2. Despite ONA's data contributions, there is no indication of a concerted effort to include IKS in the most recent RPA
DFO (2023a)	Snow crab	Newfoundland and Labrador (Divisions 2HJ3KLNOP4R)	Indigenous inclusion is limited to acknowledgement that the "Torngat Joint Fisheries Board-DFO collaborative trap survey" was used in the assessment
DFO (2023c)	Walrus	Hudson Bay-Davis Strait	Indigenous inclusion is limited to (1) the statement that "Hunters from Nunavik report that Walrus hunting has declined because there are fewer dog teams to feed," and (2) data in DFO (2023c)'s Figure 2, which includes "haul-out sites obtained from previous surveys and discussions with Inuit hunters"
DFO (2024a)	Walrus	South and East Hudson Bay	Indigenous inclusion is limited to the statement: "The aerial coastal photographic survey conducted in September 2022 covered all known terrestrial haul-out sites identified within the distribution range of South and East Hudson Bay (SEHB) walruses, based on previous surveys and Inuit Qaujimajatuqangit (local knowledge)"

Note: For additional details, see Data Availability Statement.

remained DFO-driven and privileged Western science over IKS (Indicator 1 score = 2).

The document on beluga in the Eastern Beaufort Sea (DFO 2023b) acknowledged the co-management context for the species and included the following statements: (1) "Upon request from DFO Fisheries Management, FJMC [Fisheries Joint Management Committee] and the Inuvialuit Game Council, a new aerial survey was co-designed and conducted in July 2019, attempting to cover the entire summer distribution of EBS beluga in Canada"; (2) the study included "new areas" which were partly based on "consultations with Inuvialuit"; and (3) "The EBS population assessment took a collaborative approach with Inuvialuit that engaged participation in the study design, field implementation/execution and the interpretation of findings for the final assessment." However, no details are provided on how hunters or other knowledge keepers were engaged in knowledge co-production nor any role of Indigenous leadership in that process. Of the 21 participants who attended the peer review advisory meeting, only six were Indigenous representatives.

The document on Pacific herring in the Strait of Georgia (SOG) and West Coast of Vancouver Island (WCVI) (DFO 2019a) focuses on the development of a Management Strategy Evaluation (sensu Punt et al. 2016), for which "DFO engaged in a series of objective-setting workshops with First Nations and the herring fishing industry to formulate biological and yield objectives for the fisheries." The analyses simulation-tested management procedures for achieving a suite of objectives, including some that are consistent with First Nations perspectives, such as (1) maintaining population abundances at or above levels equivalent to the average biomass of a historical baseline period considered to be productive (1988–2016 for SOG and 1988–1996 for WCVI), and (2) target biomass levels (for WCVI only) equivalent to 75% of the unfished biomass, or to the average biomass during 1990–1999.

TABLE 5 | Documents in which IKS contributed to the objectives and elements of research design, yet the process remained DFO-driven and privileged Western science over IKS (i.e., Indicator 1 score = 2).

Document	Species	Management unit	Justification for indicator score
DFO (2023b)	Beluga	Eastern Beaufort Sea (EBS) beluga (Eastern Beaufort Sea Beluga)	The document states that the population is co-managed through DFO and the Fisheries Joint Management Committee (a co-management body for the Inuvialuit Settlement Region) but lacks any indication of equitable knowledge co-production involving Indigenous communities (see Section 3.2.2). Nine of 11 indicators of IKS inclusivity applicable to beluga had score values of zero (Table 6). For instance, the document lacks the following element of IKS: quotes from Indigenous collaborators; IKS principles; specificity on how governance structures, communities, and knowledge holders were engaged; discussion on how IKS might have contributed to determining the spatial scales of management; IKS perspectives on change over time and how current population abundance relates to meeting Inuvialuit needs for food security and cultural continuity
DFO (2019a)	Pacific herring	Strait of Georgia (SOG) and West Coast of Vancouver Island (WCVI)	This document describes the development of a Management Strategy Evaluation (sensu Punt et al. 2016) for which First Nations contributed some of the objectives. Indigenous participants, however, were brought into a DFO-driven process that they did not co-design or co-lead (see Section 3.2.2). Additionally, 10 of the 14 indicators of IKS inclusivity applicable to Pacific herring received score values of zero (Table 6). For instance, the document does *not* include: words from Indigenous collaborators; IKS principles; specificity on how governance structures, communities, and knowledge holders were engaged; specificity on how objectives link to cultural continuity; discussion on how IKS might have contributed to understanding changes in size and/or age structures; and specificity on how management objectives link to the ecosystem role of herring in supporting a diversity of predators

Note: For additional details, see Data Availability Statement.

The analyses also attempted to include smaller spatial scales of management determined by IKS. (The attempt failed for technical reasons.) The process, however, was initiated by DFO (i.e., First Nations, some with limited technical capacity, were invited into a process that they did not co-design), privileged science over IKS, and included participation from the fishing industry. Of the 48 participants who attended the peer review advisory meeting, only eight were Indigenous representatives.

3.2.3 | A Bright Spot for IKS Inclusivity: The Ecosystem-Based Rebuilding Plan for Pacific Herring in Haida Gwaii

The document *Haida Gwaii ′iináang | iinang Pacific Herring: An Ecosystem Overview and Ecosystem-based Rebuilding Plan* (CHN et al. 2022), had the highest indicator scores (Table 6) and exemplifies a legitimate effort to include IKS in multiple formats. Notably, the rebuilding plan (1) uses "two local dialects of the Haida language, X̲aad kíl, the G̲aw Tlagée Old Massett dialect, and X̲aayda kil, the HlG̲aagilda Skidegate dialect" for species names, Haida principles, harvesting practices, and other concepts; (2) highlights quotes from Haida knowledge-keepers throughout all sections; and (3) specifies the role of Haida values and principles, including reciprocity, balance, interconnectedness, responsibility, and respect, in guiding the plan.

Haida knowledge gathered from the 1970s onwards was a key source of information, indicating that the authors consulted and built upon existing IKS work. The sources acknowledged and cited in the rebuilding plan include Haida-led IKS studies, such as the Haida Marine Traditional Knowledge Study involving 54 Haida citizens, and herring interviews with Haida men conducted by Russ Jones (a Haida hereditary chief and fisheries scientist) in 1998. In a section dedicated to "Traditional Knowledge" the rebuilding plan states that "Haida traditional knowledge of ′iináang | iinang is held by citizens of the Haida Nation and has been passed down through generations via oral histories, experiential learning, and interactions with *iináang | iinang*." The inclusion of IKS compiled from Haida sources and citizens increased understanding spatial dynamics, informed reference points and historical baselines, improved knowledge of herring ecology, helped understand the effects of different fisheries and gear types, and supported co-governance (i.e., joint management authority) and decision-making processes.

The rebuilding plan specifies objectives for cultural continuity, including (1) "Foster Haida governance of traditional use and stewardship of herring on Haida Gwaii," (2) "Protect and maintain culturally important areas and other areas of concern for herring," and (3) "Enable Haida traditional use of and cultural connections with herring, herring related activities, and habitat." Further, one of the fisheries management objectives is to

TABLE 6 | Normalised indicator scores for the three documents with varying degrees of IKS inclusivity.

	Normalised score		
Indicator ID	***Beluga/EBS* (DFO 2023b)**	***Pacific herring/SOG and WCV1* (DFO 2019a)**	***Pacific herring/Haida Gwaii* (CHN et al. 2022)**
1	0.67	0.67	1.00
2	0.67	0.00	1.00
3	0.00	0.00	1.00
4	0.00	0.00	1.00
5	0.00	0.00	0.00
6	0.00	0.00	0.50
7	0.00	0.00	0.00
8	0.00	0.50	1.00
9	0.00	1.00	1.00
10	0.00	0.00	1.00
11	NA	0.00	0.33
12	NA	0.00	1.00
13	NA	0.00	0.50
Average normalised score	0.13	0.17	0.72

Note: For score justifications see Data Availability Statement.
Abbreviation: NA, not applicable.

"Incorporate Haida traditional knowledge and recognise Haida laws in the herring management process." Additionally, the ecological objectives go beyond a single-species management approach and embrace an ecosystem perspective consistent with Haida knowledge.

The rebuilding plan highlights the collaborative nature of the rebuilding plan's development, involving the Council of the Haida Nation, Parks Canada, and DFO. Notably, the scientific component of the work is very rigorous and applies (among other analyses) a Management Strategy Evaluation (sensu Punt et al. 2016) of management procedures that support rebuilding objectives.

4 | Discussion

Western scientists and state governments engaging in resource management have long misunderstood and undervalued IKS (McGregor 2021; Snook et al. 2022; Whyte 2013). Recent years, however, have brought a rise in awareness that IKS and Western Science have complementary strengths (e.g., Ban et al. 2018; Kimmerer 2002) (Figure 1), and that the pairing of the two knowledge systems may improve fisheries management (Reid et al. 2021). At the same time, some countries with colonial histories have begun efforts to reconcile past wrongs by creating structures and processes intended to make resource management decisions more inclusive of IKS and other place-based knowledge (Strand et al. 2024). The work we present here provides a general methodology, using Canada as a case study, for gauging the extent to which rising awareness and good intentions yield tangible improvements.

Our results provide evidence that Canadian federal policies and strategies for inclusion of Indigenous Peoples in fisheries management, such as the 2019 *DFO Reconciliation Strategy*, remain largely aspirational. SARs and rebuilding plans are key advice documents used by federal fisheries managers; they are, effectively, a window into the types of knowledge and worldviews that Canada privileges in fisheries decision-making. In our sample of 78 of these documents published in the last 5 years (2019 to 1 July 2024), the vast majority (87.2%) did not meaningfully include Indigenous Peoples and IKS in the research processes and outcomes that they reported. A smaller subset of advice documents showed a limited range of Indigenous participation (9%) or IKS inclusion (≈3%) in scientific processes initiated and driven by DFO. In these cases, IKS appear to have been either an afterthought or considered in ways that served a pre-determined scientific methodology. Only one advice document met a high standard for the pairing of IKS and Western science.

The document *Haida Gwaii 'iináang | iinang Pacific Herring: An Ecosystem Overview and Ecosystem-based Rebuilding Plan* (CHN et al. 2022) is the single bright spot in our analyses. Co-produced by the Haida Nation, DFO, and Parks Canada, this document paired Haida knowledge, principles, and language with rigorous scientific methods to determine the objectives and management actions required to restore stronger relationships between herring, people, and other species in the ecosystem. This document scored high values for most indicators of IKS

inclusivity, demonstrating DFO's capacity to collaborate with Indigenous Peoples when the institution commits to doing so. Notably, the rebuilding plan was drafted after the Haida Nation successfully sued Canada for herring mismanagement in their territory (Jones et al. 2017). Nonetheless, the process of drafting the plan led to the types of relationship building and knowledge co-production that is required for Canada to advance from aspirational policies to the effective operationalisation of IKS inclusivity in fisheries management.

Advice documents were outdated or entirely lacking for 10 of the 38 focal species (26%) we considered vital to the social determinants of Indigenous health (Table 1). These include, for example, eulachon (*Thaleichthys pacificus*), which collapsed throughout much of its distribution in the late 1990s, bringing tremendous hardship to some Indigenous communities (Beveridge et al. 2020; Moody 2008).

The 13 indicators of IKS inclusivity that we developed were designed for a broad range of advice documents and fisheries management processes, yet we recognise that they reflect the combined positionalities and experiences of the author team. These indicators, therefore, should be treated as a living methodology to be revised over time with broader participation of Indigenous Peoples. Additionally, case studies involving specific Indigenous communities may require context-specific revisions. For instance, Indicator 5, on protocols for sacred locations, may be relevant to some communities but not others. Another example is the language component of Indicator 3, which may not apply to communities hit hardest by the residential school system which endeavoured to ban Indigenous languages throughout Canada, among other genocidal practices (TRC 2015).

Our document selection criteria were restricted to titles which included the names of focal species. Outside these criteria, we are aware of a marine spatial planning SAR with strong inclusivity of IKS. The document, *Biophysical and Ecological Overview of the Pacific Region Offshore Haida Gwaii Network Zones* (DFO 2024b), pertains to zones within the soon-to-be-implemented marine protected area network for the Northern Shelf Bioregion (Beaty et al. 2024). Like the rebuilding plan for Pacific herring in Haida Gwaii, it reports a knowledge co-production process between the Haida Nation and DFO in which Haida knowledge and language were paired with Western science. Moreover, the peer review meeting for this document was co-chaired by the Haida Nation and DFO (DFO 2022c), demonstrating a more proactive and equitable approach to the inclusion of IKS by the CSAS. This approach, important as it is, remains rare.

4.1 | Conclusions and Recommendations

Over the last 5years DFO has made a series of important policy statements intended to make fisheries management more inclusive of IKS yet did not back them up in law via amendments to the *Fisheries Act* or its regulations. In its current form, Section 2.5 of the *Fisheries Act* (2019) states that the Minister "may consider Indigenous knowledge of the Indigenous peoples of Canada that has been provided to the Minister." By using the words, "*may* consider," the Act does not obligate the Minister to be inclusive of IKS in fisheries advice and management decisions. Further, our results suggest that DFO's science advisory process has yet to be amended to reflect the department's own policy suite on IKS inclusivity. Our analyses document the non-response of the system and serve as a cautionary tale for other countries engaging in their own reconciliation[8] processes with Indigenous Peoples.

Our primary objective is to foster a better way forward in which the inclusion of IKS in fisheries advice and decision-making become the norm. Towards that end, we offer the following recommendations to law and policy makers and to fisheries directors, managers, and scientists in Canada and elsewhere.

1. *Enshrine into law the inclusion of IKS in fisheries advice and decision-making*. In the Canadian context, this recommendation entails revisions to the *Fisheries Act*, which currently authorises the Fisheries Minister to "*consider*" IKS in decision-making. A revised *Fisheries Act* must *require* the Minister to base decisions on advice that meaningfully includes IKS from Indigenous Peoples who *chose* to engage in collaborative fisheries management while following the principles of data sovereignty; additional provisions are needed for better alignment between the *Fisheries Act* and the *United Nations Declaration on the Rights of Indigenous Peoples Act Action Plan* (Department of Justice 2023). The UN Declaration on the Rights of Indigenous Peoples (UNDRIP) can provide guidance for implementing this recommendation in other countries.
2. *Uphold, strengthen, or create (if lacking) structures and processes for including IKS in the generation of management advice and decision-making*. In Canada, pathways for implementing this recommendation include revisions to the CSAS so that requests for advice by DFO managers are required to invite and financially support knowledge co-production with Indigenous Peoples, including Indigenous participation in steering committees who guide the development of goals and objectives, and as co-chairs of peer review meetings. Other countries will differ in their structures and processes for implementing this recommendation, yet in all cases principles of equity and inclusivity apply. Strand et al. (2024) provide a recent synthesis of these principles, as applied to ocean management in an international context; they emphasise that success in knowledge co-production and joint decision-making hinges on the extent to which all parties commit to creating a safe ethical space for knowledge plurality. The implication is that longer processes and more flexible timelines may be required to achieve more meaningful outcomes.
3. *Develop and implement co-governance agreements for collaborative fisheries management with Indigenous Peoples*. Strand et al. (2024) state that ocean management plans "are more likely to succeed if situated within co-governance agreements that recognise the authority of Indigenous governments and communities for managing ocean areas and aspects such as fisheries and protected areas in collaboration with other levels of government." Canada is potentially leading in the development of these kind of agreements, such as the *Fisheries Resources Reconciliation Agreement* (FRRA 2021). In our results, the rebuilding plan for Pacific herring in Haida Gwaii (CHN et al. 2022), scored highest for inclusivity of Indigenous governance (Indicator 2) and

for the average of all indicators, suggesting that these kinds of agreements need to become more widespread in Canada and elsewhere with implementation pathways supported by state governments. In a Canadian context, however, the *Fisheries Act* remains a stumbling block to implementing this recommendation.

4. *Invest in IKS*. The world over, Indigenous Peoples have been disenfranchised by colonisation and struggle with personnel and financial shortfalls. Without the ability to purchase boats and be on the water, for instance, many aspects of IKS cannot be practiced. More generally, knowledge co-production is most meaningful when Indigenous Peoples have the resources to collect and manage their own data. For these reasons, it is imperative for state governments to financially support Indigenous Peoples in their practices of IKS and in their contributions to knowledge co-production (Strand et al. 2024).

5. *Identify and mitigate shortfalls in policy and practice*. The indicators of IKS inclusivity that we developed (Table 2) can guide, with locally appropriate revisions, periodic examination of policies and practices by state governments and help identify potential mitigation measures. These same indicators can also guide, proactively, the development of new advice documents.

6. *Invest resources in managing species vital to Indigenous Peoples, even if they lack commercial value*. In Canada, "major stocks" prescribed under the *Fisheries Act* receive priority resources for assessment. These "major stocks" exclude several species and populations vital to determinants of Indigenous Health (e.g., our results show that advice documents were outdated or altogether lacking for 26% of focal species); the *Fisheries Act* requires revision so that such species and populations also are prioritised for assessment, regardless of commercial value. While the mechanism for implementing this recommendation will differ in other countries, the same principle applies everywhere: state governments must work with Indigenous Peoples to ensure that species and populations vital to culture, food security, and health are assessed and jointly managed.

7. *Invest in the professional development of state government personnel so that they learn to value IKS and meaningfully collaborate with Indigenous Peoples*. Non-Indigenous peoples often lack an understanding of IKS and of the impacts of colonisation. Education is a key precursor for reconciliation with Indigenous Peoples (TRC 2015) and, therefore, for collaborative fisheries management. State governments must support and require their personnel to engage in Indigenous-led re-education initiatives that decolonise relationships and the telling of history. DFO's Technical Expertise in Stock Assessment program, for instance, developed a seminar series in which Indigenous speakers present on IKS and knowledge co-production to an audience of fisheries scientists and managers; similar initiatives must become more widespread.

Our analyses and recommendations provide an opportunity for fisheries management to move away from Eurocentric perspectives, in which marine species are treated as commodities for maximum sustainable exploitation, to more holistic perspectives and ecosystem approaches strengthened by IKS (Figure 1). This transformation would foster more reciprocal and respectful relationships between people and the ecosystems we depend on, fortifying socio-ecological resilience in the face of climate change and other stressors (Frid et al. 2023; Kimmerer 2002; Reid et al. 2021).

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Conflicts of Interest

The authors declare no conflicts of interest.

Data Availability Statement

Our analyses are based on a spreadsheet containing information on each advice document analysed, including their full citation hyperlinked to the original document. The spreadsheet also includes scores for each indicator and justifications for each score. The spreadsheet, along with a fuller description, is available in the Zenodo repository https://doi.org/10.5281/zenodo.14940425.

Endnotes

[1] Many Indigenous Peoples are leading their own initiatives to manage their fisheries or other uses of their inherent lands and waters without involving other levels of government or necessarily pairing their Indigenous Knowledge with Western science. Although beyond the scope of our analyses, the importance of such work cannot be overstated.

[2] https://www.justice.gc.ca/eng/csj-sjc/principles-principes.html.

[3] https://waves-vagues.dfo-mpo.gc.ca/library-bibliotheque/40947208.pdf.

[4] https://www.isdm-gdsi.gc.ca/csas-sccs/applications/Publications/search-recherche-eng.asp.

[5] https://www.dfo-mpo.gc.ca/fisheries-peches/ifmp-gmp/index-eng.html.

[6] https://www.pac.dfo-mpo.gc.ca/fm-gp/mplans/herring-hareng-ifmp-pgip-sm-eng.html.

[7] After our manuscript went to press, the DFO library published a final but "unofficial" version of this rebuilding plan at https://waves-vagues.dfo-mpo.gc.ca/library-bibliotheque/41284161.pdf. The "official" version that would be discoverable by our methodology remained unavailable at publication time.

[8] In the words of the late Honourable Murray Sinclair, former co-chair of Canada's Indian Residential Schools Truth and Reconciliation Commission (https://nctr.ca/), "Reconciliation is about atonement. It's about making amends. It's about apology. It's about recognizing responsibility. It's about accounting for what has gone on. But ultimately, it's about commitment to maintaining that mutually respectful relationship throughout, recognizing that, even when you establish it, there will be challenges to it (https://www.csps-efpc.gc.ca/video/ssontr-eng.aspx)."

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Supporting Information

Additional supporting information can be found online in the Supporting Information section.