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PERSPECTIVE

Mismatches in salmon social–ecological systems: Challenges and opportunities for (re)alignment in the Skeena River watershed

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Abstract

Mismatches between institutions and social–ecological systems (SESs) are one of the foremost challenges in natural resource management. However, while mismatches are often cited in the literature as a major challenge, empirical evidence of mismatches and their consequences is limited. This is particularly true for complex SESs, such as on the Pacific Coast of North America, where salmon drive interactions across multiple environments, jurisdictions, and scales. Here, I use the theoretical concept of fit to examine institutional alignment in a large-scale Pacific salmon SES, the Skeena River watershed in British Columbia, Canada. Utilizing Canadian federal environmental assessments as a proxy for colonial environmental governance institutions, I describe the common causes and consequences of mismatches between institutions and salmon SESs. This case study suggests that mismatches are threatening salmon sustainability and negatively affecting Indigenous People's rights, livelihoods, and approaches to resource management and stewardship. I argue that improving social–ecological fit in salmon SESs will require new or revitalized forms of environmental governance that consciously fit the underlying social–ecological dynamics. While these findings are based on the Skeena River watershed, they may be generalizable to other salmon SESs in which mismatches between social and ecological processes and institutions exist.

Key words: social–ecological systems, mismatch, salmon, Indigenous Peoples' rights, Indigenous governance, Skeena River watershed

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Introduction

Mismatches between institutions and social–ecological systems (SESs), often termed *institutional mismatches* or *problems of fit*, are a major sustainability challenge in natural resource management (Young 2002; Cash et al. 2006; Cumming et al. 2006; Folke et al. 2007; Galaz et al. 2008; Epstein et al. 2015). Institutions often fail to match the diversity of local settings and the complexity of the ecosystems with which they interact (Holling and Meffe 1996; Young 2002; Wilson 2006). When the scales of social organization and environmental variation are mismatched, problems can arise in either the institutions that are responsible for management and (or) the ecological systems that are being managed (Young 2002; Cumming et al. 2006). For example, fishing quotas based on the utilitarian concept of maximum sustainable yield can often be mismatched with the natural dynamics of fish populations they exploit which can undermine the resilience of the biological system and result in depleted

fisheries (Acheson and Wilson 1996). These kinds of mismatches can be difficult to respond to and, if unaddressed, can degrade SESs either through disruption of function, inefficiencies in the system, and (or) simplification through the loss of important system components (Cumming et al. 2006; Galaz et al. 2008; Young 2002). Addressing and resolving problems of fit are therefore critical to the sustainable management of natural resources and the well-being of the diverse cultures and communities they support.

Salmon-based SESs (**Fig. 1**) are ubiquitous across western North America (Yoshiyama 1999; Muckle 2007). As an ecological keystone species, Pacific salmon (*Oncorhynchus* spp.) influence myriad species serving as a direct food source for more than 40 species of vertebrates including other salmon, trout, birds, and mammals (Willson and Halupka 1995; Gende et al. 2002; Garibaldi and Turner 2004; Galbreath et al. 2014). Salmon are also important drivers of nutrient and energy flows (Bilby et al. 1998; Cederholm et al. 1999) increasing production at all levels of the food chain, from bacteria and algae communities to top predators, such as bears (Hilderbrand et al. 1999; Hocking and Reynolds 2011; Walsh et al. 2020).

In addition to their ecological role, salmon also provide provisioning, cultural, and supporting services to local communities. For more than 10,000 years, salmon have shaped the traditions, cultures, spiritual practices, and governance systems of Indigenous Peoples on Canada's North Pacific Coast (Newell 1993; Trosper 2003; Garibaldi and Turner 2004; Vining and Cristancho 2004; Nabhan 2006; Muckle 2007; Alfred 2009; Cuerrier et al. 2015; Noble et al. 2016). Specific locales for harvesting salmon have been used by Indigenous Peoples for millennia creating a deep sense of place and reinforcing a strong cultural and spiritual connection with the land (Garibaldi and Turner 2004; Cuerrier et al. 2015). These fishing sites provide a focal point for culturally significant events, ceremonies, and intergenerational teachings about the natural world (Garibaldi and Turner 2004; Vining and Cristancho 2004). This deep cultural knowledge of salmon and sustainable management practices has been shared and passed down through generations and laid the foundation for Indigenous governance and decision-making (Turner et al. 2000; Trosper 2002; Johnsen 2009; Atlas et al. 2020).

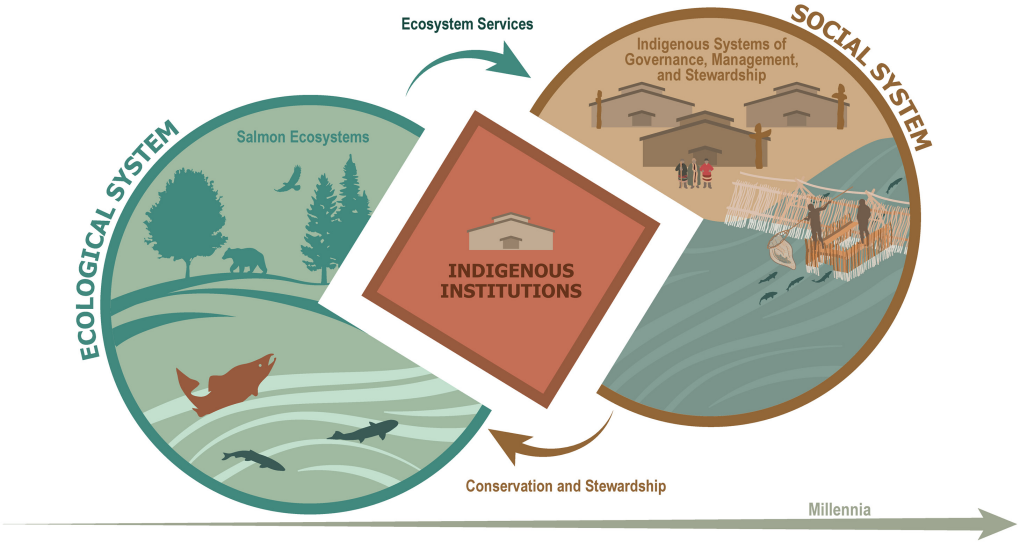

Fig. 1. Illustration of salmon social–ecological systems found across western North America. These salmon social–ecological systems are comprised of salmon ecosystems and Indigenous systems of governance, management, and stewardship that are connected through local-scale Indigenous institutions.

Archeological records suggest that pre-colonial Indigenous societies sustainably managed local salmon ecosystems (Trosper 2002; Johnsen 2009; Campbell and Butler 2010). While Indigenous Peoples had the means to deplete local salmon resources and to even cause their extinction (Mathews and Turner 2017), traditional Indigenous governance systems evolved in ways that helped to maintain healthy and productive salmon populations, thus strengthening social–ecological fit (Anderson 2016; Trosper 2002, 2003; Mathews and Turner 2017; Atlas et al. 2020). The salmon SESs of western North America are therefore often cited as model examples of resilient SESs based on their ability to buffer environmental disturbances, self-organize, and learn (Trosper 2002, 2003; Campbell and Butler 2010; Atlas et al. 2020).

Yet, despite being recognized as a model of resilient SESs (Trosper 2002; Campbell and Butler 2010), their long-term sustainability is increasingly uncertain. Salmon SESs face a growing number of threats including declining salmon populations (Gustafson et al. 2007; Malick and Cox 2016; Price et al. 2017), habitat loss and degradation, and anthropogenic climate change (Crozier et al. 2021). Threats to the sustainability of salmon SESs are particularly acute in the Skeena River watershed, Canada's second-largest salmon-producing river. Across the Skeena, many salmon populations are now at a fraction of their historical abundance (Price et al. 2019) leading to curtailed salmon fisheries and contributing to economic hardship and food insecurity for local communities. Indigenous communities throughout the Skeena River watershed have identified mismatches between environmental governance institutions and salmon SESs as a key threat to the long-term sustainability of the system (Moore et al. 2015b). Yet, while mismatches are hypothesized to negatively affect the sustainability of the Skeena salmon SES, there is a limited understanding of the mechanisms through which institutional mismatches arise, how they affect salmon SESs, and what is required to overcome them (Cash et al. 2006; Cumming et al. 2006).

In this paper, I describe the changing landscape of environmental decision-making in the Skeena River watershed and explore how these changes give rise to mismatches between colonial environmental governance institutions, in the form of Canadian federal environmental assessments (EAs), and salmon SESs. Using the long-established SES of Indigenous Peoples (i.e., First Nations) on Canada's North Pacific Coast and salmon ecosystems, I identify the sources of institutional mismatch and their consequences for the salmon SES, including impacts on Indigenous Peoples' rights, livelihoods, and approaches to resource management and stewardship. I conclude with recommendations on how to remedy mismatches and improve the fit between salmon SESs and environmental governance institutions, including ways in which Indigenous governance, management systems, and knowledge can offer pathways to sustainability. While this research focuses on a case study of the Skeena River watershed, the findings may be generalizable to other salmon SESs where mismatches between environmental governance institutions and salmon SESs are generating conflict and tension over environmental decisions.

Changing landscape of environmental decision-making in Canada

In traditional Indigenous societies, the management and harvest of salmon were placed-based, with management decisions governed locally (Turner et al. 2000; Berkes 2012). In northwestern British Columbia, Canada, including the Skeena and Nass River watersheds, governance was typically organized through a series of *Wilps* or houses headed by individual titleholders or chiefs (Trosper 2002; King 2004). Each individual *Wilp* exercised jurisdiction over a unique territory and their *Wilp* members on issues such as access, succession, protection of land and resources for future generations, and affirmation of authority and responsibility over their territory. Titleholders were responsible for preserving the function and integrity of all lands and resources belonging to the *Wilp*, including

salmon, and for ensuring the continued prosperity of their community by properly managing the resources under their control. Management strategies were informed by the experiences of community members who fished the same sites year after year and had intimate knowledge of local salmon populations. The traditional ecological knowledge accrued from generations of engagement with salmon has allowed Indigenous Peoples to devise management strategies and rules that protect salmon habitat and sensitive life stages and to minimize the risks of overharvest and population collapse (Turner et al. 2000; Berkes 2012; Atlas et al. 2020). These rules shaped Indigenous laws which in turn have shaped the structure and organization of Indigenous systems of governance and management (Atlas et al. 2020).

Until nearly the end of the nineteenth century, Indigenous Peoples on Canada's North Pacific Coast were sovereign nations left to regulate their resource-based cultures and economies with little interference from settlers or their governments (Trosper 2002; King 2004). When European explorers arrived in the mid- to late 1700s, First Nations had well-established institutions that governed their relationship with their ancestral lands and resources (Turner et al. 2000; Trosper 2003; King 2004; Liu et al. 2007; Menzies and Butler 2007; Turner and Turner 2007). However, as increasing numbers of explorers settled along the coast of western North America, the traditional political and economic systems of Indigenous Peoples became increasingly destabilized (Newell 1993; Alfred 2009; Mccreary and Milligan 2021). Colonial acts of dispossession and assimilation stripped Indigenous Peoples of land, severed access to salmon fisheries (Harris 2001; Silver et al. 2022), and disposed them of the political, cultural, and socioeconomic responsibility to govern according to their traditional laws. Over time, long-standing systems of Indigenous natural resource management were dismantled and replaced with state-led systems of resource management (Adams et al. 2014; Atlas et al. 2020). This transformation fundamentally altered the scales of decision-making, with decisions related to natural resources use and management now made by centralized management agencies often located thousands of kilometers away from the affected communities and the SESs they are part of (Cash et al. 2006; Adams et al. 2014; Atlas et al. 2020). This shift toward centralized systems of resource management has decoupled local resource users from management decisions, limiting the ability of local knowledge and values to influence decision-making processes (Holling and Meffe 1996; Atlas et al. 2020). This profound transformation in the scale of governance institutions brought on by colonization has led to mismatches between colonial institutions and locally evolved Indigenous institutions.

In colonial natural resource management systems, many decisions related to the use of natural resources are informed by EAs. Defined broadly, EAs are processes used by decision-makers to assess and predict the ecological, social, health, and economic impacts of proposed development and industrial activities (Cashmore et al. 2004; Clarke Murray et al. 2018). EAs are intended to provide decision-makers with information to facilitate better, and more informed, decisions about trade-offs associated with a proposed human activity. In Canada, the federal government undertakes its own EAs for projects that fall under the jurisdiction of the Canadian *Impact Assessment Act 2019*. Provinces and territories also have their own EA acts, which cover provincial/territorial responsibilities, and which vary widely in nature and scope. Some Indigenous government have developed their own EA processes, largely in response to their exclusion as decision-makers in state-led EA processes (Usher 2000; Manuel and Derrickson 2015; Eckert et al. 2020).

In modern day Canada, jurisdiction is divided between federal, provincial/territorial, and Indigenous governments. Indigenous rights and title are recognized through Section 35 of the Canadian *Constitution Act* (Canadian Charter of Rights and Freedoms, 1982) and, in many cases, through legal treaties. Section 35 clearly outlines the Government of Canada's fiduciary obligations to consult with Indigenous communities whose traditional lands are subject to industrial development. Supreme Court decisions issued over the past several decades (e.g., *Delgamuukw v British Columbia* 1997;

Tsilhqot'in Nation v British Columbia 2014) have further affirmed existing Indigenous inherent and treaty rights to land and water resources and clarified the jurisdictional and decision-making aspects of Aboriginal title and Indigenous governance rights. While modern Canadian case law has set important legal precedents for recognizing treaty and unceded title rights of Indigenous Nations, these rulings have not fully resolved issues around the role of Indigenous governments in environmental decision-making or provided guidance on how provincial/territorial and federal environmental decision-making processes might adapt to the new reality. As such, there remains a glaring disparity between the Indigenous rights won in court, the human rights commitments made by Canada on the international stage (e.g., United Nations Declaration on the Rights of Indigenous Peoples), and the translation of these commitments and legal precedents in environmental decision-making policies and processes.

Diagnosing mismatches in a salmon SES

Most studies of institutional fit focus on one of three types of fit: ecological, social, and social–ecological. Ecological fit considers whether institutions match the core features of the ecological systems with which they interact (Folke et al. 2007; Galaz et al. 2008; Young et al. 2008). In contrast, social fit considers the congruence between institutions and the preferences, values, and needs of human actors (Olsson et al. 2007; Meek 2013). Social–ecological fit is the least well-defined and often involves identifying the contextual attributes of SESs that contribute to, or detract from, the sustainability of interlinked SESs (Epstein et al. 2015).

To evaluate the extent to which Canadian federal EAs are compatible with the Skeena salmon SES, I utilized a framework of institutional fit developed by Epstein et al. (2015). Specifically, I examined the social and ecological attributes of the SES that give rise to problems of fit focusing on three commonly considered ecological dimensions – spatial, temporal, and functional (**Table 1**) and three social dimensions – spatial, participation, and values/interests/beliefs (**Table 2**). Given the well-known challenges associated with examining social–ecological fit (e.g., difficulty identifying all of the contextual attributes of the SES that may be affecting institutional performance; Agrawal 2003; Poteete et al. 2010; Epstein et al. 2014), I considered the social and ecological dimensions of fit separately while recognizing the inherent interplay between these two dimensions in fundamentally interlinked SESs.

The perspective I share in this paper has been informed by both the literature and my personal experiences. My personal experiences include working as a practitioner for a non-governmental organization on Skeena salmon-related issues for the past 15 years including observing several Canadian federal EA processes. As a scholar-practitioner and as a non-Indigenous author, I have attempted to reflect critically on my positionality during the writing of this paper. I recognize that my perspective is inextricably tied to my experiences working as a non-Indigenous Euro-Canadian scholar and practitioner and with that comes inherent biases and perceptions that reflect the privilege that I have been afforded as a non-Indigenous scholar. While I have tried to suspend biases based on my experience as a white settler, I recognize that my privilege permeates this study in ways that I cannot understand or recognize.

Causes and consequences of ecological mismatches

Ecological fit: spatial

Spatial fit refers to alignment between the geographical extent of ecological systems and the institutions that govern them (Cumming et al. 2006; Folke et al. 2007; Galaz et al. 2008; Epstein et al. 2015; Cumming and Peterson 2017). Spatial mismatches between EAs and salmon ecosystems often occur when defining the spatial boundaries of an assessment area (**Table 1**; **Fig. 2**). Determining a

Table 1. Causes of ecological mismatches between environmental assessments (EAs) and the Skeena salmon social–ecological system.

Dimension of Ecological Fit	Definition	Causes of Ecological Mismatches
Spatial	Misalignment between the geographical extent of ecological systems and the institutions that govern them	• Scope of assessment area is narrowly defined and does not match the natural scales of salmon ecosystems • Impacts to salmon and salmon-dependent communities outside of the assessment area (e.g., upstream/downstream) are not considered in the EA
Temporal	Misalignment between the temporal scales under which ecosystem processes operate and the ability of institutions to govern on ecologically appropriate time scales	• The current status of salmon populations is not taken into account when evaluating potential risks to salmon • EAs do not consider how the status of salmon populations may change in response changing environmental conditions because of regime shifts or anthropogenic climate change
Functional	Misalignment between the functional linkages of ecological systems and governance institutions	• Failure to recognize how fine-scale habitat and population diversity support ecosystem structure and function • Failure to consider how project activities may contribute to the erosion of biocomplexity and negatively affect functional linkages (e.g., energy flows, predator–prey interactions) within the ecosystem

Table 2. Causes of social mismatches between environmental assessments (EAs) and the Skeena salmon social–ecological system.

Dimension of Social Fit	Definition	Causes of Social Mismatches
Spatial	Misalignment between the scale of governing institutions and locally evolved Indigenous institutions	• Indigenous institutions are placed-based and govern resource management decisions locally, controlling resource access, land use, and stewardship decisions across ancestral territories • EAs are not required to adhere to local Indigenous natural resource management systems and regulatory regimes, such as Indigenous land use plans
Participation	Misalignment between governing institutions and the expectations and psychological needs of stakeholders	• Failure of EA processes to satisfy innate needs for human agency and self-determination • Continue assertion of colonial jurisdiction and law in EA processes and policies • Disregard for Indigenous Peoples' legal rights to self-government and self-determination
Values/Interests/ Beliefs	Misalignment between governing institutions and the interests, beliefs, values, and social customs of affected groups	• Differences between the profit motivated values that underlie EA policies and Indigenous land ethic • Indigenous values focus on the protection of the natural world and sustainability for future generations • Reciprocity-based world views center the responsibilities of rights holders to salmon and their community

reasonable geographic scope for an EA can be challenging, particularly for highly migratory species such as salmon, whose habitats include a diversity of freshwater, estuarine, and marine environments that span vast geographic scales (Bottom et al. 2009; Malick et al. 2017a). Hatching and rearing in freshwater streams, rivers, and lakes, maturing into adults in the ocean environment, and returning at the end of their life cycle to freshwater spawning grounds, salmon ecosystems are inherently fluid

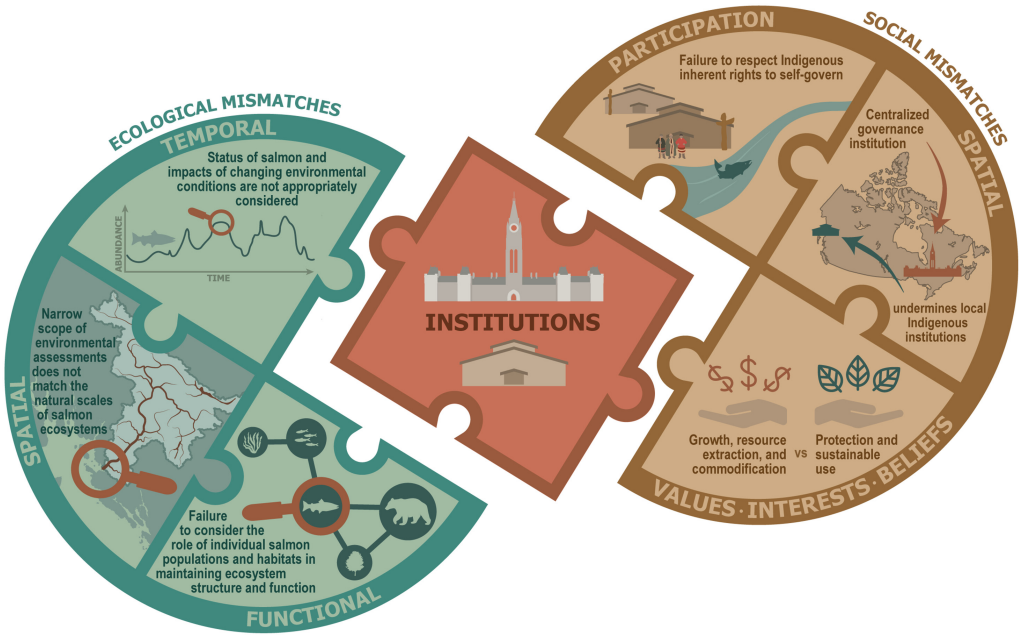

Fig. 2. Mismatches between Canadian federal environmental assessments and the Skeena salmon social–ecological system based on the ecological (spatial, temporal, functional) and social (spatial, participation, values/interests/beliefs) dimensions of the system.

and open (Bottom et al. 2009; Malick et al. 2017b). Dividing salmon ecosystems into smaller units of assessment, as is often required in EAs, creates spatial mismatches between the natural boundaries of salmon ecosystems and the scale of impacts considered in EAs (Lee 1993; Young 2002; Cumming et al. 2006). Scale choice can therefore have important repercussions for the representativeness of an EA, and impacts can be overlooked if thorough consideration is not given to the natural scale of salmon ecosystems when defining the geographic scope of EAs (Joao and João 2002; João 2007; Moore et al. 2015b).

In the Skeena River watershed, most spatial mismatches between EAs and salmon ecosystems have centered around development projects proposed for the river's estuary, an important habitat for all species and populations of salmon originating in the Skeena River watershed (Carr-Harris et al. 2015). For example, in one high-profile EA, the proponent proposed to construct and operate a liquefied natural gas (LNG) facility on Lelu Island, a small island in the middle of the Skeena River estuary. The location of this project was problematic due to its proximity to Flora Bank, an intertidal eelgrass habitat of critical importance to all species of salmon (Higgiins and Schouwenburg 1973; Carr-Harris et al. 2015). In spite of the importance of this estuarine habitat to Skeena River salmon, the assessment area for this EA was constrained to the immediate footprint of the project and a 10 km buffer surrounding nearshore marine shipping routes (Canadian Environmental Assessment Agency 2016). The EA did not consider how the degradation of Flora Bank could affect the abundance, productivity, and diversity of all Skeena salmon populations that utilize the estuary environment (Carr-Harris et al. 2015; Moore et al. 2015b). This project illustrates how spatial mismatches between the narrow consideration of environmental risks in EAs and the natural scales of salmon ecosystems can result in important impacts to salmon and salmon-dependent communities being overlooked in EAs.

Ecological fit: temporal

Temporal fit relates to the rate at which ecosystems change and the ability of governance institutions to both consider and respond to these changes on ecologically appropriate time scales (Cash et al. 2006; Galaz et al. 2008; Engle and Lemos 2010; Epstein et al. 2015). Temporal mismatches can occur when EAs do not appropriately consider the status (e.g., abundance relative to biological thresholds) of components of the ecosystem when predicting how industrial development may affect valued ecological components, such as salmon (**Table 1**; **Fig. 2**). As the vulnerability of salmon populations to disturbances depends, in part, on their current state, considering the current status of salmon populations is important for accurately assessing the potential impacts of a proposed project. For example, depressed populations are inherently more vulnerable to disturbances than large populations (Hutchings and Reynolds 2004). Understanding the current state of a population therefore provides an important basis for estimating the potential impacts of industrial development, and failure to consider current salmon status has the potential to underestimate the biological risks posed by project activities.

Temporal mismatches can also emerge when EAs assume stationary environmental conditions when predicting how industrial activities may impact salmon populations through time (**Table 1**). Salmon exist within a broader trans-Pacific Ocean and climate system that can change over decadal and centennial scales (Rogers et al. 2013) and exhibit sudden nonlinear change from one set of physical and biological conditions to another (Bottom et al. 2009; Rocha et al. 2018). Large-scale oceanic and atmospheric changes, commonly referred to as regime shifts, are common in the North Pacific (Francis and Hare 1994; Hare et al. 1999). These regime shifts can have important consequences for salmon ecosystems, including changes in productivity and reduced resilience (Redmond and Koch 1991; Francis et al. 1998; Bottom et al. 2009), decreases in salmon biomass (Cheung and Frölicher 2020), and shifts in the distribution of salmon (Cheung et al. 2015). Failure to appropriately consider the cumulative consequences of changing environmental conditions in combination with industrial development may lead to underestimating risks to salmon within EAs.

The Skeena River watershed provides an illustration of how temporal mismatches between EAs and salmon ecosystems can emerge by failing to appropriately consider the current status of salmon or the dynamic nature of the broader ecosystem in which they are embedded. In the same EA described above, the project was predicted to result in the permanent loss of salmon habitat, meeting the definition of serious harm under Canada's *Fisheries Act 1985*. However, the proponent concluded that there would be "no adverse effects on the viability of local populations" (Canadian Environmental Assessment Agency 2016, p. 62). When making this determination, the proponent did not meaningfully consider the current status of salmon populations. The status of salmon was instead based on two sources of information – existing status designations under the Canadian *Species at Risk Act* (SARA) *2002* and field studies undertaken by the proponent. As no salmon species within the Skeena River watershed have been formerly assessed or listed under SARA (in fact, no commercially exploited species such as Pacific salmon have ever been listed under SARA; Schultz et al. 2013; Turcotte et al. 2021), the only information the EA drew upon to characterize the status of salmon was a 15-month field study conducted by the proponent to determine the presence of salmon in the study area. While this field study confirmed the presence of all species of salmon in the EA area, it did not consider any information on the status of the populations these salmon came from, despite the fact that information on salmon status and trends was readily available (Connors et al. 2013). Additionally, the EA made no acknowledgement of the dynamic nature of salmon ecosystems and how the status of salmon populations may change in response to changing environmental conditions as a result of regime shifts or other climate-driven changes. Failure to explicitly and adequately consider status or the dynamic nature of salmon populations in response to changing ecological

conditions therefore gives rise to temporal mismatches and may undermine the assessment of the effects of development on salmon over time.

Ecological fit: functional

Functional fit refers to alignment between the functional linkages in ecological systems (e.g., predator–prey interactions, food webs, energy flows) and governance institutions (Cumming et al. 2006; Epstein et al. 2015). Functional mismatches occur when EAs consider the interlinked components of salmon ecosystems independently, thereby ignoring potentially important feedbacks that can occur within them (**Table 1**; **Fig. 2**; Folke et al. 2007; Lee 1993). As the second-largest salmon producing system in Canada, the Skeena River watershed exhibits high levels of population and species diversity (Gottesfeld and Rabnett 2008). Five species of Pacific salmon spanning more than 900 individual spawning populations utilize nearly every freshwater environment in the Skeena River watershed that is accessible from the Pacific Ocean (**Fig. 3a**; "Pacific Salmon Explorer" 2022). These individual salmon populations play functionally distinct roles that, collectively, are essential to the maintenance of the ecosystem overall. Individual populations are uniquely adapted to their local freshwater environment displaying diverse life-history characteristics in response to the variation in spawning and rearing habitats (Hilborn et al. 2003; Moore et al. 2010; Brennan et al. 2019). Locally adapted life-history traits such as spawn timing, age-at-seaward migration, age-at-maturity, and location of freshwater residence are all a function of the specific habitat conditions (e.g., water temperature, water depth, stream gradient, gravel size) that salmon encounter during their lifetime.

This biocomplexity – the diversity of life history characteristics and local adaptations to the variation in spawning and rearing habitats (Hilborn et al. 2003) – is important to aquatic and terrestrial consumers who often rely on specific populations of salmon distinguished by their unique life-history traits (Willson and Halupka 1995). For example, salmon populations spawning in small tributary streams tend to spawn earlier to avoid colder temperatures that are common later in the year (Lisi et al. 2013). Often these smaller spawning populations are the only salmon available for a substantial window of the salmon-foraging season (Schindler et al. 2013). In the Wood River system (Alaska, USA), which shares many similar characteristics to those of the Skeena, the small streams and the salmon populations they support contribute disproportionately to bear foraging opportunities, accounting for half of total consumption by bears while representing only one-fifth of total salmon production (Armstrong et al. 2020). As a result, any human activities that erode biocomplexity may negatively impact food webs and energy flows in salmon ecosystems (Levi et al. 2012; Armstrong et al. 2020; Price et al. 2021), undermining the overall structure and function of the ecosystem.

While in theory EA processes are intended to support biodiversity management goals when evaluating proposed projects, most EAs do not consider how proposed developments may modify or degrade ecosystem structure and function and salmon populations and their habitats are often seen as substitutable. For example, when significant adverse effects are identified within EAs, most projects are approved because their impacts are thought to be effectively mitigated or justified. However, mitigation is narrowly defined and often focuses on replacing or substituting habitat that is destroyed or degraded to ensure no net loss of habitats. For example, to compensate for the proposed destruction of ~23,000 m^2 of marine habitats used by juvenile salmon during the construction of an LNG terminal in the Skeena River estuary, proposed habitat offsetting measures included creating new habitats such as eelgrass beds, intertidal shoreline habitats, and subtidal rocky reef habitats (Canadian Environmental Assessment Agency 2016). Whether these new habitats function similarly to the destroyed habitat is uncertain. However, given the inherent unpredictability in ecological restoration and species responses, and previous research that suggests that attempts at no net loss have failed (e.g., Lindenmayer et al. 2017; Quétier et al. 2014; Quigley and Harper 2006), compensatory measures appear to be an ineffective strategy for minimizing impacts to biodiversity within EAs. To mitigate adverse ecological consequences, EAs must recognize

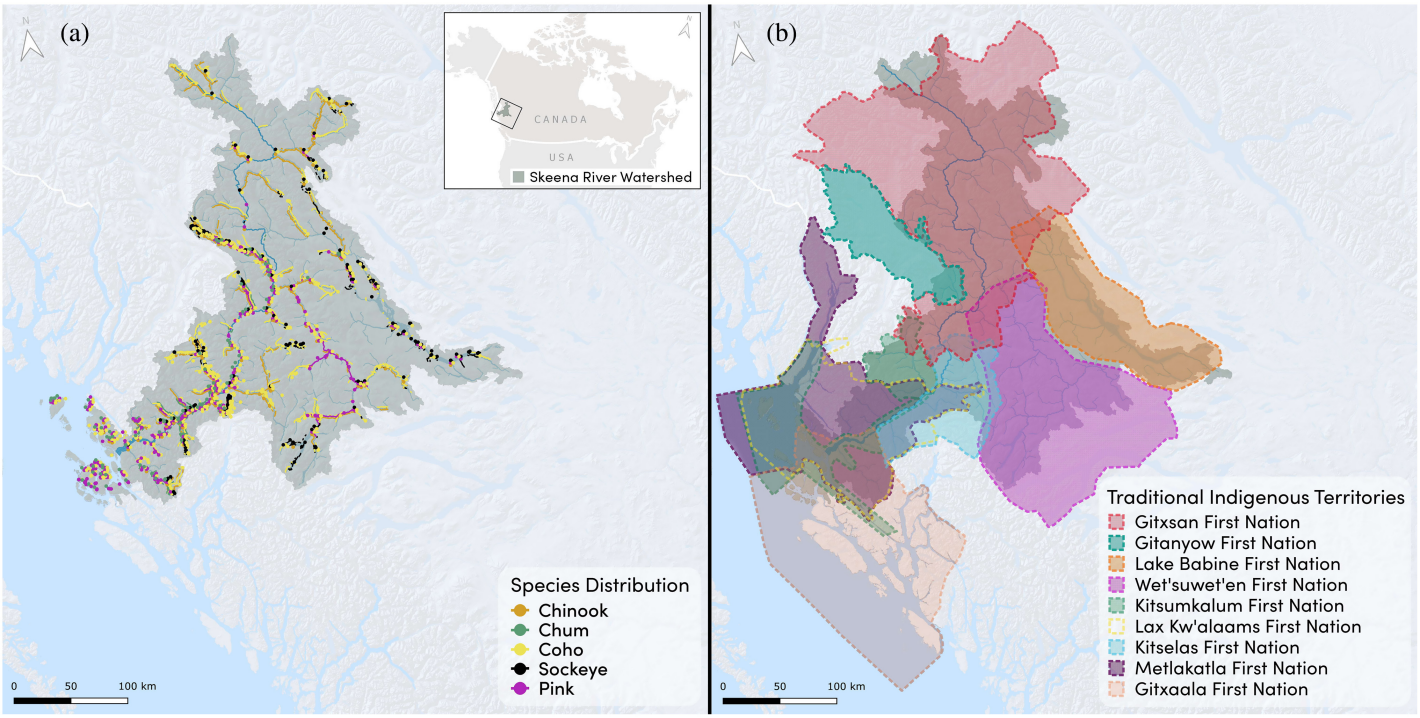

Fig. 3. Illustration of the biological and sociocultural diversity found in the Skeena salmon social–ecological system. (*a*) Distribution of spawning habitat for each species of Pacific salmon found in the Skeena River watershed. (*b*) Approximate traditional territories of Indigenous Nations in the Skeena River watershed. *Note*: The distribution of spawning habitat was mapped based on publicly available information from the Pacific Salmon Explorer (2022). The traditional territories were digitized based on statement of intent maps published by the BC Treaty Commission (2022) and publicly available information available through Native Land Digital (2022). Both maps were plotted using the BC Albers NAD83 projected coordinate system and use publicly available basemap data from ESRI (2022) and the Government of Canada (2022).

the role that salmon play in maintaining the structure and function of ecosystems and ensure that projects do not contribute to the erosion of biocomplexity.

Overcoming ecological mismatches

To conserve the biocomplexity that underpins salmon resilience, EAs must account for the biophysical reality of salmon ecosystems, identify potential losses of, or threats to, salmon biocomplexity, along with their causes, and address their impacts. This includes taking into account the impacts of industrial development at the genetic, species, and ecosystem levels, from local to regional scales, and considering the role that ecological processes, such as migratory patterns for salmon, the role of the species that prey on them, and production of their food species they rely on, play in maintaining system resilience (Gontier et al. 2006). For example, when proposing industrial development plans proponents should be required to account for how small, spatially isolated salmon populations, and the thousands of years of evolutionary adaptations to local environments they embody, are impacted by industrial development projects, individually and cumulatively, to ensure that projects do not homogenize habitats and contribute to the loss of salmon populations or important salmon habitats. Another important strategy for maintaining salmon biodiversity is conserving the processes – both focused and far-reaching – that generate habitat heterogeneity (Moore et al. 2010; Moore and Schindler 2022). This requires protecting the complex landscapes and processes that produce the dynamic habitat mosaics that underpin salmon biocomplexity and recognizing that systems with high

levels of biodiversity and habitat heterogeneity have more opportunities to adapt to, and recover from, inevitable state changes (Schindler et al. 2003; Bisson et al. 2009; Healey 2009; Moore et al. 2010; Lapointe et al. 2014; Moore and Schindler 2022).

Given the enormous spatial scales of connectivity that operate in large river systems like the Skeena, there is also a need to more fully consider how upstream and downstream impacts of human activities can affect the broader salmon ecosystem (Wiens 1989; Stanford and Ward 2001; McCluney et al. 2014; Moore et al. 2015a). Regional Strategic Environmental Assessments (RSEAs) have been proposed as one way to take a whole systems approach and to include both Indigenous and non-Indigenous Peoples in environmental decision-making processes that affect their land, social relationships, and ways of life (Brown and Therivel 2000; Dalal-Clayton and Sadler 2005; Fischer 2007). Regional assessments are designed to systematically evaluate the cumulative effects of multi-sector land and resource uses under different future scenarios (Gunn and Noble 2009; Unalan and Cowell 2019; Buse et al. 2020). In the Beaufort Sea in the Canadian portion of the western Artic Ocean for example, local Indigenous communities and the Government of Canada came together to undertake a RSEA to provide strategic directions and conduct analyses of environmental considerations pertaining to future offshore oil and gas activity in the region (KAVIK-Stantec Inc. 2020). This RESA supported environmental decisions by exploring possible future resource development while considering trade-offs and changes in the state of the ecosystem. A critical aspect of the RSEA included the collection of baseline data, including existing and future stressors and trends such as climate change, and the identification of sustainable thresholds for any identified valued components. In the Skeena River watershed, RSEAs could help to establish a knowledge base relating to the status of salmon populations and their habitats, current activities and development affecting them, the spatial extent and scope of their habitat, and identify appropriate thresholds and management triggers for sustainability assessments for individual projects. This approach would help to address the current fragmentation in the management of human activities that affect the same interconnected salmon ecosystem and improve our understanding of the bigger picture of cumulative effects in a region.

Causes and consequences of social mismatches

Social fit: spatial

Spatial fit refers to the alignment between governing institutions and the scales or levels of social organization (Folke et al. 2005; Armitage et al. 2008; DeCaro and Stokes 2013). In the Skeena salmon SES, spatial mismatches in EAs largely stem from differences in the scales of decision-making between Indigenous governance institutions and colonial environmental governance institutions (Moore et al. 2015b; Atlas et al. 2020; **Table 2**; **Fig. 2**). There are at least nine different Indigenous nations whose traditional territories are found within the Skeena River watershed (**Fig. 3b**). Many of these nations continue to utilize traditional or revitalized local Indigenous institutions to manage and steward their traditional lands and waters. For example, the Gitanyow Nation of the upper Skeena River watershed has developed a comprehensive land use plan (LUP) for their territory (*Lax'yip*) based on the traditional laws and legal principles that have guided the Gitanyow in managing their *Lax'yip* for millennia (Gitanyow Hereditary Chiefs Office 2017). The Gitanyow Lax'yip LUP supports the Gitanyow Chiefs in managing the cumulative effects of industrial development in their *Lax'yip* by outlining specific management objectives and measurable targets required to sustain critical habitats, connectivity, and ecosystem function. However, Indigenous legal systems are not explicitly recognized under Section 35 of the Canadian *Constitution Act*, and contemporary Canadian EA laws and policies are not required to follow or adhere to Indigenous LUPs in EAs or recognize Indigenous laws (Booth and Skelton 2011; McCreary and Milligan 2014; O'Faircheallaigh 2017). This means that the natural resource management systems that Indigenous Peoples have developed based on their own laws and legal principles

are not recognized within EAs leading to mismatches between these locally evolved Indigenous institutional arrangements and state-led EA policies and processes.

Social fit: participation

Participatory fit refers to the alignment between governing institutions and the expectations and psychological needs of individuals affected by them (Viteri and Chávez 2007; DeCaro and Stokes 2013; Madrigal-Ballestero et al. 2013). This dimension of social fit is based on the premise that governing institutions that allow for meaningful stakeholder participation satisfy innate needs for self-determination, procedural justice, and sense of agency. When individuals see environmental decision-making as participatory and inclusive, they are more likely to perceive an institution as fair and endorse a system of governance. This in turn provides intrinsic motivation to cooperate with the rules and leads to higher "institutional acceptance" – how much individuals endorse a system of governance (DeCaro and Stokes 2013).

Participatory mismatches between EAs and salmon SES occur when EA processes and policies do not align with local definitions of participation (**Table 2**). For many Indigenous communities in the Skeena, there is very low institutional acceptance of EA policies and processes (Moore et al. 2015b; Gemeinhardt 2016; Leighton 2016; Marsden 2016; Rupert et al. 2016; Watkinson 2016; Witzke 2016; Canadian Environmental Assessment Agency 2017). This lack of institutional acceptance largely stems from the ongoing failure of EAs to recognize Indigenous inherent rights to self-government and self-determination (Usher 2000; Kirchhoff et al. 2013; Manuel and Derrickson 2015; Eckert et al. 2020). Contemporary EA processes often exclude Indigenous communities from decisions that have the potential to impact the health of the resources they depend on for their social, cultural, and economic well-being (Sallenave 1994; Stevenson 1996; Kirchhoff and Tsuji 2014; O'Faircheallaigh 2017). In the case of the Gitanyow, this has resulted in their exclusion from EA processes related to several large-scale LNG projects proposed for the Skeena River estuary, all of which have the potential to adversely affect the health and abundance of salmon returning to Gitanyow territory (Carr-Harris et al. 2015). This mismatch undermines the agency of the Gitanyow peoples and their efforts to exercise self-determination and their inherent and legal rights to their traditional homelands and resources. As a result, the Gitanyow launched a legal challenge against the proponent of one LNG project and the government of Canada challenging their exclusion from the EA (Bennett 2016). The continued assertion of colonial jurisdiction and law in EA processes in combination with the ongoing failure of the Canadian government to adapt EA policies and processes in ways that recognize and respect the laws, knowledge, and rights of Indigenous Peoples is leading to conflict and litigation over EA decisions in the Skeena River watershed and beyond.

Social fit: values/interests/beliefs

Another important dimension of social fit is the alignment between governing institutions and the values, interests, beliefs, worldviews, and social norms of societies (Ebbin 2002; Clifton and Majors 2012; Meek 2013; Cole et al. 2014). Mismatches often occur because of differences between the underlying values and motivations of state-led EA processes and policies and the communities affected by them (**Table 2**; Trosper 2002). In the Skeena River watershed, EAs have shed light on the contrasting, and often conflicting, belief and value systems of Indigenous communities and contemporary EA policies and processes. Like in many western societies, Canadian EA processes largely reflect colonial capitalistic values of growth, resource extraction, and commodification (Rosser 2006; Curran et al. 2020). These values are frequently at odds with Indigenous values and worldviews which emphasize the conscious protection and sustainable use of the non-human world (Trosper 1998, 2002; Turner et al. 2000; Artelle et al. 2018; Ban et al. 2019; Claxton and Price 2019). For millennia, Indigenous

societies have been guided by a system of ethics that defines the proper use of the land and its resources and instills a sense of respect and reverence for all living things (Turner et al. 2000; Trosper 2002). Leadership authority over land depended upon adherence to ethical and generous behavior as well as sustainable resource management that ensured the long-term productivity of resources under a Chief's control (Trosper 2002; King 2004). Failure to manage the resources properly, such as a failure of the salmon to return, would threaten the leadership position of a titleholder (Trosper 2009).

Beliefs in reincarnation also played an important role in promoting the conservation and sustainable use of natural resources. Because most Indigenous People believed they would personally be reincarnated within their own lineage or clan, reincarnation beliefs encouraged people to make decisions that promoted sustainability and to think about long-term sustainability in the management of natural resources (Turner et al. 2000). Reincarnation beliefs are the basis for the concept of concern for future generations that is a hallmark of Indigenous values and worldviews (Trosper 2009). For instance, central to the Gitanyow LUP is the concept of Wilp sustainability defined as, "the conditions under which ecosystem function, sociocultural and economic well-being are maintained, and risk to ecological integrity is low, thus providing the ecological foundation of the long-term sociocultural and economic well-being of each Wilp" (Gitanyow Hereditary Chiefs Office 2017). Wilp sustainability is based on the concept of *Gwelx ye'enst*, which is the right and responsibility to pass on the *Lax'yip* in a sustainable manner from one generation to another (Simgigyet'm Gitanyow 2021). Ensuring Wilp sustainability is central to protecting the Gitanyow's Aboriginal rights and title and thus underpins all aspects of the Gitanyow's decision-making.

While the Wilp sustainability objectives align in principle with the high-level sustainability goals outlined in Canadian EAs, project approval depends on whether a project is in the public interest, rather than whether it will contribute to net sustainability. There is no barrier to weighting other factors (e.g., economic, political) more heavily than sustainability considerations, or prohibition against making decisions that would exceed ecological limits or otherwise undermine sustainability. Gitanyow hereditary Chief Malii described his frustration with the lack of adherence to sustainability principles in EA decisions, "No matter what the project is, or where it is located, the end result is always the same – no significant adverse effects. Government EAs are about finding ways to mitigate impacts, not about ensuring sustainability or having a real yes or no decision – is the project in our best interests?" (Marsden and Smith 2021). Differences in the underlying values between colonial and Indigenous environmental governance institutions often mean that decisions emanating from EA processes do not align with Indigenous values of sustainability such as those espoused in the Gitanyow LUP, leading to conflict and mistrust over environmental decisions (McCreary and Milligan 2014; O'Faircheallaigh 2017; Artelle et al. 2018; Curran et al. 2020; Eckert et al. 2020; Mccreary and Milligan 2021).

Overcoming social mismatches

Empowering Indigenous governance and management institutions is one avenue for alleviating the negative impacts of social mismatches in salmon SES (Atlas et al. 2020; Herse et al. 2020). In Indigenous knowledge systems, scales and systems of governance are often more attuned to local ecological structures and processes and therefore less prone to the kinds of mismatches that are common in colonial environmental governance institutions (Atlas et al. 2020). Management decisions are informed by detailed knowledge of local biodiversity and ecosystems, knowledge which is generated at fine spatial and temporal resolutions through the harvesting and stewardship of local resources (Turner et al. 2000; Berkes 2009; Sheil et al. 2015; Lyver and Tulianakis 2017; Artelle et al. 2018; Atlas et al. 2020). This detailed on-the-ground knowledge allows Indigenous management institutions to adapt to site-specific conditions and provides a mechanism for enhancing the fit of governance

systems with the ecological systems they are managing from the bottom-up (Brown 2003; Olsson et al. 2007; Galaz et al. 2008).

To date, efforts to align scales of environmental decision-making with scales of ecological impacts have been hindered by underlying power imbalances between colonial and Indigenous governments, which become obstacles to effective environmental decision-making (Goetze 2005; Tipa and Welch 2006; Kotaska 2013; Simms et al. 2016; Atlas et al. 2020; Eckert et al. 2020; Thompson et al. 2020). Hierarchical social relations continue to dispossess Indigenous Peoples of their lands and self-determining authority (Curran et al. 2020). Despite growing partnership and cooperative management rhetoric across Canada, Indigenous Peoples continue to be largely excluded from settler colonial environmental governance frameworks and are under-represented in decision-making processes (Boelens et al. 2012; Daigle 2018; Arsenault et al. 2018; Diver et al. 2019). As currently enacted, top-down Canadian federal EA processes do not enable equitable power sharing with Indigenous Peoples. Consequently, Indigenous Peoples have few mechanisms to meaningfully engage and effectively influence decision-making through state-led EA processes (Gibson 2012; de Kerckhove et al. 2013). Empowering Indigenous institutions in EAs will require a fundamental redistribution of power within the Canadian environmental decision-making landscape.

In Canada, a number of different policy agreements have shifted regional decision-making agency toward Indigenous governments in both co-management and government-to-government processes (Wyatt 2008; Berkes 2009, 2021; Housty et al. 2014). However, these collaborative decision-making approaches are not without challenges. In many cases, colonial governments remain reluctant to share authority with Indigenous Peoples or, in instances where co-governance has been established, fail to substantively acknowledge Indigenous rights, knowledge, governance authority, and legal systems (Klain et al. 2014; Simms et al. 2016; Bennett et al. 2017; Curran et al. 2020). For example, in the Yukon Territory in northern Canada, modern land claim and self-government agreements acknowledge Yukon First Nations as an order of government in Canada with jurisdiction over clearly defined territories. However, despite the presence of land claim agreements that include power sharing with Indigenous governments, there are real and significant limitations of the Indigenous rights outlined in these agreements including in the authority to make decisions and to have jurisdiction over the waters within their traditional territories (Wilson 2020). This example illustrates that effective co-governance does not just require the legal acknowledgement of rights and authority but also the ability to exercise these rights. Realizing the benefits of co-governance will require rethinking jurisdictional arrangements associated with environmental decision-making to move toward acknowledging joint and, in some cases sole, Indigenous jurisdiction and independent Indigenous legal and governance systems.

Increasingly, Indigenous law is directing environmental decision-making and, in the process, changing the landscape of environmental governance in Canada (Curran et al. 2020). In 2021, the Gitanyow Hereditary Chiefs and the governments of BC and Canada signed the Gitanyow Governance Accord – a tripartite agreement that commits the Gitanyow, the Province of BC, and Canada to revitalizing and achieving legal recognition of Gitanyow hereditary governance, including Gitanyow self-government ("British Columbia Ministry of Indigenous Relations and Reconcilation" 2021). As part of the Accord, the Gitanyow developed the *Gitanyow Wilp Sustainability Assessment Process* (GWSAP), a modern Indigenous legal instrument that sets out requirements for Indigenous-led assessments of industrial development projects in Gitanyow *Lax'yip* based on the Gitanyow's own laws (Simgigyet'm Gitanyow 2021). The GWSAP requires "all actors (e.g., companies, state governments) to follow Gitanyow strategic direction, such as the Gitanyow Lax'yip LUP, and prohibits proposed projects from accessing the *Lax'yip* without the consent of the impacted Wilp. Everything in the GWSAP is Gitanyow-led in order to uphold the *Ayookxw* (Gitanyow law), ensure

Wilp sustainability, and inform the decisions of impacted Wilp about whether to grant free, prior and informed consent (Marsden and Smith 2021)." The GWSAP signals a fundamental change in the status quo through the redistribution of power and recognition of the Gitanyow's rights to self-government and self-determination as expressed through their laws, customs, and values – a critical ingredient for achieving good social fit.

While shifts toward more collaborative governance models certainly provide opportunities for the resurgence of First Nations communities and their own governments (Adams et al. 2014), we must be cognizant of the risks they present for reinforcing existing power relations or channeling assertions of Indigenous rights into state-based administrative and legal processes, like EAs, that ultimately feed into unilateral decision-making by the state. If we are not careful in the revitalization of Indigenous institutions, this can result in First Nations taking on increasingly "state-like" forms of governance which fail to reflect their relationships to the land (Nadasdy 2003, 2017; Wilson 2020). If co-governance arrangements are to be successful, Indigenous Peoples cannot be forced to engage in governance systems that are shaped by settler understandings and worldviews. Effective co-governance arrangements will need to support and empower existing and (or) emerging forms of Indigenous governance and management grounded in their ancestral legal traditions, such as the Wilp-based governance structure of the Gitanyow First Nation. This will require recognizing Indigenous jurisdiction and legal orders in EA processes and policies and accepting that there is no longer a unilateral crown decision-maker – there are also Indigenous decision-makers with delegated authority.

Pathway forward

Over the past century, salmon SESs across Canada have become increasingly decoupled as a result of colonization. Colonial acts of dispossession and assimilation have severed Indigenous Peoples' access to salmon, dispossessed them of their lands and waters, and removed them as sovereign governments taking care of their ancestral territories. In the process, complex systems of Indigenous governance and resource management that were once able to enhance social–ecological fit have now been systematically dismantled. Today, many long-established salmon SESs are mismatched with colonial environmental governance institutions, including Canadian federal EAs. This problem of fit is undermining the resilience of Pacific salmon, and the diverse cultures and communities they support.

I argue that ultimately solutions to overcoming mismatch do not lie in amending EAs to better account for salmon SESs but rather in developing more stringent and effective laws that protect salmon biocomplexity. The current patchwork of colonial laws and policies governing natural resource management in Canada is failing to protect salmon and the coupled SESs they are part of. This is, in part, because contemporary environmental governance institutions are ill equipped to effectively safeguard the biocomplexity of salmon ecosystems that is a hallmark of their resilience. Reconciling problems of fit will require strengthening the legal mechanisms for protecting salmon biocomplexity to ensure that salmon, and the social, cultural, and economic benefits they provide, can thrive and persist.

The need to protect salmon and their habitats has long been recognized and was a driving motivation behind the development of Canada's national policy for the Conservation of Wild Pacific Salmon (known colloquially as the Wild Salmon Policy; Fisheries and Oceans Canada 2005). The primary goal of the Wild Salmon Policy is to conserve and protect the diversity of wild Pacific salmon and their habitats. While the Wild Salmon Policy has been broadly endorsed (e.g., Cohen Commission; Cohen 2012), the Government of Canada has struggled to implement it in a meaningful way. This is in part due to the lack of legal instruments to enforce adherence to the policy in resource management decisions. This has meant that the policy has only served to offer guidance for the conservation and management of salmon but lacks any clear enforcement mechanisms when it comes to ensuring

that salmon, and the ecosystems they are part of, are not adversely impacted by human activities. Recent amendments to Canada's *Fisheries Act 1985* have strengthened legal requirements to ensure that major fish stocks are sustainably managed and to rebuild them if they decline to low levels. However, by focusing on stock aggregates it is unclear how salmon biocomplexity will be meaningfully considered under the Act. Furthermore, many of the threats that salmon experience (e.g., degradation of freshwater spawning and rearing habitats) are encountered during the freshwater phase of their life cycle, a jurisdiction where federal authority is lacking. Although responsibility for fish habitat resides with Fisheries and Oceans Canada, the Province of British Columbia also has a mandate to regulate land and water use. Through acts and regulations linked to this mandate, the Province can greatly influence the extent to which fish habitat is affected largely through the management of human activities (e.g., logging, urban development, water withdrawals). In examining the effectiveness of provincial legislation and regulations in protecting and restoring salmon, however, British Columbia's Auditor General (Office of the Auditor General of British Columbia 2004) found that the provincial government had no formal legislation to protect salmon habitat and that freshwater salmon habitats remain vulnerable to degradation as a result of cumulative anthropogenic stressors.

Endangered species legislation is another mechanism through which Canada has sought to protect salmon biodiversity. The Canadian *Species at Risk Act* (SARA) *2002* aims to identify species at risk of extinction, protect them from further harm, and establish programs to support their recovery. Yet despite its explicit focus on the conservation of biodiversity, the SARA falls short of protecting salmon biodiversity due to the consideration of socioeconomic factors in addition to the available scientific information on extinction risk (Waples et al. 2013; Turcotte et al. 2021; Office of the Auditor General of Canada 2022). Furthermore, the SARA only comes into play once a species faces an imminent risk of extinction. Reactive policies like this are arguably too little too late to be an effective mechanism for conserving biodiversity. For instance, out of the more than 300 species assessed since SARA first came into effect in 2004, no species have fully recovered and the majority of species still remain at risk (Office of the Auditor General of Canada 2022).

There is growing recognition that Indigenous laws, governance, and management can offer pathways for the effective conservation of nature (Turner and Berkes 2006; Polfus et al. 2016; Artelle et al. 2018; Ban et al. 2018; Atlas et al. 2020). Indigenous societies have been shaping and sustaining ecosystems for more than 12,000 years (Ellis et al. 2021), and there is evidence that Indigenous managed lands and waters are some of the most biodiverse areas remaining on the planet (O'Bryan et al. 2021). Enduring Indigenous institutions have arisen, in part, from their need to consider and protect the natural properties of salmon ecosystems in harvesting and management practices (Lepofsky et al. 2005; Campbell and Butler 2010). Indigenous resource management systems recognize the links between salmon, people, and ecosystems, thereby producing resilient human–salmon relationships. Indigenous laws coded in oral stories have provided direct guidance on how to manage human relationships with salmon ecosystems for millennia (Nelson and Shilling 2018). Traditional Indigenous societies had sophisticated laws and property rights institutions that supported the sustainable use of lands and resources and promoted harvesting practices that ensured that local salmon populations returned year after year (Trosper 1998, 2003; King 2004; Johnsen 2009). While colonization has suppressed Indigenous governance, Indigenous nations are reasserting their right to govern their lands and waters according to their traditional laws. The Gitanyow First Nation have shown how traditional Indigenous laws can be applied in contemporary environmental decision-making contexts and help to support the protection of salmon biocomplexity. Restoring the capacity for Indigenous Peoples to manage the landscape according to their values, customs, cultural practices, and laws offers a potential pathway for overcoming the negative consequences of mismatches and for fostering resilient salmon SESs.

Other efforts to provide more stringent legal protections for salmon include a global movement to extend legal rights to nature. The "Rights for Nature" movement aims to secure basic fundamental rights for nature, just as humans have rights, and the right for ecosystems to exist, flourish, regenerate, and naturally evolve without human disruption. To date, more than 20 countries worldwide have recognized the rights of nature at some level of government (Challe 2021). In 2008, Ecuador became the first country in the world to formally recognize and implement the Rights of Nature in its constitution. The Constitutional Court has since upheld these rights including in a recent ruling in which the court ruled that the Los Cedros cloud forest had a right to be protected from activities that threatened its existence ("Los Cedros and the Rights of Nature" 2022). Similar cases have been brought forward in New Zealand, Colombia, India, Peru, Argentina, Pakistan, and the United States (Challe 2021). The Yakama Nation and the Sauk-Suiattle Indian Tribe in the United States recently sued the city of Seattle on behalf of salmon alleging that the city's hydroelectric dams fail to provide passage for salmon and thus violated salmon's right to exist (Lee 2022). While the Rights for Nature movement is gaining momentum, it remains unclear how successful these lawsuits can be in gaining adequate, long-term protection of salmon ecosystems. However, a growing number of lawsuits involving the rights of nature might set a precedent for national and local governments to act on biodiversity conservation by opposing human activities that might prove destructive to a particular ecosystem. The lawsuits also draw attention to environmental justice issues faced by marginalized communities, particularly Indigenous communities, who are stewards of these natural ecosystems and whose livelihoods and cultural and spiritual practices depend on them.

Moving forward, we need to rethink our relationship with nature and reimagine how salmon are considered in environmental decision-making processes. The resurgence of Indigenous laws, governance, and management combined with recent advances in the development and application of nature-based rights offer two potential pathways for strengthening protections for salmon ecosystems and salmon-dependent communities. The path forward will need to draw from these types of solutions to problems of fit if there is to be any hope for addressing current mismatches in salmon SES.

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Author contributions

KC conceived and designed the study. KC performed the experiments/collected the data. KC analyzed and interpreted the data. KC contributed resources. KC drafted or revised the manuscript.

Competing interest statement

The author declares there are no competing interests.

Data availability statement

The data shown in **Fig. 3a** are publicly available from the Pacific Salmon Explorer (2022) and for **Fig. 3b** from the BC Treaty Commission (2022) and the Native Land Digital (2022). Both figures use publicly available basemap data from ESRI (shaded relief) and the Government of Canada (Province and Territory Cartographic Boundaries).

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