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Indigenous stream caretaking for Pacific salmon: ancestral lifeways to guide restoration, relationships, rights, and responsibilities

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Abstract

Restoring the relationships, rights, and responsibilities of Indigenous Peoples to their salmon kin is central to a sustainable and just future with Pacific salmon, particularly as Nations lead the restoration of freshwater salmon habitat in their territories. As a group of Indigenous and non-Indigenous researchers from across British Columbia, we come together in a respectful and transparent way to uphold ancestral Indigenous Pacific salmon stream caretaking knowledge, longstanding Indigenous rights and relationships to land and waters, and our joint responsibilities to care for these watersheds. To do this, we begin by describing traditional governance systems that house Indigenous salmon stream caretaking practices. Through a literature review and conversations with co-authors, we then describe eight Indigenous salmon stream caretaking practices. Finally, we share three contemporary focal stories of Indigenous salmon restoration projects that uphold ancestral knowledge; "Syilx sockeye restoration", "səlilwətaɬ (Tsleil-Waututh) led salmon habitat restoration in xʔəʾɬilwətaʔɬ (Indian River Watershed)", and nuučaanuɬ (Nuu-chah-nulth) Peoples and salmon: responsive methods through steadfast lifeways'. We present stream caretaking knowledge and the focal stories as learning opportunities that may guide future human-salmon relationships and restoration.

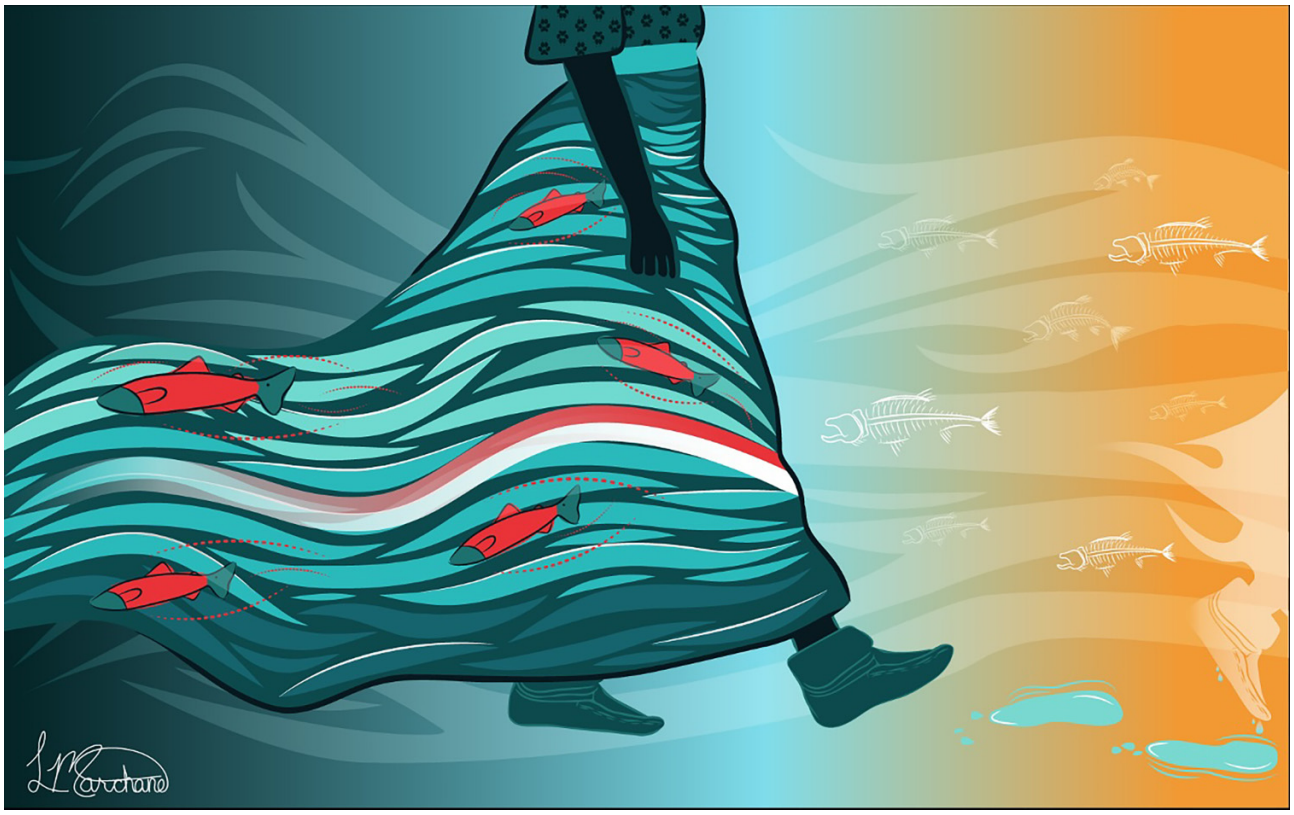
Key words: Pacific salmon, Indigenous restoration, stream caretaking, salmon restoration, Indigenous stream governance, Indigenous lifeways

Introduction

Social-ecological crises are profoundly altering ecosystems and inequitably impacting communities, spurring recognition of the need to centre equity and diversity in restoration, management, and conservation (Brown and Brown 2009; Corntassel 2012; Elias et al. 2021; Parsons et al. 2021; Salomon et al. 2023). These crises are impacting Indigenous lands and waters that have been cared for over generations through ancestral knowledge and governance systems. In various ecosystems, from forests (Dickson-Hoyle et al. 2022), to beaches (Wickham et al. 2022), to rivers (Fox et al. 2017), guided by ancestral knowledge, Indigenous Peoples are restoring their lifeways and caretaking practices by asserting their rights and relationships with the land. Within the Pacific salmon (*Oncorhynchus* spp.) region, from California to Alaska, Indigenous Peoples have developed deep, reciprocal relations with their salmon kin over thousands of years. These relationships continue today despite declining salmon populations, degradation of freshwater salmon habitat, and fisheries management that too often ignores generational Indigenous rights and relations to lands and waters (Fig. 1, Atlas et al. 2021; Coté 2022; Reid et al. 2022; Esquible et al. 2024). Indigenous Peoples' relationships with their salmon kin offer an incredible learning opportunity to guide salmon habitat restoration that embraces ancestral Indigenous knowledge, for the potential benefit of all (see Table 1 for key definitions).

We (the co-author team) are a group of researchers, both Indigenous (belonging to First Nations in what is known today as British Columbia) and non-Indigenous, connected

Fig. 1. Transform to restore (Lauren Marchand, 2023). Syilx illustrator Lauren Marchand created "Transform to restore" as an intention-setting image, to articulate the goals and vision expressed by the collaborative at an author workshop on 26 June 2023. "*Ancestral energy surrounds us, guiding Indigenous People through time. Salmon remains return to water for abundance, sustaining today's Indigenous communities. Present-day Indigenous People bear equal responsibility for the land. Coyote prints symbolize transformation, navigating two worlds with unchanging teachings. Orange and blue colours symbolize the balance between the past and present.*" Artist statement by Lauren Marchand, 2023. (Supplemental Material A).



by our concern for Pacific salmon, our work to support the resurgence of Indigenous salmon stewardship, and our commitment to conduct research and restoration in a more respectful, holistic way. Respect, inclusion, transparency, reciprocity, and consensus have guided this process. These principles connect each member, and their unique position, context, and knowledge, allowing for sharing across Nations, communities, and contexts. The author group includes members of, and/or people working on behalf of, the following Nations: X̲aayda (Haida), Nisg̲a'a, Syilx, səlilwətaɬ (Tsleil-Waututh), and two nuučaanuɬ (Nuu-chah-nulth) Nations, ƛaʔuukʷiʔatḥ (Tla-o-qui-aht) and Hupačasath. We draw from these unique knowledge systems and their shared values and practices. We are students, mentors, researchers, and knowledge carriers, and with that comes the responsibility to ensure that future generations understand the complexity of our world.

We hold collective understandings that guide our work. We acknowledge that as researchers we have a responsibility to uphold Indigenous rights (Ignace et al. 2023); thus, we aim to co-create research that supports Indigenous self-determination of salmon systems (United Nations 2007; Harris 2008; Sayers 2021). Within research, we carry the obligation to adhere to Indigenous data protection and research protocols (such as the First Nations Information Governance Centre's Principles of OCAP ® (data ownership, control, access, and possession) and Nation-specific research agreements) (Ignace et al. 2023; Cannon et al. 2024). Our work acknowledges how Indigenous rights are woven together with responsibilities to lands and waters, as the "cultural and political are joined and inseparable, and they are both generated through place-based practices–practices that require land" (Simpson 2017, pp. 49–50). We remind ourselves that land and water are inseparable. We consider rivers as more than bodies of water but as "holistic, historical, and cultural agents with lives and rights of their own" (Hikuroa et al. 2021, p. 67). As veins and blood are important to the functioning of our bodies, so are the rivers and waters important to the functioning of our world. We know that within the context of many Indigenous legal orders, salmon and other fishes have agency and rights, with "whom humans share territories, stories, and reciprocal duties" (Todd 2017, p. 138). We understand that Indigenous knowledge is living and adaptable and has not been extinguished, but suppressed and driven underground, and therefore can be (and is being) reawakened (Corntassel 2012; Simpson 2017, Table 1). "Because sometimes it's not teaching them (Indigenous Peoples) something new, but waking up, waking up ancestral knowledge" (K̲ii'iljuus Barbara Wilson 4 August 2023). Finally, we believe that for sustainable, thriving futures, we need to work together to create active,

Table 1. English language glossary of key terms (in order of appearance in main text).

Term	Definition
Stream caretaking	Place-based, deliberate actions woven into governance and lifeways that maintain healthy salmon stream habitat, strong salmon populations, and equitable human-salmon relationships[a,b]
Ancestral Indigenous knowledge	Living, adaptable knowledge that informs lifeways, practices, and beliefs. Knowledge that is embedded within oral histories, that span generations, and is collected through centuries of being on the land, observing changes and patterns[c,d]
Reawaken	To acknowledge, uphold, honour, and respect Indigenous knowledges ignored, outlawed, or suppressed by colonization [e,f,g]
Indigenous-led salmon restoration	Actions taken to create or care for salmon habitat, support salmon populations, and repair relationships between people and place[h,i]
Transparency	Working together without hidden facts, actions: Living your words[j]
Lifeways	The ways Indigenous Peoples conduct themselves in the world daily, guided by certain practices, principles, and laws. Lifeways encompass all aspects of life, both tangible and intangible. For example, lifeways include understanding and acting on the seasonal cues, asking permission before harvest, and not taking the biggest fish[g,k]
Indigenous governance	Systems of responsibilities tied to specific territories that flow through the hereditary leaders. These systems implement legal and guiding principles through social structures and place-based practices. The underpinnings are respect, responsibility, and transparency to maintain balance in social-ecological systems[l,m,n]

[a]Langdon (2006).
[b]Thorton et al. (2015).
[c](personal communication, Kii'iljuus Barbara Wilson 9 October 2023).
[d]McGregor (2021).
[e](personal communication, Kii'iljuus Barbara Wilson 4 August 2023).
[f]Corntassel (2012).
[g]Simpson (2017).
[h](Hill et al. (2021).
[i]Todd (2017).
[j](personal communications, Niis Wes Gidansda to Kii'iljuus prior to 2009).
[k](personal communication, Kii'iljuus Barbara Wilson 4 August 2023).
[l](personal communication, Kii'iljuus Barbara Wilson 9 October 2023).
[m]Brown and Brown (2009).
[n]McHalsie (2007).

holistic care for systems and to be transparent about our intentions, understandings, and processes as we have been here.

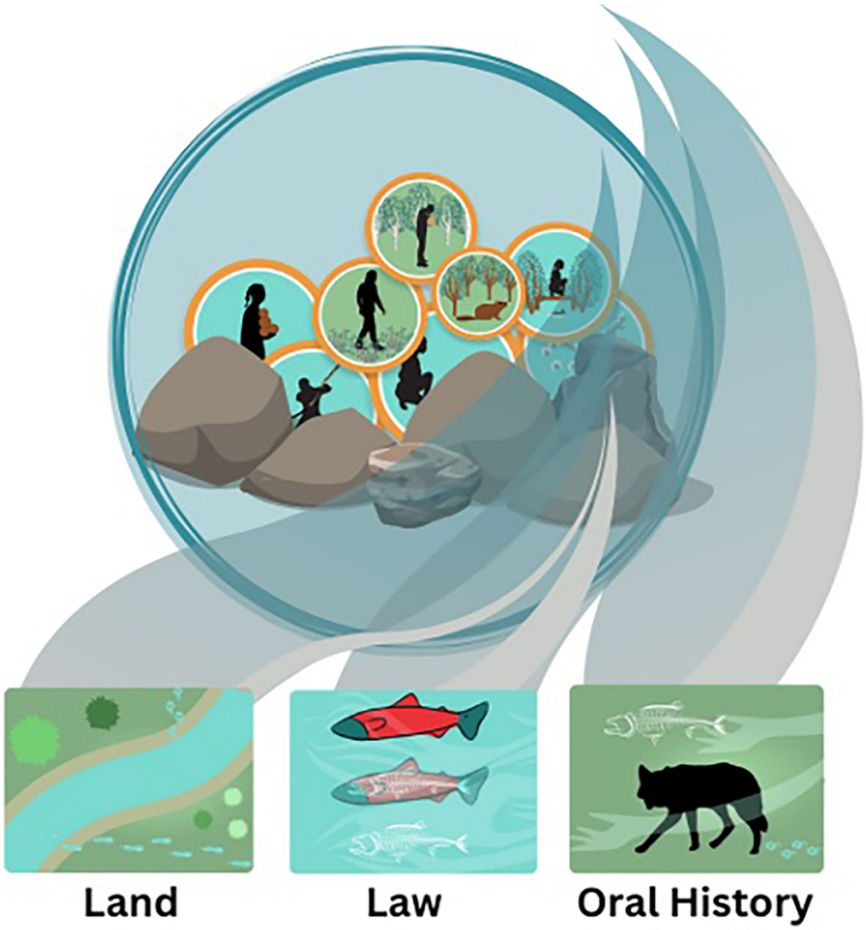
It is with both urgency and care that we gather Indigenous knowledge of human-salmon relationships and recognize its value in guiding restoration activities today. The intention of this paper is to uphold ancestral Indigenous knowledge of Pacific salmon stream caretaking, longstanding Indigenous relationships and rights to land and waters, and our shared responsibilities to care for these ecosystems. Given the resurgence of Indigenous sovereignty (Brown and Brown 2009; Coulthard 2014; Simpson 2017), the gravity of climate change (IPCC 2023), and the declining trend observed for many wild Pacific salmon populations (Price et al. 2017; Pacific Salmon Explorer 2022; Reid et al. 2022; Atlas et al. 2023), this gathering of knowledge comes at critical point in time and will add to the growing momentum of Indigenous-led restoration. In this paper, we gather and bring attention to specific Indigenous stream caretaking practices to support restoration of Pacific salmon streams. We begin by describing how certain Indigenous governance systems house stream caretaking practices. We then illustrate eight examples of Indigenous stream caretaking practices. Finally, we present three focal stories of current Indigenous-led Pacific salmon habitat restoration that uphold ancestral knowledge in a contemporary context. Collectively, this paper illuminates opportunities for restoration activities that can transform salmon habitat, support healthy salmon populations, and strengthen human-salmon relationships.

Methodology

This collaboration focuses on First Nations across the land now known as British Columbia (BC), Canada, with some examples from other Pacific salmon regions such as coastal Alaska, USA. With more than 200 Nations in BC, practices, laws, and oral histories vary due to distinct or isolated languages, locations, and cultures. The following work represents only a fraction of the complex realities across these divergent yet interrelated systems. While multiple Indigenous knowledge systems are represented here, this does not (and cannot) represent all Indigenous salmon knowledge.

The knowledge presented here was gathered through both literature review and documented conversations with Indigenous knowledge holders included in the authorship team To put emphasis on alternate, Indigenous-led resources, we accessed sources both in and outside of academic publishing, such as Nation websites and reports. For a complete list of sources used in our review of knowledge documenting stream caretaking, please refer to Supplemental Material B. We also included direct quotes as much as possible to amplify the voices of Indigenous knowledge holders and not transform their original context, tone, and intention. We augmented what was written in the literature with conversations and stories shared within the author group. These stories were a non-structured method of gathering knowledge that brought depth to the work beyond the published literature. As Margaret Kovach (2021, p. 156) describes, "Story nurtures relationship. Story kindles reciprocity. Story compels

Fig. 2. Governance systems house Indigenous salmon stream caretaking practices (Artwork by Lauren Marchand, 2023). Orange circles showcase eight Indigenous stream caretaking practices that are bound to and flow from the land, protected and maintained by law, and guided by oral histories. Governance systems house stream caretaking practices, and mandate how, when, and where they are implemented.



responsibility. Story thrives where there is respect. Story is a gift. And in research, this changes everything." Throughout the paper, particular attention is given to language used, and the notions and histories related to certain terms. Particularly, for stream caretaking practices, we have opted to use terms that better reflect Indigenous ways of knowing than those more technical or jargon-heavy and prominent in the literature.

Indigenous stream governance

Indigenous salmon stream caretaking was, and continues to be, embedded in complex governance systems that mandate how, when, and where practices are implemented (Table 1). Caretaking practices are guided by language, stories, and oral histories that are shared across generations through ceremony, laws, and lifeways (Reid and Ban accepted) (Fig. 2). As we discuss governance systems and stream caretaking practices below, we use the present tense. Many of these activities are still enacted today, while in other cases, colonial interference has disrupted them. By using present tense, we are acknowledging the continued role and presence of Indigenous Peoples on their territories and within their salmon systems.

While each Nation is unique, there are common understandings, including that people are part of ecosystems and hold relationships with the land, water, and all creatures, and that salmon have their own rights and personhood (Berkes et al. 2000; Langdon and Sanderson 2009; Claxton and Price 2020; Johnson 2020). Caretaking practices are generally maintained and protected through law and guided by oral history. Families and individuals hold inherited responsibilities to specific territories such that decisions, like when and where to harvest, are overseen by a hereditary leader or the person assigned that responsibility (McHalsie 2007). The responsibility for the territory is often passed on across generations within families alongside intergenerational learning (Jones 2002; Haida Marine Traditional Study Participants et al. 2011; Atlas et al. 2021). Oral histories provide important teachings on how to care for rivers and fish, harvest, and live in relationship with salmon (George 2003; Carothers et al. 2021; Morin et al. 2021). Responsibilities within governance practices provide the guidance and foundation for effective stream caretaking, create and protect important structures that maintain human-salmon relationships, and are vessels that carry

stream caretaking practices through time and space. Importantly, restoration activities that attempt to apply caretaking practices outside of their governance context risk being unsuccessful or potentially harmful. As language underpins law and influences its interpretation, we have included Table 2, outlining some key governance terms from four Nations represented in the authorship team. This table highlights some differences and similarities in core principles of governance approaches among Nations. See Supplemental Material C Table C.1 for additional terminology.

Indigenous stream caretaking practices

Within Indigenous governance, stream caretaking practices are conscious, deliberate actions woven into lifeways that maintain healthy salmon stream habitat, contribute to strong salmon populations, and equitable human-salmon relationships (Fig. 3). Stream caretaking is also practiced through the limitation of these practices in areas of importance such as salmon spawning grounds. We reiterate that the application of these caretaking practices outside of their governance context do risk causing harm or failing to benefit salmon and the communities they are connected to.

Assessing systems health

Ecosystem health is assessed through being on, and living in relationship to, the land (Turner and Reid 2022) (Fig. 4). Assessing system health is a holistic version of active stream monitoring. Nisga'a, like many First Nations, hold knowledge of what plants are blooming at specific times when salmon species are active or migrating, supporting a "highly developed capacity for building up a collective database" (Corsiglia and Snively 1997, p. 4). Kii'iljuus Barbara Wilson describes how for the Haida, "*our phrase "Sk'awGan Gaalang skaasda" tells us specifically that when the salmon berries ripen and turn colour overnight, then it is time to go to the west coast to catch TaaGun (spring salmon). The action of the berries' turning colour is like the phosphorescent trails made by the salmon as they swim at night.*" (Kii'iljuus Barbara Wilson, Haida, in Wilson et al. 2022). Thus, Haida kuuniisii (ancestors) "*used berries as a calendar to tell us about the timing of what is happening under the waters of our oceans*" (Niis Wes, n.d in Wilson et al. 2022). Over generations, assessing system health creates understandings of natural stream habitat patterns, acknowledges changes in patterns, and works within seasons to time actions and caretaking activities accordingly. From this collective knowledge, stream caretaking practices can be undertaken to maintain optimal habitat conditions and reduce variability and uncertainty. Today, climate change is disrupting the predictability of many natural cycles, leading to possible constraints in maintaining traditional caretaking practices (Proverbs et al. 2021; Charlie et al. 2022; Turner and Reid 2022). For example, salmon jumping in inlets and river mouths in the fall used to be an indicator of abundance of a returning run. Within Nuu-chah-nulth territories warmer ocean temperatures, particularly on the surface, are resulting in salmon residing lower in the water and not jumping out (personal communication Jared Dick 13 May 2025). While constraints are present, Nations continue to practice active monitoring in a changing climate. New indicators are emerging to understand patterns within systems, contributing to these evolving, cumulative databases over time (Wale and Parrott 2024).

Enhancing salmon migration

There are many accounts of Indigenous Peoples enhancing salmon migration by removing barriers to upstream spawning grounds (Corsigilia and Snively 1997; Jones 2002; Langdon 2006; Carothers et al. 2021) (Fig. 5). Sometimes wrongly equated to colonial stream cleaning that focused on removing all stream material (Dolloff 1986), enhancing salmon migration aims to maintain habitat connectivity by selectively removing material that blocks upstream spawning habitat at most normal water levels (such as logs, branches, sediment, and rocks) while leaving other stream material in place that provides rearing habitat complexity or carries other known benefits. This enhancement of salmon migration is governed by the people and families that hold hereditary rights to specific streams and decisions are made that take into account seasonality and holistic watershed dynamics. For example, Tlingit salmon stream trustees hold both an obligation and intergenerational knowledge to ensure that adult salmon can successfully pass from the estuary into the stream (Langdon 2006).

In Haíłzaqv (Heiltsuk) practice, in the spring prior to spawning, those who hold harvest rights remove trees and branches that fall during winter and block access to upstream spawning habitat (Jones 2002). Logs and branches in streams that do not block passage, and contribute to creating rearing or resting habitat, are not removed (Jones 2002). Rocks are generally not removed as they provide habitat for fish to rest or hide from predators, but, if necessary, they may be repositioned in the stream bed to allow for upstream passage (Jones 2002). In areas where material is unable to be cleared or where passage is impeded by sediment accumulation, small trenches in the gravel are created for salmon to pass through (Jones 2002). Generations of Haíłzaqv caretaking supported enhanced salmon migration as described by Cyril Carpenter "That's how badly the rivers can be blocked by windfall and debris. The salmon could not go up there. Our ancestors knew this, they saw this and they were part of the manpower that kept all these rivers clear so they could guarantee that the salmon would come back. They had a farming system in place… I was always told by the old people that we have to look after the river" (Cyril Carpenter, Haíłzaqv, in Jones 2002, p. 166).

Similarly, for people from the ʕaaḥuusʔatḥ Nation (one of the nuučaanuł Peoples), enhancing salmon migration is a duty that requires understanding system balance and salmon behavior. ʕaaḥuusʔatḥ people remove material to avoid washouts that may damage salmon redds, yet streams are not completely cleaned out. Log jams and big pieces of wood are often left as they provide protection for salmon and eggs, specifically in the fall when the waters rise so "fish could dig down beside the logs in the gravel" (George 2003, p. 73). Through ancestral knowledge and hereditary responsi-

Table 2. Nation-specific governance language from the Nations represented by the authorship team.

Haida	Nisga'a	nuučaanuł (Nuu-chah-nulth)	Tsleil-Waututh	Syilx
Kil Yahdas—law	**Ayuuk̲**—law[e]	**hl̓awiłmis**—laws	*Language revitalization ongoing, unable to confirm term at this time*	**Stɬtaɬt**—Translated to Title and Rights; til is an exact line between two points. Used in the context of the syilx relationship with the land, *stɬtaɬt* refers to the truth that connects the syilx to our skčxʷipla? **skčxʷipla?**—The laws and discipline given to the syilx People by Creator that sets out the way that all of creation relates to each other and teaches people how to live in relation to all other life[i]
k̲'aaygang.nga—long, long ago ancient stories[a]	**Adaawak̲**—oral histories [e]	**hahuupa**—teachings[f]	**snəẘeyəɬ**—teachings and ways of being[h]	***captikʷɬ***—sacred texts; teaching stories and oral traditions; creation stories that hold the laws [i]
Tllgaay or **Tllga**—land, ocean and people for which a hereditary chief has responsibility and authority to caretake[b]	**Ango'oskw**—territory for hunting/fishing, taken care of through inherited responsibilities[e]	**ḥahw̓uuɬi**—a chief's territory	*Language revitalization ongoing, unable to confirm term at this time*	***qaɬyilmixʷm***—*hereditary Chief of a syilx tribal area or a syilx Village—also used for Hereditary Salmon Chief*
Tllgaay—the land	**Ts'eets'iks**—the land[e]	**nisṁa**—the land[g]	**təməxʷ**—the earth, the entire world, the territory, the environment	***tmxʷulaxʷ***—*the land, waters, and place as cycles. From root word tmixʷ—all the lifeforms that exist as a lifeforce of a place*
TllX̲anda—stewardship, to take care of[b] **Gina G̲a K̲yaht'as**—to look after everything	**Haboo̲ldi**—keep/look after something (to)[e]	**ʔuuʔaaɬuk**—taking care of	*Language revitalization ongoing, unable to confirm term at this time*	**səxʷtxtə̀m**—caretaking[i]
Gina 'waadlux̲an gud ad kwaagid—everything depends on everything or Interconnection	**Sayt-k'i̲lim-goot**—to be united with one heart, one path, one nation (literally one heart)[e]	**hišukʔiš čawaak**—everything is one, everything is interconnected	*Language revitalization ongoing, unable to confirm term at this time*	**skčxʷipla?**—The discipline given to the Syilx People by Creator that sets out the way that all of creation relates to each other and teaches people how to live in relation to all other life[i]
Yahguudang—all acts must be done with respect. We respect each other and all living things[c,d]	**Kwhilx̲oosa'anskw**—have/show respect (to)[e]	**ʔiisaak**—respect	**ʔaχʷəstəl̓**—reciprocal giving, reciprocity	***xˇaʔxˇaʔstiṁ***—*to hold sacred, or in high ceremonial respect*
K̲'uuljaad—matriarch **Nang jaada k̲'uulas**—boss woman **Iitl'lgaay**—village chief **Kilslaay**—chief not living in his own village or a highly respected person	**Sigidimnak̲'**—matriarch[e] **Sim'oogit**—chief[e]	**Hakuum**—a woman of high rank	*Language revitalization ongoing, unable to confirm term at this time*	***sḵʷumə̀lt***—*a woman Chief in Southern Syilx and in Northern Syilx—a woman of high rank and respect and advisor along with the Chief*

Note: The absence of a phrase in this table does not indicate that this phrase is absent, nor irrelevant to the Nation. Language revitalization is an ongoing process within communities, and to honour this delicate process, only terms that were outwardly available, or confirmed by Nation members, have been used in this table.

[a]Wilson and Harris (2006).
[b]Salomon et al. (2023).
[c]HlG̲aagilda X̲aayda Kil K̲'aalang Skidegate Haida Immersion Program X̲aayda Kil Glossary (2021).
[d]Council of the Haida Nation and Government of Canada (2018).
[e](FirstVoices.com. Nisga'a Portal. First Peoples' Cultural Council).
[f]Atleo (2004).
[g](FirstVoices.com. Nuu-chah-nulth (Barkley) Portal. First Peoples' Cultural Council).
[h](ʔəxʔixəltə̀ [Paddling Together] Tsleil-Waututh Nation 2022–2025 Strategic Plan).
[i](Syilx siwɬkʷ Strategy 2021).

Fig. 3. Indigenous stream caretaking practices (Lauren Marchand, 2023). Eight stream caretaking practices are shown here: assessing systems health, enhancing salmon migration, enriching stream habitat, harvesting salmon predators, working with beavers and trees, returning salmon bones to the water, moving salmon to strengthen populations, and harvesting salmon for thriving populations. These practices can transform salmon habitat, support healthy salmon populations, and maintain human-salmon relationships.

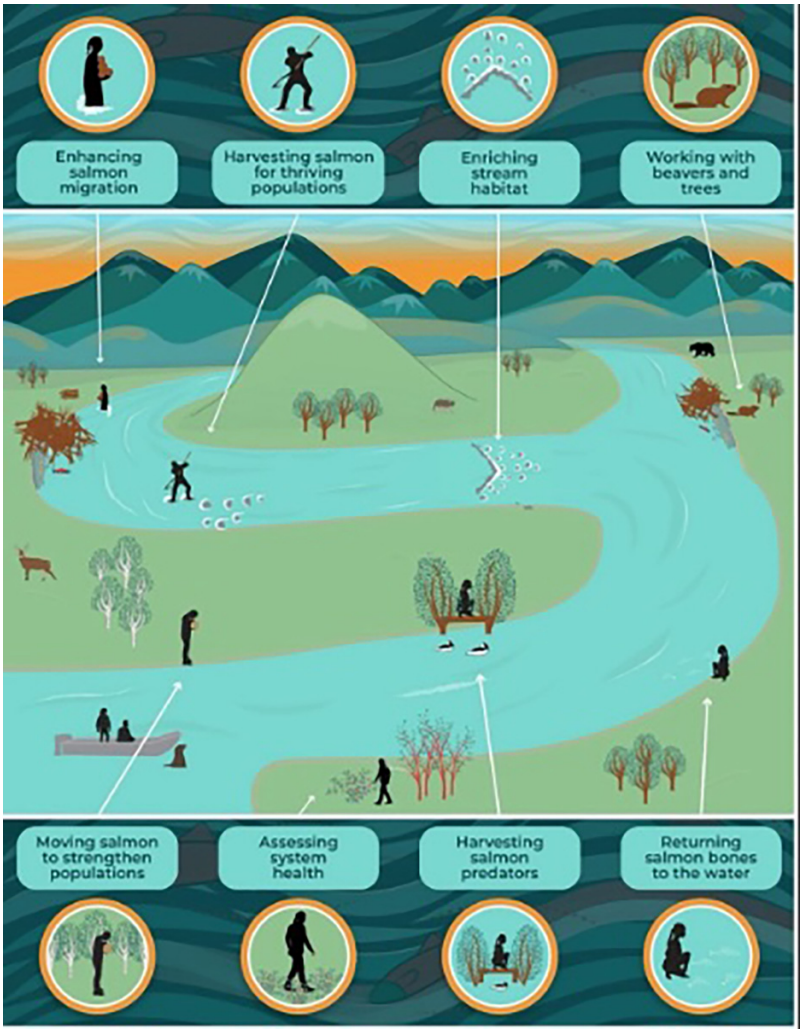


Fig. 4. Assessing systems health.

Fig. 5. Enhancing salmon migration.

bilities, enhancing salmon migration maintains stream complexity for juvenile salmon while reducing migration barriers for spawning salmon.

Enriching stream habitat

Enriching stream habitat, sometimes referred to as "stream-scaping," involves rearranging boulders and rocks to

Fig. 6. Enriching stream habitat.

create preferred habitat for spawning adults, and rearing and migrating juveniles (Langdon 2006) (Fig. 6). In some Haida streams, a V structure is built up within the middle of and the deepest parts of the stream bed to create pools and passageways. This provides habitat for young fish in the creek until they are ready to go to sea and enables the returning salmon to continue upstream during times of drought (personal communication Kii'iljuus Barbara Wilson April 6th, 2023). These V structures are built in the estuary and are replicated inland until streams become too steep for such modification (personal communication Kii'iljuus Barbara Wilson 6 April 2023). Langdon (2006) describes how Tlingit Peoples build stone structures in the Neva River to enrich salmon habitat. In some locations, stones are placed across approximately 40% of the riverbed in a semicircle to create slow moving water. Rocks are also placed across the entire river channel to create a large, slow-moving pool. Both modifications slow water to create salmon resting or spawning habitat, accumulate gravel for spawning habitat, and improve visibility to support selective sex and size harvest (Langdon 2006).

Other stream modifications also improve existing fishing sites or create new ones (Langdon 2006; Menzies 2016). On Haida Gwaii, there is evidence of how the Kuuniisii corral returning salmon in the areas adjacent to streams for fishing and sorting which fish would continue upstream. Kxooyax Stream, in Gitxaała territory, is an example of a human-designed system highly modified to support salmon harvest. At the creek mouth and entrance channel, there are several rock features including deep V structures that alter the stream flow and provide gaffing and dip netting access points, and stone holding pools to allow for selective harvest (Menzies 2016). Hagwil Hayetsk Charles Menzies states that the "lower reaches of Kxooyax Stream have been extensively modified and engineered to facilitate access to the salmon fishery. The complexity and extent of the features represent a significant intergenerational commitment in securing access and managing the use of salmon at this place." (Menzies 2016, p. 136).

Harvesting salmon predators

Harvesting salmon predators is a practice used to remove various predatory species from streams to reduce mortality of salmon (Fig. 7). For example, Tlingit Peoples developed methods to harvest some types of ducks that otherwise dive down and dig up salmon redds to eat the eggs (Langdon 2006). Using a small platform built on the stream large enough

Fig. 7. Harvesting salmon predators.

Fig. 8. Working with beavers and trees.

for one person to crouch hidden by branches, a few salmon eggs are released into the stream attracting a duck to the platform. When the duck is close enough, it is captured by hand. Because gulls only prey on floating eggs and do not disturb redds, Tlingit Peoples do not harvest them from salmon systems (Langdon 2006). There is also knowledge of Tlingit Peoples actively trying to reduce Dolly Varden populations as Dolly Varden can be predators of salmon eggs, fry, and smolts. Tlingit built Dolly Varden traps by placing wooden boxes with holes after alder stakes in a V formation, or after fallen logs across streams to capture the Dolly Varden but allow for salmon smolts and fry to pass (Langdon 2006). As Thomas Jack describes "you have to let the smaller salmon and dollies come out… and right where the "V" comes, you have a trough… you put a box, fill the box with holes in it, and the bigger trout will swim and fall into that… and you take that and make a dry fish out of it." (Thomas Jack, Tlingit, Langdon 2006, p. 124).

Additional predators of salmon that are harvested include seals and sea lions (McKechnie and Wigen 2011). These pinnipeds can congregate at river mouths, in estuaries, or even substantially up rivers to consume high numbers of inmigrating adult salmon (and at times out-migrating juvenile salmon) (Wright et al. 2007).

Working with beavers and trees

Salmon stream habitats are shaped by the other plants and animals that call them home, and working with other species, particularly beavers (*Castor canadensis*) and trees, is a form of stream caretaking (Fig. 8). Beavers have large impacts on salmon rivers by building dams and thus altering stream habitats, hydrology, temperatures, and connectivity (Malison et al. 2015). Depending on the context, beaver dams may be opened up to enable adult salmon migration, or the dams may be left in place to provide selective fishing opportuni-

ties and create rearing habitat. For some Tlingit Peoples, certain beaver dams disrupt salmon spawning habitat access and are removed under the instruction of the stream caretaker (Langdon 2006; Carothers et al. 2021). Thomas Mills describes how they started taking beaver dams apart on the Neva River after "we weren't getting as much sockeyes as we used to and pretty soon we just looked up, walked up the whole river to find out why. And when we got up to the lake over there, we saw that the beavers blocked out the whole lake where the sockeye couldn't get into the lake and the bears and wolves and stuff were just having a field day" (Thomas Mills, Tlingit, Langdon 2006, p. 124). With the introduction of beaver to Haida Gwaii in the 1930's, riverine ecosystems became altered by beaver activity (Gaston et al. 2008). Beavers on Haida Gwaii target specific trees such as cedar (*Thuja plicata*) and crab apple (*Malus fusca*), altering forest and riparian ecosystems (Gaston et al. 2008). Many streams are blocked by beaver dams preventing passage of spawning salmon. In the case of multiple, consecutive dams, sediment and organic matter accumulation can occur and thus reduce oxygen availability to salmon (Gaston et al. 2008). Alternatively, Sts'ailes people use beaver dams as a natural weir, opening a small part of the dam to allow salmon to pass before blocking it off temporarily. With the dam closed, salmon congregate downstream allowing Sts'ailes Peoples to harvest selectively for males (Ritchie and Springer 2010).

Within stream caretaking, trees and riparian shrubs are also an important factor to consider. Diverse riparian forests provide shade, organic inputs, and bank stabilization which are critical for juvenile and adult salmon (Cunningham et al. 2023). Shaded stream habitat, and the cooler water temperatures they support, are an important consideration when deciding where to build stream modifications (see "Enriching stream habitat" section). Alder trees provide antiseptic properties to streams (personal communication Kii'iljuus Barbara Wilson 6 April 2023). Thus, stream habitats close to alders are selected when moving salmon populations (See "Moving salmon to strengthen populations"). In certain ecosystems, cottonwood, particularly black cottonwood (*Populus trichocarpa*), create important riparian habitats, supporting a diversity of plant and animal species, and are harvested by Indigenous Peoples for medicine, food, and textiles (Egan et al. 1997). Other riparian shrubs, such as Devil's club (*Oplopanax horridus*) and Salmonberry (*Rubus spectabilis*), provide important access to food and medicine.

Returning salmon bones to the water

Returning salmon bones to the water is an important practice for many First Nations (Fig. 9). In Nisga'a culture, salmon need the scent trail from the bones to return from the ocean to their home stream otherwise "the fish will feel insulted and will not come back" (Corsiglia and Snively 1997, p. 3). Similarly, Kwakwaka'wakw people return salmon bones to the streams so the fish can reconstitute themselves and reincarnate the following year (personal communication Chief Kwaxistalla Adam Dick to Duer, in Thorton et al. 2015). Nancy Turner and Fikret Berkes summarized a conversation between Nancy Turner and Dr. Mary Thomas, Secwépemc elder, who spoke of how she "watched and helped while her grandmother carefully moved the carcasses of the salmon after they had spawned, from the banks of the Salmon River back into the water. Her grandmother explained that the salmon would nourish the baby fish to come" (Turner and Berkes 2006, p. 502). The Salmon Chief in Syilx culture completes the Syilx first salmon ceremony by asking for an abundant run of salmon, while returning the first salmon bones and remains back into the stream (Good Water 2018). Returning salmon bones to the water is a shared practice amongst many Nations to strengthen human-salmon relationships and care for salmon streams.

Fig. 9. Returning salmon bones to the water.

Fig. 10. Moving salmon to strengthen populations.

Moving salmon to strengthen populations

Moving salmon eggs between streams is a way that First Nations respond to environmental events impacting salmon streams, address localized shortages of salmon, and increase spatiotemporal diversity of salmon runs (Jones 2002; George 2003; Thorton et al. 2015) (Fig. 10). Moving salmon to strengthen populations, or transplanting, is performed in response to floods, droughts, and landslides where streams are blocked by stream material, severely degraded by sediment deposition or erosion, or have changed water course. According to Tlingit oral tradition, moving salmon began in response to the aftermath of the great flood when salmon were no longer found in many streams (Langdon 2006). In Tlingit practice, the eggs and milt are swirled together in a watertight basket. In areas with good flow, holes are created in the new streambed and the mixture is poured into the hole and covered back up (Langdon 2006). ʕaaḥuusʔatḥ Peoples "sometimes used to take the eggs in the gravel and move them to a good location, if the stream was jammed up or if it changed course. The old people knew these practices." (George 2003, p. 74). In Haida practice, after fertilization oc-

Fig. 11. Harvesting salmon for thriving populations.

curs, the eggs are transplanted in wet moss from the compromised stream to a new stream. Usually, the selected stream is surrounded by an understory of various berry bushes, small trees, rotting tree remains, and alder trees as alder trees provide shade and antiseptic properties (personal communication Kii'iljuus Barbara Wilson 6 April 2023). Nisga'a practice involved using bentwood boxes to move salmon (personal communication Sim'oohit Hleek Dr Joseph Gosnell 2018).

Moving salmon is also used to establish new salmon runs in streams with no or small runs (Haggen et al. 2006). Haíłzaqv People move sockeye in their territory, as John Bolton states "… like all the systems that we have in our area… they didn't always have sockeye. They took sockeye from Rivers Inlet and how they did that is they put baskets in the spawning beds in rivers and after the sockeye spawned, they'd pull the baskets out and they'd transport them up this way and they put them out in our rivers and let the eggs spawn out there." (John Bolton, Haíłzaqv, in Jones 2002, p. 183)

Finally, Tlingit Peoples establish late-season chum salmon runs to extend the fishing and processing season (Thorton et al. 2015). In Thorton et al. (2015), Herman Kitka Sr. recounts knowledge from his elders around transplanting chum salmon eggs and milt from a mainland river in Southeast Alaska to an island stream at Deep Bay. The Tlingit language for this process used by Herman Kitka Sr's father was Wudas[?] yík héendei xáat áwé, meaning "We're the ones that raised it and put it in the river (Thorton et al. 2015)." Because mainland chum salmon spawn later in the season compared to local populations, they are moved from the mainland to the island and planted in spawning habitats located near the smokehouse to provide the clan with access to oilier, mainland salmon (preferred for drying compared to island salmon) later in the year when they have more time to process it (Thorton et al. 2015). Thorton et al. (2015) suggest that transplanting contributes to social-ecological resilience by improving the abundance, predictability, and spatiotemporal distribution of salmon for human use, in turn bolstering the community's ability to adapt to change.

Harvesting salmon for thriving populations

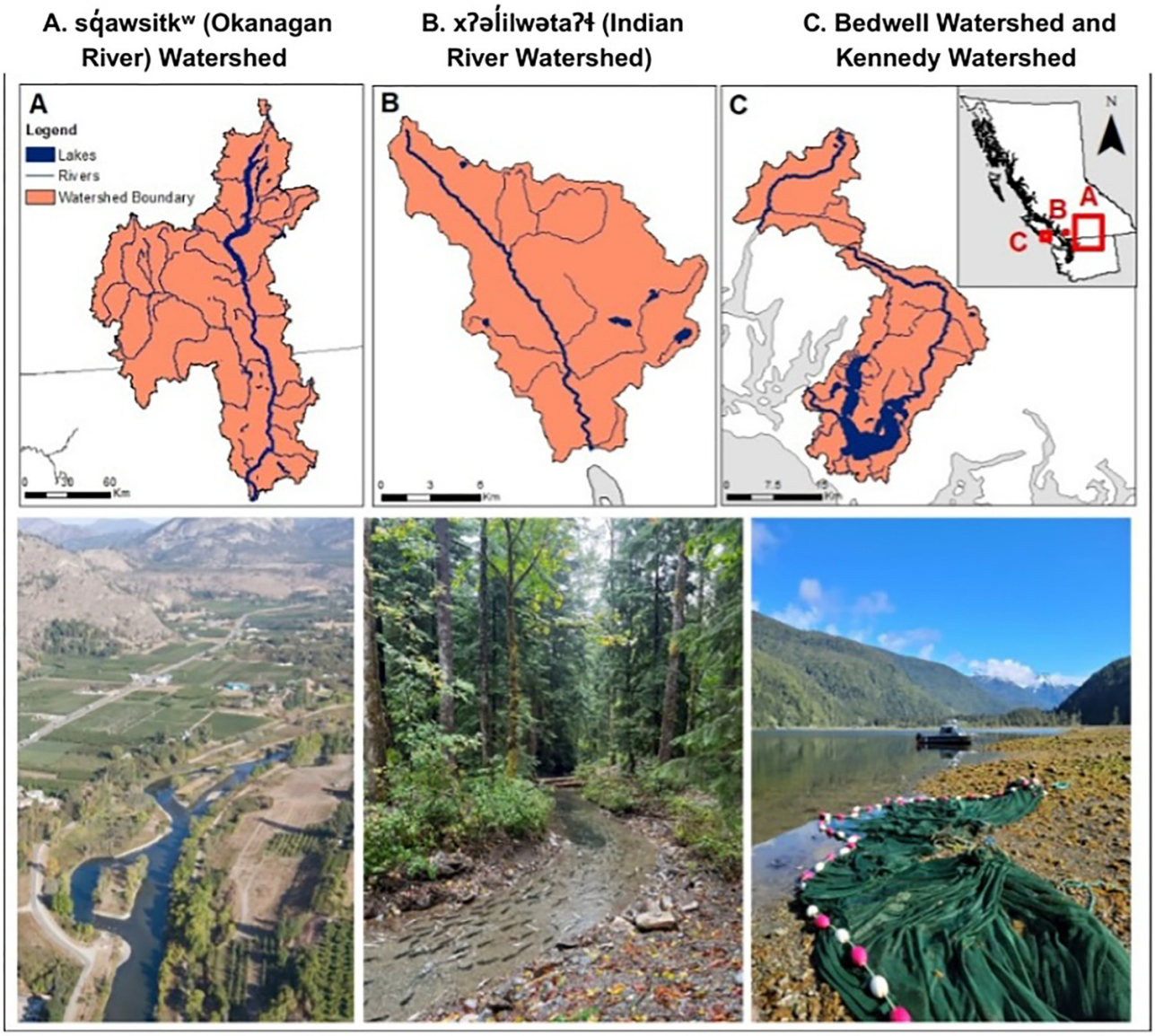
Harvesting salmon for thriving salmon populations is a practice aimed at decreasing impacts of fishing by selectively harvesting based on size, sex, or status of the run (Fig. 11). Across many different First Nations, harvesting efforts are focused on catching males and releasing females to maximize the number of females returning to spawn (Jones 2002). Because a single male can fertilize the eggs of several females, a higher number of males can be harvested sustainably compared with females (Morin et al. 2021).

Harvesting efforts may also select for size, such as allowing larger, healthier fish to pass that may have more success spawning. Various sources describe how harvesting salmon for thriving populations, or "selective harvesting," supports salmon populations over time. For example, Clara Peratrovich describes the process of gaffing sockeye in Tlingit territory and comments that males have "a slight hump and they're bigger. The males are flat and big. You can always tell the round belly of the female. In fact, that's the only type that the Native people target for is the male. They don't bother with the female. …that's the reason why the fish was so plentiful. Nobody bothered with the female." (Clara Peratrovitch, Tlingit/Haida, in Langdon 2006, p. 138). Using paleogenetic analytical techniques to assign sex identification to salmonid bones, Morin et al. (2021) identify that two of the four sites within Tseil-Waut (Burrard Inlet) show a significant bias towards harvesting male chum salmon compared to female, dating between 2300 and 1000 BP (ca.400 BCE-CE 1200). Morin et al. (2021) suggest that sexually selective harvest, specifically at weirs, is an intentional fishing technique of the Tsleil-Waututh People to ensure sustainable salmon harvest over generations. This assertion aligns with present day practices that occur across BC and beyond.

Harvesting for thriving salmon populations also allows for increased processing efficiency since male fish are generally larger than females (Jones 2002). Dana Charlie states "The other reason [for targeting male salmon] is that males have more meat. You lose 4–5 pounds from a 10 lb (female) salmon to bones and the reproductive system. On a 10 lb male, you only lose about 1 lb of that. There's not much cavity inside the male like there is in the female. I won't clean a female for smoking, there's just not enough flesh there. Kind of a waste of time, for me it is" (Dana Charlie, Sts'ailes, in Ritchie and Springer 2010, p. 48). While this quote may sound like there is disregard or dismissal for female salmon, leaving the females to continue upstream is an act of care that supports populations to continue.

To inform more holistic salmon restoration and contrast the narratives built up through the Doctrine of Discovery and Terra Nullius that Indigenous Peoples did not play an active role on the land and water, we have focused this review on active practices Indigenous Peoples have taken for generations, and continue to take, within their territories. Not emphasized here, but equally important, is the knowledge and protocols that inform decisions about not taking action. For example, harvesting salmon for thriving populations can also refer to the process of voluntarily implementing harvesting closures. This can support more adults reaching spawning grounds and contributing to stronger returns in future years (Atlas et al. 2021). Knowing when not to harvest is a form of adaptive management that requires deep knowledge of the system and ongoing assessment of a system's health, but has not been the primary focus of this review.

Fig. 12. Three focal story salmon watershed systems located across British Columbia, Canada including Canada-U.S. border and Washington State. (A) sḵawsitkʷ (Okanagan River) Watershed (photo by Kevin Dunn), (B) xʔəʾl̓ilwətaʔɬ (Indian River Watershed) (photo by Graham Nicholas), and (C) Bedwell Watershed and Kennedy Watershed (photo of Bedwell Watershed by Colton Van Der Minne). Maps created by K.B. with data from iMAP BC and US Geospatial Data Gateway.



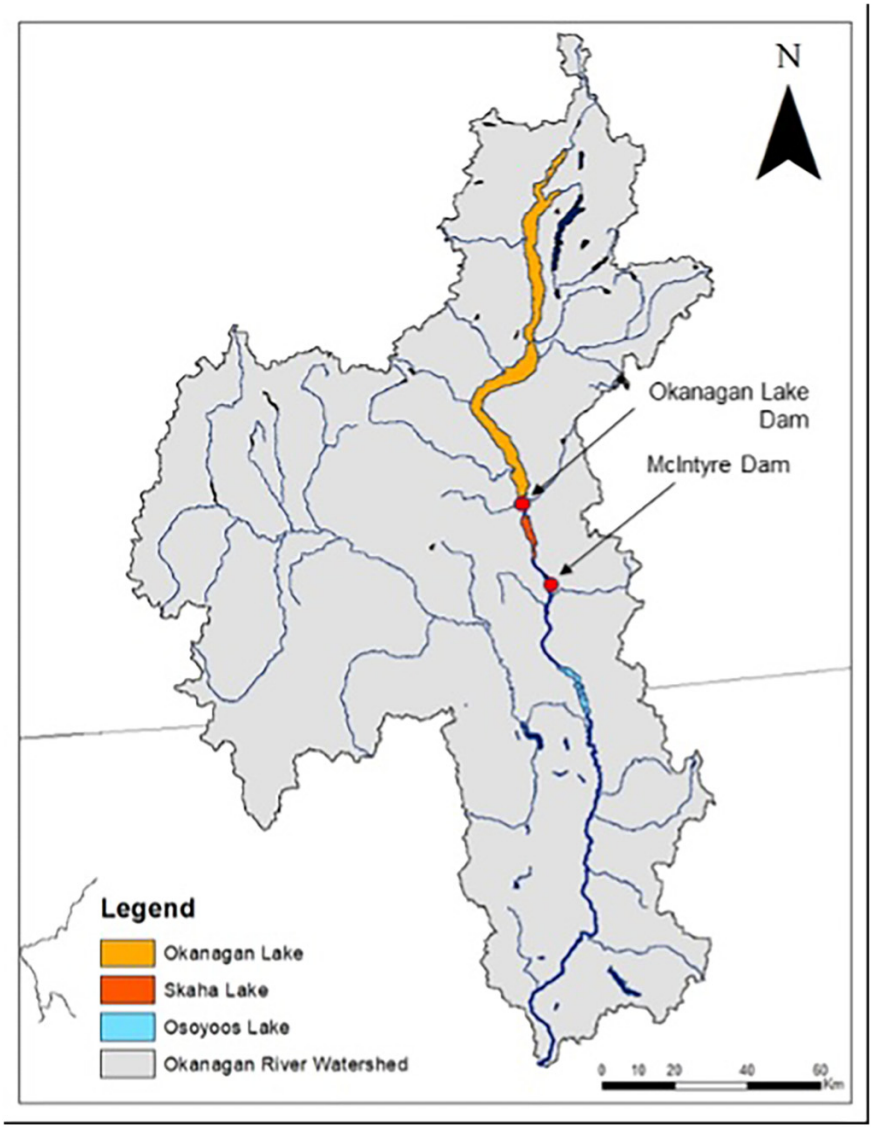
Focal stories

Grounded in governance systems, the Indigenous salmon stream caretaking practices described above are adaptive systems to care for salmon and streams, improve salmon harvest, and maintain human-salmon relationships over thousands of years. While these practices have been disrupted by colonial systems, today there is work being done to revitalize, rebuild, and reawaken them. Indigenous Peoples are restoring their caretaking practices and responsibilities through stream restoration across BC and beyond. Here, we present three focal stories of contemporary Indigenous salmon restoration from across British Columbia; "Syilx sockeye restoration" by Jeanette Armstrong, Ryan Benson, and Kari Alex; "səlilwətaɬ (Tsleil-Waututh) led salmon habitat restoration in xʔəʾl̓ilwətaʔɬ (Indian River Watershed)" by Graham Nicholas; and "nuučaanuɬ Peoples and salmon: responsive methods through steadfast lifeways" by Colton Van Der Minne and Jared Dick (Fig. 12). The content, narrative, and point of view was determined by the authors, to highlight and honour their work in their own way.

Syilx sockeye restoration—by Jeannette Armstrong, Kari Alex and Ryan Benson

The nxˇʷəntkʷitkʷ (Columbia River watershed) spanning both the United States and Canada once thrived with numerous sockeye salmon (*Oncorhyncgus nerka*) populations, includ-

Fig. 13. sḵawsitkʷ (Okanagan River) Watershed. Map created by K.B. with data from iMAP BC and US Geospatial Data Gateway.



ing the Canadian sḵawsitkʷ (Okanagan River) sockeye population that spawned and reared in South Central British Columbia. Okanagan sockeye historically passed through Osoyoos Lake into BC and north to Skaha and Okanagan lakes (Kennedy and Bouchard 1998; Ernst 2000; Long 2005) (Fig. 13). Historical records show that salmon overall were once about ten times more abundant in the Columbia River than today (Wagner 2023). The Syilx-Okanagan Nation are a salmon people, and sockeye salmon has a vital nutritional, cultural, and spiritual significance (Blanchet et al. 2021). It has been noted that Syilx would eat four or five times as much salmon as game during the year (Spier 1938).

The wave of European settlement starting in the 1800s marked the beginning of the large-scale fragmentation and destruction of sḵawsitkʷ. With colonization, water management changed from reciprocity with nature to a system of possession and control over resources (Phare 2009). European settlement brought dams, agriculture, water engineering, and overfishing—without consent. These changes were accompanied by European-centric fish management which altered fish assemblages both in Indigenous fish numbers and adding exotic fish species (Clemens et al. 1939; Ferguson 1949; Northcote et al. 1972; Okanagan Nation Alliance 2001, 2002, 2003; Rae 2005; Webster 2007). In the Canadian portion of the Okanagan, approximately 84% (30.4 km) of the river has been channelized, straightened, narrowed, and diked (Bull 1999; NPCC 2004), and only 16% of the river remains in a natural or semi-natural state. The channelization of the sḵawsitkʷ destroyed kilometers of sockeye spawning habitat, and the construction of McIntyre Dam blocked salmon migration to Skaha and Okanagan Lakes (Wagner 2023). As a result, the river length has been reduced by 50% (Bull et al. 2000), and sḵawsitkʷ is considered one of the most endangered rivers in British Columbia (ORC 2008).

Only three sockeye populations remain in the Columbia River, originating from Redfish Lake in Idaho, Lake We-

natchee in Washington State, and from Osoyoos Lake in British Columbia. All three populations have exhibited recent year increases in returns relative to their multi-decadal averages. Okanagan sockeye (Osoyoos) have accounted for more than 80% of the aggregate return since 2006.

The Syilx Okanagan Nation Peoples are the Indigenous səxʷtxt̓əm (caretakers, stewards) of the sḳawsitkʷ ecosystem and have managed the sockeye and other species of Skaha Lake and the Okanagan River system for countless generations (Armstrong 2020). Disputes between Syilx Okanagan Nation Peoples and the Canadian Department of Indian Affairs, involving salmon rights and habitat, were common (Ernst 1999). In 1914, Chief Baptiste Cheanut wrote to the Royal Commission of Indian Affairs, "we spoke to you about our trouble when your commission was here Oct 9th…the Indians need fish every day, a short time after we take the land [interpreted as the reserve system] somebody take the river away from us."

Traditional ecological knowledge TEK regarding sḳawsitkʷ, and Syilx Okanagan səxʷtxt̓əm include the responsibility to respect and protect siwɬkʷ (water) and tmixʷ (all life forms). This right has existed for the Syilx Okanagan Peoples since time immemorial. The Okanagan Nation Alliance (ONA) was formed in 1981 as a First Nations government that represents eight Okanagan member communities. The ONA Fisheries Department was formed to provide technical support to the Syilx Okanagan Nation member communities to address the extreme habitat degradation and salmonid losses within sḳawsitkʷ. The ONA has been working to enact the Nation's vision to bring back the health of sḳawsitkʷ, best summarized by late Chief Albert Saddleman's direction to "put the river back and put back the fish." (Okanagan Nation Alliance 2021).

The ONA and the Colville Confederated Tribes held a workshop in 1997 to formally explore the possibility of bringing sockeye back to the Okanagan Lake (Peters et al. 1998). "Putting the river back" was approached by two main efforts: multi-phase river restoration (construction) and improving the decision-making process for flow-timing through dam releases at lake outflows. The Okanagan River Restoration Initiative (ORRI) Steering Committee began in 1999 and established an initial vision of restoration. ONA found partners at Fisheries and Oceans Canada and the Provincial Ministry of the Environment. Together they developed funding and collaborative arrangements with governmental parties in the United States (Correia et al. 2022). ORRI restoration projects include bringing back instream habitat diversity (deep pools near riffles), lateral diversity (meanders, islands, and gravel bars), boulders, and large woody debris. McIntyre Dam was reconfigured to allow for salmon passage in 2009.

The Fish Water Management Tool (FWMT) decision-support system was deployed in 2004 to facilitate "fish friendly" water storage and release decisions at the Okanagan Lake Dam (Hyatt et al. 2015; Alexander and Hyatt 2020; Ng et al. 2023). Detailed records of annual fish-and-water management strategies show reductions in the frequency of flood-and-scour or drought-and-desiccation events that could have induced density-independent losses of sockeye eggs, alevins, and lake-rearing fry (Hyatt et al. 2015). An increase of 148% was observed in the mean annual index of sockeye smolt production from Osoyoos Lake in years following FWMT deployment (2004–2021 brood-year test-interval) by comparison with years prior to FWMT deployment (1996–2003 brood-year control interval; Stiff et al. 2023).

To "put back the fish," the Syilx salmon reintroduction initiative began in 2004 to return salmon to Skaha and Okanagan Lakes. Sockeye broodstock was gathered from Osoyoos Lake, eggs hatched in a hatchery, and fry released into Skaha Lake. Total hatchery fry released into Skaha has ranged from 350 000 to 4.5 million (Stefanovic et al. 2016, 2018). Since 2018, 10 000 (ceremonial) to 4 million fry were also released into Okanagan Lake. In 2022, full passage into Okanagan Lake came to fruition. Approximately 5000 adult sockeye migrated into Okanagan Lake that year. All were hatchery origin and the majority migrated and spawned in natal release streams (McGrath et al. 2023). These massive reintroduction efforts have re-established previously extirpated sockeye populations in both Skaha and Okanagan lakes.

The efforts in the Canadian Okanagan were also aided by enhancement work in the lower Columbia River. This coordinated approach has resulted in record-breaking returns of sockeye to the Okanagan in 2010, 2012, 2014, 2016, 2020, and 2022, which marks the culmination of a remarkable turnaround for populations of this species in the Columbia River Basin. The all-year average of 185 836 total returns of Okanagan sockeye from 2008 to 2021 exceeds the annual average total production of 47 863 during 1967–2004 by roughly a factor of four. The other two remaining Columbia sockeye populations have not shown equivalent increases in adult production. Although both Wenatchee and Okanagan adult sockeye abundance reflected similar ups and downs over the decades, the relative proportion of Okanagan to total Columbia sockeye returns has gone from 62% to 83% since 2004, suggesting that the larger portion of improvement has occurred in the Okanagan basin (Kahler and Bickford 2013).

Throughout the process, community consultations, ceremony, and celebration at each step provided guidance and continued governance. The insights and holistic perspectives of the Okanagan Nation səxʷtxt̓əm (Armstrong 2012; Terbasket 2016) will continue to guide future research. The Columbia River Treaty (CRT) was scheduled for renewal in 2024. In preparation, Tribal and religious leaders signed the "Declaration on ethics and modernizing the CRT" sent to Canadian and United States governments (23 September 2014) calling for five principles including: "Healthy ecosystem function as an equal purpose to economic and other purposes," and "….healthy waters and flows that provide for abundant and sustainable native fish and wildlife populations." However, as of early 2025 the renegotiation of the treaty has been put on pause by U.S. administration (Crawley 2025). The success of the Okanagan salmon restoration highlights the importance of governance by Indigenous communities to influence regulatory regimes that have previously excluded them from decision-making and limited access to their territories.

Səlilwətaɬ-led salmon habitat restoration in xʔəʾl̓ilwətaʔɬ/Indian River Watershed—by Graham Nicholas

The səlilwətaɬ (Tsleil-Waututh) Nation has been stewarding and managing their territory since time out of mind. Prior to European contact and colonization, the ancestral səlilwətaɬ had sophisticated management systems throughout their lands, including practices to ensure sceːɬtən (salmon) populations persisted and remained abundant for future generations (Morin et al. 2021). Today, the ability to harvest sceːɬtən for community and cultural needs has been greatly limited by a variety of factors. səlilwətaɬ lifeways are threatened as they have generally become disconnected from the four main pillars of their traditional subsistence foods—sceːɬtən, sɬewəθ (herring), clams, and maʔəqʷ (duck/marine birds)—due in part to colonial government policies leading to impacts such as overharvest (at times causing extirpation) and contamination. sceːɬtən in xʔəʾl̓ilwətaʔɬ (Indian River Watershed) are one of the last remaining cultural keystone species within səlilwətaɬ core territory that can still be readily accessed by the community, and are a priority for the Nation to protect and restore for future səlilwətaɬ generations.

Today, as part of the xʔəʾl̓ilwətaʔɬ/Indian River Watershed Integrated Stewardship Plan, səlilwətaɬ-led stewardship and restoration is focused on understanding and addressing the negative stressors impacting sceːɬtən within xʔəʾl̓ilwətaʔɬ (Tsleil-Waututh Nation 2022). In conjunction with the impacts of colonial forestry practices, climate change is affecting the watershed through more frequent intense weather events such as heat domes, drought, and atmospheric rivers. In assessing the system's health by walking the river and side channels year-round, at least once a week, the Nation has witnessed how extreme weather events, coupled with altered, fragile hillslopes, with unmaintained historical infrastructure (road, culverts, and pipelines), increase the frequency and severity of road washouts and hillslope failures such as landslide and debris torrents.

The erosion of improperly decommissioned logging roads is causing large volumes of rock and sediment to enter the river, blocking, and filling in critical salmon spawning habitat and elevating the river's bedload. This overburden of boulders and gravel has been observed by the Nation to reduce the water holding capacity of channels, while also physically disconnecting channels from the mainstem. This is preventing salmon from accessing channels to spawn in, and potentially increasing mortality of salmon fry if they become trapped in isolated pools when the water table drops in the summer.

səlilwətaɬ recognizes that to truly restore the watershed a "top down" approach is needed—addressing upslope stressors which influence downstream habitat. This includes properly decommissioning historical logging roads to directly mitigate the accelerated input of aggregates into the river. This is a difficult and expensive undertaking: the government and industries that allowed these impacts to occur need to take responsibility for restoring the landscape they altered. In the meantime, səlilwətaɬ will not sit idle and watch salmon populations struggle to access adequate spawning and rearing habitat while waiting for those conversations and commitments. In the absence of the Province fulfilling its obligations, səlilwətaɬ is actively working to restore the river to conditions needed to protect salmon in xʔəʾl̓ilwətaʔɬ. Since 2013, səlilwətaɬ has led eight restoration projects in xʔəʾl̓ilwətaʔɬ, totaling roughly six kilometres of spawning and rearing habitat that has been created or restored. Through this restoration, səlilwətaɬ is enacting traditional stream caretaking practices such as enhancing salmon migration and enriching stream habitats. However, the scale of disturbance is different than it once was, and as a result novel approaches are required, such as using heavy machinery to clear side channels and create new habitat.

səlilwətaɬ current restoration strategy is directed to groundwater-fed side channels that primarily support k̓ʷal əxʷ (chum) spawning and kʷəxʷəθ (coho) rearing. Side channels are the primary focus as the mainstem of the Indian River is so dynamic and powerful that restoration activities have a greater rate of failure. Groundwater-fed side channels maintain stable water levels during high river flows in winter and freshet, and during low summer drought conditions. Additionally, groundwater remains colder (5–6 vs. 13–15 °C) compared to the mainstem during summer months, which helps buffer water temperatures within the whole system. These channels are critical to help alleviate drought conditions that are becoming more common.

"Brandt" and "5k" channels are two successful groundwater side channel restoration projects led by səlilwətaɬ in 2022 and 2023. Both channels were heavily affected by a massive landslide event in 2017, initiated by a major rain-on-snow event. The landslide sent a torrent of rock, boulders and logs down a major tributary of the Indian River, that blocked the outlet of Brandt channel and infilled 5k channel, disconnecting both channels from the mainstem.

These restored groundwater side channels were critical in September 2023, when the mainstem of the Indian River went subsurface and dried up for the second year in a row. Salmon were unable to access roughly 3.5 km of spawning habitat, and were pooling up in large schools, in a limited amount of water resulting in large pre-spawn die-offs due to extremely low oxygen levels. By having 5k channel functional, steady streams of cool groundwater provided both spawning and refuge for the huːṅ (pink salmon), which do not typically spawn in groundwater channels. Situations like this highlight the need for continued restoration of groundwater channels in the xʔəʾl̓ilwətaʔɬ. səlilwətaɬ will continue to steward xʔəʾl̓ilwətaʔɬ and the fish which rely on this system for generations to come, with the goal of reconnecting the community to salmon and the associated cultural practices and protocols.

Nuučaanuɬ peoples and salmon: responsive methods through steadfast lifeways—by Colton Van Der Minne and Jared Dick

Nuučaanuɬ (Nuu-chah-nulth) Peoples are traditionally governed by the awiih (hereditary chiefs), who administer many aspects of nuučaanuɬ relationships with nature. For example, T'aaq-wiihak (permission to fish) is given by the awiih

and can be taken away if a fisher does not follow the rules and protocols for their territory. Other important positions in the community are čačaluk, who are streamkeepers that care for the watersheds and salmon runs (Uu-a-thluk 2012). They pay close attention to the salmon and have the authority to open and close specific runs. Opening and closing runs is an example of harvesting salmon for thriving populations, and includes the Nuu-chah-nulth teaching of leaving the first salmon run of the river to go upstream to spawn before harvesting the second run. Harvesting decisions are made in response to the number of fish returning and the health of the run. čačaluk care for the watersheds by directing activities such as the managing of debris, materials, and at times salmon eggs within streams. Stream caretakers assess systems health through regular stream walks and snorkel surveys. Based on this collective knowledge, restoration decisions are made to enhance salmon migration, such as removing log jams that impede salmon migration and cover critical salmon habitat. Answering to the awiih, these positions help maintain respectful relationships between nuučaanuł Peoples, the land and waters, and the living beings found within them that are central to our culture and identity.

The decisions of the abovementioned people, and indeed the lifeways and relationships of all nuučaanuł Peoples, are guided by our core principles. One such principle is ʔiisaak (respect). We are taught at a young age to respect ourselves, respect each other, and respect all that is contained within the ḥaḥuułii (chiefly territories) of our awiih. Ensuring that harvest of a plant or animal is sustainable and protecting them, is showing them the due respect. By doing so, they will continue to provide for us and future generations because our relationship is known to be reciprocal. In practice this means that we are taught to never take more than we need, never be greedy, and never waste. In short, we are taught to harvest in a way that always centers the continued thriving of the population(s) in question.

The nuučaanuł approach to respectfully managing resources is rooted in hišukʔiš čawaak which means "everything is interconnected, everything is one" (Atleo 2004). This holistic approach is based around taking care of the entire ecosystem, rather than its individual components. It is understood that you must care for the forests to care for the salmon. How we interact with the system will have an effect on how it reacts or behaves, as we are not external to—but deeply integrated into—the system. By respecting and managing all components we are nurturing the connections we know and those we do not: our own version of taking a precautionary approach.

In nuučaanuł territory today, there are several organizations that represent the fisheries interests and responsibilities of the nuučaanuł Peoples. One of these organizations is Uu-a-thluk, a fisheries organization launched by nuučaanuł awiih in 2005 and administered by the Nuu-chah-nulth Tribal Council. Another organization is Ha'oom Fisheries Society, formed in 2020 to facilitate the rights-based commercial fisheries for five nuučaanuł Nations: Ahousaht, Ehattesaht, Mowachaht/Muchalaht, Hesquiaht, and Tla-o-quiaht. Ha'oom was formed in response to a series of court cases between the five Nations and the government of Canada in relation to commercial fishing rights.

These organizations answer to their member Nations' governments: the Hawiih, chief and council, or a combination thereof at the discretion of each Nation. Colonial laws also require that they answer to boards of directors. The Ha'oom board is composed of community members from each of the five Nations, while the Nuu-chah-nulth Tribal Council's board is composed of one representative from each of the fourteen member Nations. Nevertheless, each organization and their boards understand that they are first and foremost accountable to their Nations' governments.

Salmon caretaking efforts and practices by the Nations, and the organizations working for us, have retained their fundamental functions but have changed by necessity to combat the growing complexity and scale of today's challenges. For example, the reverberations from historic logging practices combined with the climate-induced increased frequency of extreme weather events regularly cause our mountain sides and riverbanks to slough into our streams (Jakob 2000). Combating such frequent large-scale disturbances has pushed us to adopt new technologies; exchanging our axes for chainsaws and our baskets for excavators. Restoration activities span from acute projects in response to weather events, such as removing log jams to allow for salmon passage, to long term projects such as planting trees to restore riparian habitat impacted by historic logging practices. Knowledge holders are central to restoration in Nuu-chah-nulth territories, providing guidance on restoration location and priorities.

Effectively rebuilding our salmon populations has also required us to alter how we interact with the salmon and their eggs. Many of our Nations use hatcheries to incubate the eggs and thus facilitate the transplanting of many salmon fry to struggling rivers. Hatcheries across Nuu-chah-nulth Nations vary in size and scope, depending on context, status of the local salmon population(s), and the goals of the Nation. Given the degree of degradation of salmon habitat and populations in Nuu-chah-nulth territories, hatcheries, which function similarly to Western hatcheries, have become a common tool to enact our stream caretaking rights and responsibilities to steward salmon populations. This process is more intrusive and artificial than our historical practices, as it involves a high degree of our control over salmon reproduction and rearing, but it has become necessary to overcome modern-day pressures salmon endure.

Through the evolution of our relationships and practices, so too has our knowledge evolved. Contemporary salmon stream caretaking by the Nations and their organizations often takes the form of research. To continue to manage our lands and waters with the respect they deserve requires us to deepen our understanding of the complex interconnections of hišukʔiš čawaak and how they are changing. Much of the recent research conducted by nuučaanuł Nations has been focused on juvenile salmon. Furthering our understanding of their life-history and ecology has empowered our awiih and Nations to make informed decisions about our changing interactions, such as how to best operate our hatcheries or restore our streams. Our awiih and leadership continually en-

courage us to conduct our own research, generate our own data, and use it to manage the ḥaḥuułii to the best of our abilities.

In the face of these changes and others, nuučaanuł Peoples face a common frustration shared with many Indigenous Peoples: colonial society attempts to externally determine what is authentically Indigenous as originating from first contact with Europeans, with little allowance for growth (Coté 2010; Vowel 2016). This even extends into colonial law, with the five Nations' fishing rights being narrowly defined as applicable to an "artisanal" fishery, "using small, low-cost boats with limited technology" (Ahousaht Indian Band and Nation v. Canada (Attorney General), BCSC 633 2018) in a ruling before it was overturned in 2021 (Sayers 2021).

In many ways, nuučaanuł Peoples today relate to streams and fish much like we always have. Governance is structured to follow the awiih, and caretaking is strongly influenced by our traditional principles including ʔiisaak and hišukʔiš čawaak. However, while we are strongly tied to our past, we are not bound by it. The key is that nuučaanuł Peoples are the only ones who can determine what constitutes our lifeways. Although there are new institutions to support nuučaanuł stream and salmon caretaking and some of our practices may appear different than they once were, at their core our lifeways are still, and will always be, nuučaanuł.

Opportunities for holistic salmon restoration

Ancestral knowledge, governance, and lifeways guide Indigenous Peoples' reciprocal relationships to salmon, including their responsibilities to care for and restore salmon streams. The eight ancestral practices, embedded in governance systems, highlight some of the complex systems of care taken to steward salmon. The three focal stories shed light on how stream caretaking actions and restoration activities today continue to be informed and grounded by Indigenous ancestral governance principles, laws, and protocols. Collectively, the practices and focal stories showcase opportunities for the resurgence of Indigenous-led restoration for Pacific salmon for more active and holistic Pacific salmon management.

The eight Indigenous stream caretaking practices gathered through this review emphasize the ways in which Indigenous stream caretaking is deeply adaptive and responsive to the existing processes, dynamics, and features of rivers and streams. Non-Indigenous restoration approaches, which draw from western knowledge and science of rivers, have historically focused on engineering interventions that attempt to command-and-control rivers (Brierley and Fryirs 2022). More recent approaches within the non-Indigenous restoration space, such as process based restoration, have begun to honour the dynamic nature of rivers and consider longer term, self-sustaining approaches to restoring salmon habitat (Beechie et al. 2010). Going forward, Indigenous Peoples' relationships with their salmon kin can offer immense learning opportunities to guide more holistic, active and collaborative restoration approaches.

The stories and knowledge shared in this synthesis are also a reminder of how Indigenous-led restoration is deeply embedded within Indigenous lifeways (see Table 1). Indeed, rivers are "hybrids of nature and culture" (Fox et al. 2017, p. 522), connecting people, places, ecosystems, and species. We all are impacted by, and have an impact on, rivers and thus hold a shared responsibility to care for them. Indigenous-led restoration, as described here in the focal stories, is an opportunity to broaden our understanding of the social dimensions of river restoration (Fox et al. 2017).

The focal stories reveal that restoration goes beyond restoring habitat features and reintroducing fish, to include restoring river values and ethics and strengthening the relationships and governance structures that connect these systems (Kimmerer 2011; Fox et al. 2017). In the case of Syilx sockeye restoration, community consultations, ceremony, and celebration are present at each step, providing governance structures to guide Syilx Okanagan Nation səxʷtxtəm as they enact their rights and responsibilities to care for and protect siwɬkʷ and tmixʷ. səlilwətaɬ salmon stream restoration sits within the larger effort to restore the four main pillars of their traditional subsistence foods (sceːɬtən, sɬewəť (herring), clams, and maʔəqʷ (duck/marine birds)) and the xʔəʾɬilwətaʔɬ/Indian River Watershed Integrated Stewardship Plan led by the Nation. Modern day nuučaanuł restoration and research is supported by Uu-a-thluk and Ha'oom under the guidance of the awiih and guiding principles like ʔiisaak and hišukʔiš čawaak. Engaging with river values and ethics is an opportunity to broaden the scope of non-Indigenous restoration to go beyond restoring ecosystem processes to restore human-nature relationships.

Diverse collaborations and partnerships between Indigenous and non-Indigenous groups can provide important skill building and tools to Nations restoring their streams and mutual learning opportunities. Whatever collaborative processes may be in place, restoration and caretaking guided by ancestral knowledge and lifeways must be led by Indigenous Peoples on whose land and rivers the work is taking place (Mauer 2021; Cannon et al. 2024). We remind readers, researchers, scientists, and restoration practitioners that the knowledge and practices shared in this work cannot be cut and pasted into contexts separate from the people, places, and governance systems they belong to. While we share eight Indigenous caretaking practices, these practices could cause ecological or cultural harm if undertaken in the wrong contexts, without permission and appropriate adaptation to new contexts. For example, while many different Indigenous Peoples moved fertilized salmon eggs to restore populations such as those harmed by landslides, these practices are fundamentally different from some modern production-scale salmon hatcheries that can erode genetic diversity and productivity of wild salmon populations (McMillan et al. 2023).

The context, climate, and approaches today are different than they once were. Both nuučaanuł and səlilwətaɬ restoration efforts must contend with the ongoing impacts of forestry, while Syilx and səlilwətaɬ are rapidly implementing adaptive responses to drought and low flow levels. Faced with these cumulative pressures, diverse partnerships and collaborations are being formed. In all three cases, the Nations and

supporting organizations are leading research on the impacts to salmon to identify priorities to care for, restore, and protect salmon populations in ways that align with their governance and lifeways. As the climate and context changes, so are the approaches used by the Nations. Cutting-edge approaches, such as the FWMT (see focal story: Syilx Sockeye Restoration), are being utilized and implemented by Nations and guided by governance and cultural protocol. In an era of Indigenous resurgence and revitalization of ancestral practices and protocols, each of the eight practices, alongside other caretaking actions, are being, and will be re-established in different ways based on Nation-specific contexts and approaches. Regardless of diverse roads to revitalization, what remains is that Indigenous relationships, rights, and responsibilities to Pacific salmon shape restoration activities, outcomes, and our collective future with salmon.

We do this work alongside a larger movement within the scientific community that aims to co-generate research in transparent and respectful ways to support Indigenous resurgence and self-determination. This work contributes to increasing calls for meaningful, just, and transparent restoration collaborations that centre Indigenous values, worldviews, priorities, and food systems (Wong et al. 2020; Ignace et al. 2023; Reid et al. 2024). Climate change and social-political power systems continue to produce inequitable outcomes within salmon social-ecological systems, revealing an ongoing need for socially conscious, values-based management (Bingham et al. 2021; Silver et al. 2022). Restoration is an opportunity to re-balance salmon social-ecological systems by upholding and restoring Indigenous land and water relationships, responsibilities, and rights. We gather, share, and celebrate stream caretaking knowledge alongside focal stories of Indigenous salmon restoration to recentre Indigenous salmon-people-place relationships so that they may inform transformative and lasting restoration outcomes.

Acknowledgments

Thank you to the fish, the water, and to all Indigenous stream caretakers, past and present, for guiding this work. Thank you to Lauren Marchand for her artistic contributions, and to SFU Community Engaged Research Initiative (CERi) for supporting the graphic aspects of this work. Thank you to the Liber Ero Research Chair of Coastal Science and Management for supporting this work and NSERC Discover Grant. Thank you to Jess Edwards from Ha'oom Fisheries Society for guidance on Ha'oom's governance structure. Thank you to the anonymous reviewers for the guidance and feedback.

Article information

Editor(s)

Irene Gregory-Eaves, Laurie Hing Man Chan

History dates

Received: 4 February 2025
Accepted: 2 July 2025
Version of record online: 4 November 2025

Copyright

Data availability

This manuscript does not report data.

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Competing interests

The authors declare there are no competing interests.

Supplementary material

Supplementary data are available with the article at https://doi.org/10.1139/facets-2025-0042.

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