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Towards Biocultural Conservation: Local and Indigenous Knowledge, Cultural Values and Governance of the White Sturgeon (Canada)

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Abstract: This paper examines the extent to which Indigenous knowledge and values have informed conservation of the Lower Fraser River population of white sturgeon (*Acipenser transmontanus*) in Canada. A review of grey literature and semi-structured interviews carried out with indigenous Stó:lō fishers and fisheries managers in the Lower Fraser Basin in 2016–2018 evidences the depth of knowledge held by Stó:lō fishers about this species and its importance to local communities. A summary of Stó:lō oral histories about the sturgeon and observations and experiences of settlement and development in the Fraser region, provides context for understanding why and how the white sturgeon came to be listed as a species at risk. However, the impacts were not only ecological; Stó:lō people were also significantly impacted by European settlement and development of the Fraser Basin over the last one hundred years. The assessment of the white sturgeon, under the Canadian Species at Risk Act in 2012 was a missed opportunity to decolonize current management approaches. The paper concludes by suggesting that a biocultural diversity conservation approach, that reflects both ecological and socio-cultural values, and is informed by scientific and Indigenous knowledge systems, is a more sustainable approach to the management of the white sturgeon and other species at risk.

Keywords: conservation; Indigenous knowledge; species at risk; cultural values; white sturgeon

1. Introduction

Biodiversity is declining around the globe [1,2]. This ecological trend is having reverberating socio-economic and cultural effects for communities dependent on biodiversity for their livelihoods and well-being; among the most affected are Indigenous peoples and other land-based cultures [3,4]. "[No] biologist would dare to suggest that more than half the known species of life could be on the brink of extinction. Yet this is well known to be the most optimistic scenario in the realm of cultural and linguistic diversity" [5] (p. 1). This interrelationship between the sustainability of ecosystems and that of society and culture can be conceptualized as biocultural diversity [6]. Increasing use of this concept challenges academics and those engaged in conservation of places and species to recognize how ecosystems and peoples are mutually interdependent. In many Indigenous territories, these interdependencies have led to unique beliefs, knowledge, practices and institutions (i.e., traditional knowledge). What can these Indigenous knowledge systems tell us?

Many conservation efforts of lands and resources around the world are led by centralized and science-oriented institutions, with little consideration for Indigenous peoples or their knowledge systems [7,8]. Opportunities to reframe the narrative and socio-political dynamics around conservation

of valued places and species are, however, emerging in international forums (e.g., Conventional on Biological Diversity) and in Canadian institutions and processes such as co-management [9–12]. While there are instructive examples in northern Canada and in respect of some key issues, there is limited engagement of Indigenous peoples and applications of Indigenous knowledge in managing endangered species [13,14].

Through case study research carried out in 2016–2018, this paper examines the extent to which Indigenous knowledge systems have informed conservation of the Lower Fraser River population of white sturgeon (*Acipenser transmontanus*) in Canada. Based on a review of grey literature and semi-structured interviews with Stó:lō fishers and fisheries managers, this paper offers new perspectives about the interconnected stresses affecting both the white sturgeon and the Stó:lō people. The processes to review the conservation status of white sturgeon under the Canadian Species at Risk Act, and the associated management strategies associated with such a designation, offers opportunities to recover the species, however, without greater consideration of Indigenous knowledge and social-ecological relationships, these protections are less likely to be sustainable.

1.1. Theoretical Context

Biodiversity and cultural diversity are strongly interrelated in many regions of the world [15,16]. Numerous scholars from different disciplines now utilize the concept of biocultural diversity in efforts to reconcile dichotomies of people versus nature [15,17,18]. Although there are a variety of metrics and indices for describing and calculating trends and patterns in the diversity of species, many of these do not reflect the complexity and richness of the relationship between people and the lands and resources around them. Indigenous knowledge adds depth to our understanding about biocultural diversity in many ways and, more broadly, offers a culturally grounded understanding of problems and solutions to pressing issues of ecological and socio-cultural sustainability [19,20].

Indigenous knowledge is defined as: "a cumulative body of knowledge, practice and belief evolving by adaptive processes and handed down through generations by cultural transmission" [21] (p. 8). The sustainability of freshwater fish species are among the pressing issues facing Indigenous peoples and about which Indigenous knowledge may contribute to improved management [22–26]. For example, many Indigenous cultures maintain customary beliefs and have developed management practices that contribute directly or indirectly to biodiversity conservation, including: sustainable resource extraction techniques, sacred groves/pools, ritual regulation of resource harvesters and buffer zone maintenance [27–29]. These practices and beliefs have historically ensured culturally important species are not over-exploited. Indeed, 21 out of 70 specific taboo species are listed in the IUCN Red List of threatened species are those which already were considered "taboo" by Indigenous or local peoples [30]. "Although they lack formal legal backing, taboos and regulations are very effective in influencing human behaviour and forcing compliance to societal values and, therefore, enhancing conservation" [31] (p. 88). However, because they lack legal backing, they are also fragile in the context of other institutions. In many cases, recognition of locally evolved values and informal systems for species conservation has been limited by government and international organizations or undermined by centralized and top-down initiatives. As a result, there is often a strong tension rather than a synergy between formal conservation programs and the socio-cultural well-being of Indigenous peoples.

In addition to harvest taboos, other kinds of locally evolved rules of stewardship, and habitat protections are embedded in the beliefs, practices and institutions of Indigenous peoples in many regions. For example, the protection of old growth boreal forest by Anishinaabe in Ontario is intrinsically tied to local values for wildlife, traditional medicines, berries and mushrooms and the protection of local watersheds valued for drinking water and fishing livelihoods [32]. In the Tibetan Himalayas, forest ecosystems have also been protected for millennia as a result of their cultural value and designation as sacred sites [33]; it has only been recently that some of these areas have been defined as a World Heritage Site. Sacred forests have persisted longer than non-sacred forests in Zimbabwe with similar examples being found in India, China and the Andes [34–37]. A critical challenge moving forward is as

follows—how are values related to the sacredness of these species and habitats recognized in broader systems of natural resource management and governance?

Evidence about the role of Indigenous knowledge in the conservation of freshwater fisheries is also developing. "Aquatic animals are often central to human connections to freshwaters by providing an important food source and/or a focal point for culturally significant events, ceremonies, and intergenerational teachings about the natural world" [38] (p. 1). Studies in Alaska indicate how herring are considered a highly significant component of subsistence production, trade, ritual and expressive culture of the Tlingit, Haida, and Tsimshian peoples. Among Sitka Natives, herring is also highlighted as sacred in oral history, names, songs, dances, regalia, and other at.óow, or sacred property [39].

Regulation or criminalizing of Indigenous rituals and ceremonies associated with fishing livelihoods have had negative impacts on conservation of species. "These losses are often precipitated through dramatic changes in the traditional use of a resource, including its extirpation, e.g., the loss of a wild salmon run, prohibition of access, e.g., lands confiscated or ownership transferred to the private sector, or significant changes in quality, e.g., contamination of a traditional food source." [40] (p. 1). For example, government efforts to criminalize 'First Salmon' ceremonies and associated fishing technologies resulted in decreasing salmon populations [40].

Historically, fisheries management has tended to focus more on the resources than on the people who use them [41]. While there are a growing number of international organizations seeking to learn from Indigenous peoples [2,42], much conservation efforts of lands and resources around the world is led by centralized and science oriented institutions, with little consideration for Indigenous peoples [7,8]. Opportunities to reframe the narrative and socio-political dynamics around conservation of valued places and species, are emerging with respect for Indigenous rights and knowledge systems. Engagement of Indigenous peoples and knowledge in respect of endangered species conservation is a key challenge in Canada and globally.

Understanding traditional systems of stewardship for freshwater fisheries is thus a critical area of learning and opportunity for conservation. It is in this context that this paper shares outcomes of research related to the white sturgeon carried out with Stó:lō First Nation fishers and fisheries managers in the Lower Fraser Basin in 2016–2018.

1.2. Setting

1.2.1. Stó:lō Peoples

The Indigenous Coast Salish, Halkomelem-speaking peoples living in the Lower Fraser watershed of south-western British Columbia refer to themselves as Stó:lō (People of the River) or tribes of Stó:lō. Stó:lō is the Halkomelem word for river. Stó:lō occupation of the lower Fraser watershed extends back thousands of years, as described in ethnographic and archaeological research [43–46]. "The Stó:lō believe that they have always lived here, using the abundance of what Mother Nature has provided for them. Over millennia, they have accommodated to the changes that have taken place in the Fraser Valley. The valley is, therefore, the context that gives the Stó:lō their identity, their traditions and stories, and their history" [47] (p. 208).

European exploration in the region began in 1790. The settlement and development that followed led to significant shifts in governance systems that led to changes in the socio-political structures and gender roles of the Stó:lō people including their use and occupation of the Lower Fraser watershed [48–50]. A significant period of exploration and settlement began after the creation of the area as a British colony in 1866, and the discovery of gold in the Thompson River leading many thousands of non-Indigenous people to move into the Fraser river region, significantly affecting Indigenous livelihoods [51]. Such settlement, coupled with the impact of previous periods of European exploration, resulted in the spread of diseases (e.g., small pox) which decimated Indigenous populations of the region including the Stó:lō [52]. The first small pox epidemic in the Lower Fraser Valley is

believed to have occurred in 1782 and it is estimated that 2/3 of the Stó:lō population died in only a few weeks [47]. The creation of reserves and forced attendance of children at residential school have further decimating effects; as did the criminalization of many subsistence and spiritual practices [47,53]. Today, the population of Stó:lō peoples is reported as 7616 people who occupy twenty-four Stó:lō communities within the lower Fraser watershed or S'ólh Téméxw [54] (Figure 1).

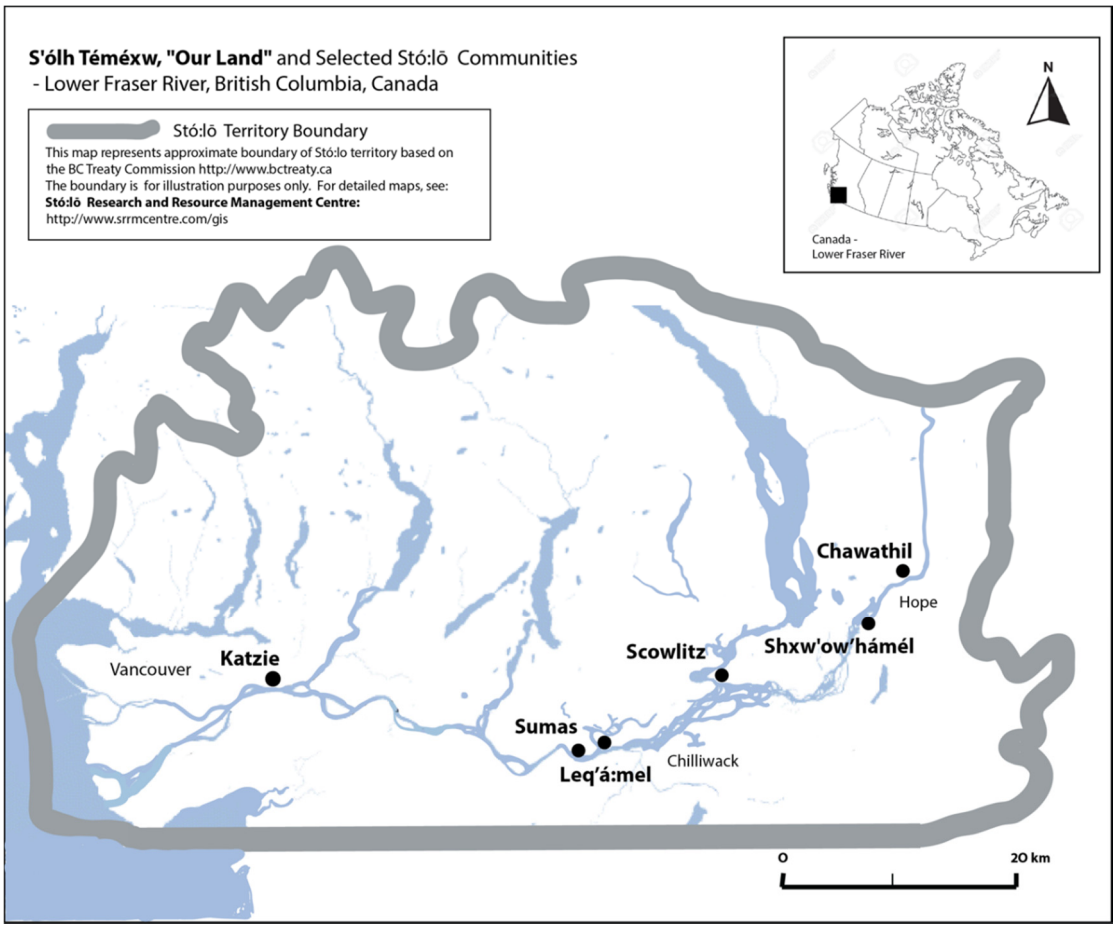

Figure 1. Study Area.

The Stó:lō peoples maintain a wide range of political, socio-cultural, and economic ties, including the use and management of the land and resources within their territory (i.e., S'ólh Téméxw). Two elected Tribal Councils, the Stó:lō Nation and the Stó:lō Tribal Council, deliver key services to many Stó:lō communities, and several Stó:lō communities are associated with Tribal entities (Tît Tribe, Pilalt Tribe, and Ts'elxweyeqw Tribe) that assist with resource management and access, but there are also a number of independently governed communities. Other organizations such as the People of the River Referrals Office (PRRO) and the Stó:lō Research and Resource Management Centre (SRRMC), provide specific services related to culture, land and resources for multiple Stó:lō communities when required.

1.2.2. White sturgeon in the Fraser Region

The white sturgeon is the largest and longest-living freshwater fish species in North America, with some individuals reported at over six meters in length and 100 years of age. The species inhabits various rivers in western British Columbia and biologists have created categories of six sub-populations based on habitat affinity. This research focuses on the population found within the Lower Fraser River in British Columbia, Canada. This population is referred to by the Canadian Department of

Fisheries and Oceans (DFO) as the Lower Fraser Stock Group (SG1). This sub-population has declined significantly in the last 100 years due to habitat degradation, by-catch in commercial salmon fisheries and the Aboriginal fishery, mortality due to illegal poaching and catch-and-release angling. As a result of this decline, the white sturgeon in this area were designated as "threatened" under the Canadian Species at Risk Act in November 2012. However, the designation as well as the broader questions of species and habitat management have not substantially considered the knowledge, practices and beliefs of Stó:lō peoples.

Management Context—There are several Aboriginal fisheries organizations and partnerships operating in the Lower Fraser River watershed that specifically consider white sturgeon (for example, Fraser River Aboriginal Fisheries Secretariat (FRAFS), First Nations Fisheries Council (FNFC), Lower Fraser Fisheries Alliance (LFFA)). Stó:lō communities have systems for selecting community representatives to sit at these tables. In many cases, these "elected" individuals also represent Aboriginal interests in fisheries issues at multi-stakeholder tables, (for example, the federal Department of Fisheries and Oceans (DFO) or provincial Ministry of Environment (BCMOE)) and non-government organizations such as the Fraser River Sturgeon Conservation Society (FRSCS). While some efforts have been made towards engagement with the Stó:lō through these initiatives, does the management of this species reflect Indigenous knowledge and the values of Stó:lō culture? It is this question that we unpack in this paper.

2. Materials and Methods

The research was carried out during 2016–2018 with the aim of revealing more about the importance of Stó:lō knowledge and its potential role in white sturgeon management. A review of archival material and grey literature related to white sturgeon was initially conducted followed by semi-directed interviews with Stó:lō fishers, fish managers and cultural advisors. The *Stó:lō Research and Resource Management Centre (SRRMC)* shared archival materials including transcripts from interviews with elders and 6 audio recordings from 1985–1995, along with historic maps and letters to from Stó:lō leaders to government officials. Grey literature including research papers, management directives, policy frameworks and government and consultant reports related to white sturgeon and the Fraser River were also identified and reviewed. Many of these documents describe the range of impacts that led to designating each species as "threatened" as well as the management strategies, monitoring programs and studies that have been carried out to inform decisions that have been made related to white sturgeon.

Eight semi-directed interviews were also carried out between May and August of 2017. All interviews were conducted in English and adhered to the principals of ethical research as defined by Royal Roads University and that of the SRRMC Research Registry. The SRRMC also helped identify potential interviewees that would be willing to share their experience and knowledge of white sturgeon. Indigenous fishers and fisheries managers that were interviewed had represented Stó:lō interests related to the white sturgeon fishery through the Fraser River Aboriginal Fisheries Secretariat (FRAFS), First Nations Fisheries Council (FNFC), Lower Fraser Fisheries Alliance (LFFA), Fraser River Peacemakers and had worked directly with Species at Risk Specialists and government agencies responsible for white sturgeon and fisheries management. Interviews were audio recorded, transcripts were verified with each individual interviewee and the research outcomes, including transcripts of interviews were provided to the Stó:lō Archives.

The outcomes of the secondary literature review and the interview transcripts were reviewed and analyzed to identify key themes: social-cultural value of white sturgeon to the Stó:lō peoples, traditional systems of harvesting and management, factors affecting white sturgeon populations, knowledge systems and values influencing species management and monitoring, data gaps and opportunities for working together.

3. Results

3.1. The Value of the White Sturgeon to Stó:lō Peoples

The Stó:lō believe traditions and stories are a necessary part of living as Stó:lō and maintaining health [47]. There are many Stó:lō stories that transmit knowledge and teach values associated with white sturgeon. Some of the unique attributes and adaptations of white sturgeon are often shared in "*sweyal*" (true news and personal stories) that convey Traditional Ecological Knowledge (TEK) about the Fraser River fishery, and Stó:lō *Shoxwyam*—the creation stories that convey cultural understanding and significance of shweli—the energy, or "life force" that connects Stó:lō to their land, relations and everything within their traditional territory, and Stó:lō's responsibility to look after everything that belongs to them and "take care of all of their relations" [55].

White sturgeon is considered an origin species to several Stó:lō communities [49,55,56] and its significance is recorded and celebrated through cultural ceremony (dance, song) and art (paintings, carving). According to a respected Stó:lō elder and cultural advisor with the SRRMC, despite significant socio-cultural change in the region, these communities have kept the sturgeon song and the sturgeon dance alive (S. McHalsie—21 May 2016).

The white sturgeon is also associated with food security and plays a key role in maintaining and connecting the people to natural systems. It has been said that during times of scarcity or hardship, the sturgeon would offer itself and feed the people. Some of these beliefs of the sturgeon as are embedded in Stó:lō transformation narratives—the origin stories that describe how individuals became sturgeon to ultimately help and serve the Stó:lō people (S. McHalsie—21 May 2016). In other words, the relationship between the sturgeon and the Stó:lō people is not just physical but is metaphysical and spiritual as described by SRRMC Fisheries Manager Ernie Victor.

> There are people who are sturgeon people and they have another level of teachings that come from sturgeon. They carry an understanding of those species, far more than most families . . . . every single year we go to the river and we feed the river and explain what we're doing, and how we're going to do it . . . we offer food and say we are asking for safety, we're asking you to know that we're coming here, our loved ones are going to come here with you, we talk to that river before we get busy on the river. (E. Victor—13 July 2016)

Stó:lō sturgeon stories are rich in detail including cultural and geographic specificity. Chief George from the Stó:lō village of Chehalis told the well-known anthropologist Franz Boas, more than 100 years ago that the sturgeon transformation story he told ostensibly refers to the current location of the Ohamil settlement or as it is known in its fuller form "Shxw'ow'hámél". Variations of sturgeon transformation stories are associated with other Stó:lō villages including Leq'a:mel, Scowlitz, Si:yita, Katzie and Chawathil [55].

These stories help to illustrate the pivotal role of *sko:wech* (white sturgeon) in shaping how Stó:lō understand their place in the ecosystem and the cycling of *shweli* (or life force) that connects people to the land, their ancestors and future generations (S. McHalsie—21 May 2016). As a result, there are numerous kinds of laws or rules about how to care for the sturgeon and its habitat. Stó:lō Fisheries manager Ernie Victor shared some of his family's connection with the Sturgeon during interviews.

> We've got people who are definitely afraid of sturgeon and they don't know why, they're just afraid of them, and they're afraid of them as children . . . my grand-auntie, she said that because that child's special, the child can sense the line between life and death and sturgeon carry a responsibility to help with that line. There aren't many differences between life and death other than physical being. Because we're all spirits, we all have *shweli*, and *shweli* is something that needs to be cared for and used in a very positive way. (E. Victor—13 July 2016)

3.2. Traditional Systems of Harvesting and Management

The sturgeon have always been critically important in terms of food security for Stó:lō people. Unlike the salmon, sturgeon were caught all year round in the Fraser River and its tributaries and *Sko:wech* was the main fresh fish available during *temxeytl* (winter, or cold time) [55]. Large fish were caught, and the meat was smoked or salted and shared with families and the community—especially elders [55,57]. The eggs of females were boiled and eaten and other parts of the fish, including the brains, and the inside of the backbone were extracted for medicine [58].

All parts of the sturgeon were used for medicine, glue, fuel, tools and so on. The black substance along the sturgeon's backbone was also used for glue. It looked like a thin tube, and when it was needed for glue, a piece was boiled in water [59] (p. 7). The isinglass from the swim bladder was also used as a waterproofing material, an ingredient in paint and to seal cracks in canoes. Sturgeon oil was used for lamp fuel, to tan or soften animal hides and for medicinal use as well as for tools and children's toys.

Since fishing required the allocation and sharing of seasonal resources between Stó:lō families and tribes, fisheries management was not a distinct practice, separate from governance and law: it was integrated with systems of rank and privilege, distinct forms of production and exchange, including extensive networks of ceremonial redistribution and trade, and protocols for recognizing and transferring rights to fishing places. While salmon fishing locations are inherited, and harvests are closely managed by family representatives (*sia:teleq*), place-based fishing rights are not necessarily associated with sturgeon (S. McHalsie—21 May 2016). High-status men carrying the sturgeon name were not restricted to fishing at a specific place (E. Victor—13 July 2016). "Just as sturgeon roamed the "River of Rivers" [the Fraser River] freely, so too could their human relatives and descendants" [60] (p. 133). Thus, Stó:lō relations with the sturgeon and traditional knowledge shaped sturgeon fishing rights. Historically, in addition to individual forms of fishing, many Stó:lō families worked together to build and maintain communal fishing weirs, or worked together using traditional methods to harvest sturgeon with spears on the river.

3.3. Factors Affecting White Sturgeon Populations

Sturgeon trade eventually became an important part of the Stó:lō mixed economy in the early 1900s that centered around fishing and subsistence harvesting, but also included some forms of agriculture, wage labor and trade. Stó:lō fishermen historically traded a portion of their sturgeon catch to the Hudson's Bay company, which in turn marketed elements of the sturgeon for commercial use. The growing global market for sturgeon led to unsustainable harvest and devastating impacts on the population. In the late 1800s, the harvest of sturgeon saw an amount of fish caught between 200 and 800 kg but the population was virtually extirpated by 1905. During this same period, the government created restrictions on Stó:lō fishing.

> The Fisheries department sent a detective up to Sumas Lake and seized all the nets belonging to the Indians who were fishing for sturgeon in that lake . . . .from the standpoint of the side of the Indians it is nothing short of a calamity, as at this season of year their only livelihood has been taken away, and they are consequently in a state of destitution. [61] (p. 43)

The primary purpose of limiting Stó:lō harvest was to create opportunities for non-Indigenous settlers in the region to harvest sturgeon for commercial purposes. Intensive commercial fishing pressure near the turn of the century reduced the historical abundance of white sturgeon in the Fraser River to dangerously low levels. Historical documents describe how on March 12, 1894, Indian superintendent A.W. Vowell, in Victoria received a petition from Stó:lō Chiefs asking that action be taken to curtail the commercial sturgeon fishery and to bring an end to the destructive American fishing methods the industry had introduced. Another letter written on April 26, 1894 from Stó:lō Chiefs to Frank Devlin (Fraser Valley Indian agent) said:

> A good many white men are yet fishing now near Harrison River, openly stealing our fish, our only food. They want to see us starving, we cannot bear it. Our Chief and all our Indians want to go tomorrow and take by force the hooks, which these white men are using and send them away. We four other Catholic Chilliwack Chiefs think it better to wait a little before taking such a step and so we decided together to write to you. [61] (p. 36)

While the government implemented some measures to curtail destructive commercial fishing practices, commercial harvests continued. ln 1897 over one million pounds of Sturgeon was sold in New Westminster by white commercial fishermen, but by 1917, due to dwindling populations, only 730 pounds were sold [62].

Between 1917 and the 1990s, a significant change occurred for Indigenous peoples including losses to culture, land and economy resulting from increased settlement and assimilative policies of the federal and provincial governments. The impacts on Stó:lō communities were grave with decreased capacity for maintaining cultural practices and livelihoods on the Fraser River. During this same period, the presence and impact of non-Indigenous/settlers in the region and development in the Fraser Basin increased dramatically with significant degradation of habitat and sturgeon populations.

Among the drivers of change for the white sturgeon was the catch and release fishery. In 2016, it was estimated that about 16,000 sturgeon licenses were sold each year for the lower and middle Fraser [63]. Advocates suggest this lucrative industry does not harm the population and that the commercial guides play an important "guardian role" as they report infractions and suspicious activity—an important role given cutbacks in DFO funding and enforcement. Advocates for the catch and release fishers also suggest that the high re-capture rate of large sturgeon from the Lower Fraser is evidence that the industry is not resulting in direct mortality, but concerns over the low juvenile recruitment and spawning success suggests stress caused by catch and release practices may have longer term effects. The intrinsic biologic factors most limiting to the white sturgeon population growth are very low early life stage survival and delayed maturation. Females and males may spawn for the first time at 26 and 11 years of age, respectively, but often it is later [64].

> While overall stocks in the lower Fraser seem stable, there are concerns about declining juvenile populations. The fear is that large females could be reabsorbing their eggs into their bodies due to stress of repeatedly being caught and released in the sport fishery. Every fish is on average being caught at least once a year the lower river. We have to ask whether it is appropriate to be fishing these fish. [63]

Stó:lō fishers continued to use nets and lines to catch sturgeon until the mid-1990s. Today there is no direct harvest of sturgeon by Stó:lō fishers. Most sturgeon intercepted in aboriginal net fisheries are released unharmed if the fish are in good condition; some fish are retained when they are found dead or in very poor condition [61]. In 1995, the Stó:lō instituted a voluntary moratorium on the Food, Social and Ceremonial (FSC) white sturgeon Fishery. At that time, they also initiated their own type of monitoring program. Since that time, they have been systematically recording information derived from unintentional sturgeon harvests by Aboriginal fishers. There are also some Stó:lō people that are First Nation Fish Officers that collect fisheries information on behalf of government at certain times of the year, but these individuals pass information on to government officials that have the power to regulate activity.

> We don't have First Nation Fish Officers. We have Fish monitors—"Fish counters". They are organized through the Fraser River Aboriginal Fisheries Society … they collect information, species, location, date, and number of fish, types of fish etc. They don't have the ability to "enforce". (E. Victor —13 July 2016)

A major challenge, however, is in the interpretation and use of this monitoring data. Monitoring forms are often filed away and stored in boxes, but unfortunately, these data have never been properly processed due to a lack of funding and resources (E. Victor—31 May 2017). Since the

mid-1990s other government-led monitoring programs have also been carried out by recovery teams and members of the Fraser River Sturgeon Conservation Society (FRSCS) who capture and tag white sturgeon throughout their range. For the most part, the FRSCS rely on contributions from volunteers including angling guides, recreational, commercial and Indigenous fishermen, test fisheries and enforcement personnel, academics, post-secondary students and various fishery monitors. Generally, collaboration between these groups is seen as a positive step (E. Victor—13 July 2016), but Stó:lō fisheries managers note the potential bias inherent in data sets generated through the tagging/tracking of "larger" sturgeon that are targeted by commercial Guides and Outfitters that take recreational fishers out on the river, and the implications of this for the stock and the pool of knowledge being generated and shared with decision-making authorities. There is no question these monitoring programs have provided insight into the existing populations and movements of white sturgeon in the Lower Fraser, but this information has resulted in some unintended consequences. According to Stó:lō Fisheries manager Ernie Victor, fishing guides now know exactly where large, mature sturgeon will be found, at all times of the year (E. Victor—13 July 2016). Many of these large fish are caught multiple times in a short period of time.

Development activity in the Lower Fraser Basin has had dramatic effects on critical sturgeon habitats. This includes draining of lands for agriculture, the building of the railway, diking for flood control and gravel extraction. In 1920, the draining of Sumas Lake to create agricultural lands began, and by 1924 seeding and ploughing of sold-off farmland began. Stories persist in the valley about farmers ploughing up live sturgeon in the marshy sections of their fields as late as the 1930s [35]. The Maria Slough was also once a very important spawning and rearing area for sturgeon on the Fraser and supported large numbers, however, with the construction of the Canadian Pacific Rail embankment, a barrier was created, blocking the seasonal migration into the Slough. Interviews with Edna and Henry Douglas (Stó:lō fishers) conducted in 1985 also suggest that Sturgeon spawned near Popkum, just below Jones Hill in a slough channel that separates an island known as "*Sememoqwa*"—a place of lots of fish cranes.

> They can't spawn there now. Figure that place, there, getting all different there now. The route of the river is changing. You think you're going in a deep spot, you just (imitation of boat scraping bottom), hit the gravel . . . .That's on account of the [railway], putting in supports of the new rocks too, for the railroad tracks. Changes our rivers all around. [65]

There are also major problems associated with gravel extraction in the Fraser Basin. Stó:lō elder, and former Chief and fisheries manager Ernie Crey described many of the competing uses affecting the health of the Fraser River and the Indigenous fishery.

> Now when people go to work, they don't think about the fishery, they see a big dirty river—they don't think of the fish in there. It's "how many barges with lumber or coal can we move down the river?" People just don't think about it. (E. Crey, 8 August 2016)

In addition to habitat loss, the recreational fishery is also perceived to have negative consequences for the sustainability of sturgeon.

> Sure, you can still see dozens of anglers on the river, but people don't organize their lives around it any more. People have their discretionary income. They don't "need" the fish, they just do it for fun. But sturgeon are different to Stó:lō. To us they are our long lost relatives . . . . (E. Crey, 8 August 2016)

3.4. Knowledge Systems and Values Influencing Species Management and Monitoring

The National Guidance document for Developing Management Scenarios for Aquatic Species at Risk Listing Decisions (December 2012) suggests developing a set of credible management scenarios as early as possible to (a) evaluate the biological outcomes and plausible courses of action, (b) estimate the social and economic costs and benefits of protection and recovery, (c) inform public consultation,

(d) improve transparency of decision making, (e) meet the requirements of regulatory analysis under the Cabinet Directive on Streamlining Regulation (CDSR). This document goes on to say "the development of management scenarios is guided by the recovery/rebuilding objective, plus knowledge of the feasibility of the objective . . . it is "often" necessary to consult with stakeholders regarding management scenarios" [66] (p. 4). The guidelines say that "once scenarios have been drafted, other DFO sectors (including DFO Aboriginal fishers sectors) may be asked to review the scenarios and provide feedback" [66] (p. 5). It is only after socio-economic analysis is undertaken, that consultation and stakeholder review will occur [66].

One key issue is the extent to which commercial uses of the river and of the fishery still tend to dominate management. The continued development of the Fraser Basin through logging, mining and large-scale settlement has led to significant changes in the river and consequently the health of river habitat. Unless these habitat issues can be addressed, species focused management will have limited value and positive impact. From the perspective of some Stó:lō leaders, the sport fishing lobby has complicated management opportunities.

> . . . all (sturgeon) fisheries (commercial, recreational, and First Nations Fisheries) ceased . . . but then a bunch of sport fishermen started to lobby, and after a while, they were able to persuade the government. They said" well we could involve ourselves in a study". So . . . they got to go out and fish, but they framed it as a "study" (laughs). Now as the years roll by, they have a full blown "catch and release" recreational fishery. (E. Crey, 8 August 2016)

> The sport fishermen are very good at lobbying the local MLAs and the Ministers. But the First Nations don't have time or resources to lobby the way the sport fishermen do. Where do you get that kind of money from? As a result, all the sport fishermen lobby—their claims of economic benefit from the sport fishing industry goes unchallenged. They start flashing all those big numbers in front of the MLAs and that's what the politicians believe . . . . You saw it with the Fraser Panel/Pacific salmon commission. DFO/MPs spend most of their time worrying about how to keep the sport fishermen or the commercial fishermen off their backs. (E. Crey—8 August 2016)

According to one Stó:lō fisheries manager, this influence is seen where the economic values of recreational fishing shapes regulation.

> [the socioeconomic assessment], it's not a cultural document. It's a socioeconomic document that looks at society's values and the principles that support Canada. Those are different than First Nation values. They're far different. There's going to be a loss in certain views, so if money wasn't as important to a sector of fishermen, would we change the fishery? The value of the dollar allows the recreational fisherman to harvest fish when spawning females are ready to give birth. The regulatory powers say that's allowed. Why? Because of the value of the dollar. (E. Victor—13 July 2016)

3.5. Gaps and Opportunites for Working Together

Another key issue is the availability of data and gaps in knowledge needed for good management. Significant resources have been allocated through the FRSCS to researchers and consultants to conduct assessments (e.g., mapping of spawning habitat) and contributing to status reports and recovery strategies. The problem is that these studies did little to directly involve Stó:lō fishers in their study design, data collection, nor did they acknowledge the wealth of TEK held by Stó:lō knowledge holders, the Stó:lō Nation archives or contemporary Stó:lō fishers regarding sturgeon spawning locations, overwintering habitat and resting/feeding areas. In the end, many of these studies have simply confirmed Stó:lō TEK of sturgeon. Stó:lō fishers have known where sturgeon overwinter, congregate and where they likely spawn for generations. However, as highlighted in this quote, there are many aspects of sturgeon health which are poorly understood, and researchers have not been asking the right questions.

> Is it measurable yet? It's still a debate, right? We do have some information . . . What's the implications of a female absorbing her eggs? What are the implications of that and from stress hormones in her system from being caught and released several times while she's pregnant? You know, what is the mortality of that? How many baby sturgeon aren't born because of that? We don't know. (E. Victor—13 July 2016)

> The more information we can share with the public the better. The Fraser River is not just a dirty River. (E. Crey, 8 August 2016)

To address information gaps, many Stó:lō people have participated in a variety of monitoring activities carried out under different white sturgeon initiatives and sit at multiple tables (such as LFFA, First Nations Fishery Council, Fraser River Aboriginal Fishery Secretariat) that deal with various aspects of the Fraser River Fishery. However, it seems more could be done to ensure Stó:lō socio-cultural and ecological interests are being addressed through monitoring programs, and conservation initiatives may become more effective if Indigenous knowledge influenced program design. One approach to achieving these outcomes may be to shift fisheries governance to more of a co-management model, and increase the role of local fishers in enforcing compliance with conservation strategies. In British Columbia, the growing revival of cultural practices is leading to increased assertions of political sovereignty and self-determination. This movement has influenced the way governments and non-Aboriginal fishermen consider Aboriginal fishing rights, and the confidence that some Stó:lō Fishermen have in asserting their rights.

DFO socioeconomic specialists working on species at risk assessments acknowledge that a mix of quantitative and qualitative information should be collected to compare the incremental costs and benefits of proposed policies, including impacts due to cultural, religious and ethical considerations that do not lend themselves to quantification and monetization. What costs do Stó:lō people incur if they can no longer fish white sturgeon, or directly connect with that part of their culture? Ensuring these costs are considered in decision-making processes is critical for Stó:lō people given the significant role sturgeon play in Stó:lō culture, livelihoods and well-being. According to a DFO senior economist:

> So, do the benefits exceed the costs? It's easier if you can quantify everything, but we know that we can't do that, so we try and make sure that we have a comprehensive enough qualitative description to make that determination. Of course, option value, bequest value, and existence values, these non-market measures, non-use values, the only way to gather those are through survey methods . . . .We do have some data from the States on some species such as white sturgeon, although they tend to be for the general population. So, they wouldn't necessarily capture what First Nations' values are. (G. Magnessen—25 July 2016)

This suggests that DFO are conducting assessment based on the information they have, but in the Lower Fraser, most of the documented "data" available for white sturgeon are generated by non-Aboriginal people. The lack of consideration of sturgeon as a key element of Stó:lō culture and livelihoods is problematic. Non-Indigenous peoples have different values related to fish and the Fraser Basin which requires management of multiple social and cultural aspects, not simply technical or ecological ones.

> So there's new processes happening, so it is changing right before our eyes . . . . Are we there yet? We're close to doing that kind of work on our own . . . . Soon as the capacity grows a little bit more, that kind of work is going to start happening and you watch. We'll be doing our own assessments, then our true management regimes that we've had in the past will start flaring up and will start showing avenues of management that I feel are far superior than what's going on now. It's just timing. (E. Victor, 13 July 2016)

Some of this capacity can be built through more education. Some effort has gone into involving Stó:lō people in developing education materials for elementary schools with the FRSCS, but more needs

to be done in terms of educating different levels of government and sectors involved in the Sturgeon fishery. For example, Fisheries Manager, E. Victor believes Stó:lō need to provide some leadership and vision to managing the banks that guide the flow of the river that have a direct impact on the sturgeon.

> TEK is more than a tool, it's a philosophy . . . You might get one guy from that sturgeon community that sees the bigger picture. But if they all see the bigger picture and then all of a sudden, you're starting to make change in that system . . . It's not our system. It isn't. But we can be a part of it when we have time. Whether you're native or non-native, if you're given information about what's going to help you feed your own self, that information's going to guide your behavior. Then all of a sudden, then we start looking at broader issues. There's a whole bunch of areas that things could be done differently. Fishermen, once they grab onto stuff like that, they start realizing that, "Okay diversity—more life, more species in our area means more fish overall. It's a part of the larger cycle". So education becomes a lot easier in that sense. You get back to sharing." (E. Victor—13 July 2016)

For Ernie Victor, it is important that the Stó:lō conduct their own assessments to generate information that will influence management of the white sturgeon. For them it is not enough to have outside "experts" prepare documents and provide completed assessments for their review.

> We can't depend on Canada to include our culture and traditions within their socioeconomic profiling. Socioeconomic being the goal, how does the government scrutinize it? Listen to what the sectors are saying and we have our say on it, but we still need to be responsible to produce our own cultural response and traditional response to the species. I think having our own assessment of the species from a cultural standpoint or from our interpretation of the social needs or from a human health standpoint is our responsibility. (E. Victor—13 July 2016)

4. Conclusions

Biocultural diversity has become an important conceptual framework for communicating about the interrelationships between the diversity of ecosystems and cultures. As indicated in previous research, Indigenous peoples, whose cultures, economies and well-being are strongly interconnected with the biophysical world, can contribute significantly to discussions on sustainability. However, in many parts of the world, including Canada, Indigenous peoples have been excluded and adversely impacted by approaches to species and natural resource management that favored settler values and uses. Although there are clear examples of how Indigenous knowledge can contribute to the management of endangered species (e.g., locally generated taboos), the governance of endangered species in Canada and internationally tends to be highly centralized and dominated by Western science with little consideration for Indigenous peoples and knowledge [14,67,68]. Such top-down centralized approaches to species conservation are proving to have limited ecological success [2,22] and in many cases, have had negative repercussions for local economies, Indigenous cultures and food security [69].

Most of the previous literature about the white sturgeon does not reflect Indigenous values and uses of this iconic species, nor does it offer insight about the combined social–ecological impacts of development and commercial/recreational fishing on the species and Stó:lō communities. This paper aimed to address this gap through a review of grey literature and semi-structured interviews carried out with Stó:lō fishers and fisheries managers. The oral histories presented in this paper suggest, as other research elsewhere has done, that the Stó:lō have well developed systems of fisheries management that supported the species and the well-being of their communities. These included practices of fishing respectfully, as well as customary laws on use (e.g., "use only what you need") which are grounded in beliefs about the sturgeon as a relation. Disrespectful or wasteful fishing practices were taboos; to dishonor of the sturgeon was to akin to dishonoring one's family and community. For example, cultural and spiritual reverence given the species and associated taboos of over-fishing coupled with its value as traditional food, seem to run contrary to current government guidelines which allow recreational catch and release fishing at times when the species may be sensitive to

disturbance. This case study and the detailed oral histories about white sturgeon in Stó:lō culture reveal the opportunities that exist to learn from Indigenous knowledge. However, the work is not comprehensive. Further research with the Stó:lō about important habitats, sensitive points with the species lifecycle and culturally appropriate practices and rules (e.g., taboos) are needed and may contribute greatly to the management of this endangered species. Moreover, further research is needed about how to ensure such knowledge is meaningfully recognized in formal institutions of management over the long-term (i.e., co-management).

The outcomes of the grey literature review and the interviews also tell us why and how the white sturgeon came to be listed as "at risk" by the Canadian government. The future seems bleak; although some data available indicate the population is stabilizing, "white sturgeon has declined greatly in abundance over the last 100 years . . . habitat degradation continues and fish are subject to mortality from by-catch in commercial salmon fisheries as well as mortality associated with a growing catch-and-release recreational fishery" [70] (p. iii). Moreover, these impacts and losses of the sturgeon also have a human dimension. Over the last 100+ years, the Stó:lō people have suffered significant loss with the arrival of settlers, spread of diseases, residential schools, criminalization of cultural practices, and land and resource degradation (i.e., overfishing) [47,48,55,60]. Within this context the loss of the sturgeon is among many losses associated with colonization. Current policies that allow habitat destruction and recreational fishing to continue, while restricting the First Nation subsistence harvesting, highlight the injustices and inequities inherent in many of Canada's decision-making processes related to natural resources. Similar to other First Nations histories and other land and resource case studies in British Columbia [71], the Stó:lō are struggling with a legacy of health, social and economic disadvantage. Colonial policies that repress cultural values and practices also degrade the traditional systems that encourage sustainable harvesting and protection of important species and habitats. The assessment of the white sturgeon, under the Canadian Species at Risk Act in 2000 was a missed opportunity to address the marginalization of Stó:lō First Nations' knowledge, values and culture in the management of the white sturgeon. However, with the passing of legislation in British Columbia to implement the United Nations Declaration on the Rights of Indigenous Peoples, and federal efforts towards reconciliation, there may be new opportunities to care for the white sturgeon with meaningful engagement of the Stó:lō people.

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