

Indigenous culture and adaptation to climate change: sockeye salmon and the St'át'imc people

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Abstract This paper provides a culturally-informed understanding of the impacts of climate change on a highly important subsistence activity that has been practiced by First Nations of central British Columbia for thousands of years. The paper begins with a review of the science regarding sockeye salmon and climate change. It discusses harvest patterns, and how the timing of runs has changed. A survey was conducted by the first author regarding St'át'imc traditional fishing at a historic site on the Fraser River, in 2005. The results show that the impacts of climate change are apparent to those conducting traditional fishing practices, in terms of changed timing and abundance of salmon runs. These perceptions fit closely with the information available from scientists and management agencies. These changes are highly problematic for the St'át'imc, in that the preservation method (drying) is tied to seasonal weather patterns. The whole cultural setting, and the relevance of salmon for subsistence would be highly altered by climate change that leads to changes in the timing and abundance of sockeye salmon. The paper discusses mitigation and adaptation alternatives, but also indicates the scope of these seem limited, given the resource systems and the context of these activities.

Keywords Climate adaptation · Fishing · First Nations · Fraser River · Indigenous people · Sockeye salmon · Subsistence · Traditional harvest

1 Introduction

The Fraser River has been described as the most important salmonine-producing river system in North America (Northcote and Larkin 1989). The fishery for Fraser River sockeye salmon has the past been the most economically valuable commercial salmon fishery in Canada, shared

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with fishers from the United States under the Pacific Salmon Treaty (Williams 2007). For thousands of years, the annual sockeye salmon runs (*Oncorhynchus nerka*) of the Fraser River of British Columbia have provided an abundant harvest for indigenous (First Nations) people, along the British Columbia coastline and in the Fraser River. First Nations communities depend on the sockeye runs to provide salmon for food, and ceremonial purposes as well as traditional exchange practices. Sockeye salmon migrate to spawning beds distributed from near the river mouth to more than 1000 km upstream in important tributaries in the Fraser system, providing protein and nutrients through much of the 230,000 km² of the Fraser basin.

In recent years, production of Fraser sockeye has declined precipitously and it was recently classified as ‘endangered’ by the International Union for the Conservation of Nature Salmonid Specialist Group (IUCN) in the first ever global endangerment assessment on a salmonid (IUCN-SSG 2009). There are many hypotheses for the causes of this decline, including freshwater and ocean habitat changes, over-fishing, diseases, and other factors, all of which were recently evaluated by a ‘think tank of sockeye experts’ (STTS 2009) and in 2010 is being evaluated by a federal judicial inquiry (the ‘Cohen Inquiry’). Global climate change is likely playing a large role in this decline. Various authors have examined the potential impact of global climate change on particular life stages of sockeye salmon with many of the analyses done on Fraser sockeye stocks (e.g., Henderson et al. 1992; Hinch et al. 1995a, b; Swansburg et al. 2002; Rand et al. 2006; Farrell et al. 2008; Hague et al. 2010; Martins et al. 2010) as well as on overall production rates (e.g., Klyashtorin 1998; Levin 2003) and concluded that Fraser sockeye salmon would experience declining production based on recent changes in climate, and production would continue to decline as climates continue to change.

This paper has three broad objectives. First, it discusses a recent synthesis of expert views on the effects of climate change on sockeye salmon (McDaniels et al. 2010). Second, the paper uses the results of extensive interviews conducted during a subsistence fishery of the St’át’imc people of central British Columbia on the Fraser River in 2005. The St’át’imc have lived along the Fraser River for thousands of years and sockeye salmon have played a deep and significant role in their lives. They have always been a fishing society, and many of the people continue to catch and preserve sockeye salmon as a crucial part of their traditional hunter-gatherer harvest activities, and as important sources of healthy protein. The paper presents the context of St’át’imc fishing and the significance that fishing has on their lives and discusses the people’s understanding of climate change, and the effects it has on their ties to the salmon and their lives. While this paper focuses on the St’át’imc First Nation, the impacts of climate change on them are similar to potential impacts on other First Nations of the Fraser system, and illustrative of how indigenous people engaged in subsistence activities may be affected by climate change. Third, the paper discusses the limited options available to mitigate or adapt to the effects of climate change on sockeye salmon, and the implications or viability of these options for the St’át’imc people.

2 Fraser sockeye salmon

2.1 Life history and adult abundance trends

Sockeye salmon are anadromous. Thus, adults spawn in freshwater, but juveniles spend a significant part of their lives in the ocean. They are also semelparous so they only spawn once and die after spawning. Young spend generally 1 year in freshwater (though a small segment spend 2 years) before migrating to sea where they grow to adult size and return to their natal stream to spawn (Burgner 1991). Details on life-stage specific movements and migrations for

sockeye salmon can be found in Hinch et al. (2006). Fraser River sockeye populations are characterized by a 4-year cycle of abundance with 1 or 2 years in four having much greater abundance than others. The causes of this cycle remain unknown (Ricker 1997). Fraser sockeye also fluctuate in abundance in relation to decades-long cycles in ocean environmental conditions (Mantua et al. 1997). Presumably in response to one of these oceanic regime changes, Fraser River sockeye began increasing in abundance dramatically at the end of the 1970s, reaching historic high abundance in the mid 1990s. After 1995, abundance in terms of annual harvest surplus began to decline, in coincidence with changes in ocean conditions (M. Lapointe, pers. comm.).

2.2 River temperatures and adult migrating Fraser river sockeye salmon

Pacific salmon populations living near the southern extent of their range in the Columbia River, Washington and the Fraser River, British Columbia have already experienced significant increases in summer freshwater temperatures since the 1950s (Patterson et al. 2007; Crozier et al. 2008a, b) and such increases during spawning migrations have been identified as a major threat to the future viability of salmon populations in both the Columbia and Fraser River systems (Rand et al. 2006; Farrell et al. 2008). Indeed, several studies have quantified a negative relationship between episodes of unusually warm river temperatures and salmon health and mortality (Naughton et al. 2005; Young et al. 2006; Patterson et al. 2007; Crossin et al. 2008; Mathes et al. 2010).

Most of the 150 stocks (i.e. populations) in the Fraser River initiate adult river migrations between July and October, encountering a range of temperatures. The 40-year average daily temperatures are lowest in July and October (~15°C), and highest in August (~19°C; Patterson et al. 2007). The Fraser River, has experienced an average increase in peak summer water temperature of >1.5°C over the past 40 years. Eight of the past ten summers (as of 2009) have been the warmest on record (Morrison et al. 2002). Thus all stocks now encounter warmer river temperatures than they once did, and, one group of stocks, the Late-runs, which includes the world-famous Adams run, encounter temperatures 3–6°C warmer than historic. This has occurred because since 1994, Late-runs have begun entering the Fraser River 2–6 weeks earlier than normal (Cooke et al. 2004) and while the causes are not clear, evidence suggests that changes in ocean environments and endogenous migratory cues are responsible (Hinch and Gardner 2009).

Early migrating Late-run adult sockeye experience 50–95% mortality prior to spawning (Cooke et al. 2004; Hinch and Gardner 2009) and the causes of mortality have been shown to be related to the higher migratory temperatures encountered (Crossin et al. 2008; Mathes et al. 2010). Other Fraser runs of sockeye are also perishing at relatively high levels when river temperatures are relatively warm (Martins et al. 2010). Because Late-runs have changed their river entry timing, and because the Fraser River is much warmer in summer now than the past, segments of all Fraser River sockeye stocks now encounter river temperatures >19°C during a portion of upstream migration. This change has profound evolutionary significance because no sockeye stock anywhere in the world is known to have initiated river migration at 20°C (Hodgson and Quinn 2002). River temperature is therefore an important factor in the search for causes of the current declines in stock abundance (Crossin et al. 2008).

2.3 Climate change and Fraser river sockeye salmon

Global climate change is expected to bring higher average temperatures and altered precipitation patterns in the Fraser River basin, which will alter the habitat for sockeye salmon

throughout their life cycle stages. The Pacific Climate Impacts Consortium provides access to a range of climate change scenarios for the Fraser Basin, drawing on various global circulation models (GCMs) and future greenhouse gas emission scenarios. There is a high level of uncertainty within and among the scenarios and models, although all indicate warmer air temperatures and changes in precipitation patterns. Over all scenarios of emissions and economic activities, and over all models, estimates of average annual increase in air temperature for the Fraser Basin by 2070 range from about 2.5 °C to about 5.5 °C compared to the average for 1980 to 1999 (PCIC 2008). Hydrological models for the Fraser River predict earlier peak summer water temperatures with a 2–4°C average warming of the Fraser River over the next few decades, relative to temperatures experienced in the 1990s (Morrison et al. 2002; Rand et al. 2006; Ferrari et al. 2007; Hague et al. 2010).

All life stages of Fraser River sockeye salmon could potentially be affected by climate change. A study conducted by McDaniels et al. (2010) elicited the views of some of the world's most knowledgeable technical specialists regarding the effects of climate change on Fraser River sockeye salmon. This study differentiated among eight different life stages, and three different areas in the Fraser Basin (more northern location require further travel by sockeye to reach the spawning grounds). It also considered two potential climate change scenarios. The study elicited judgments of vulnerability to climate change effects at each stage in the life cycle, and overall. The results showed that under a high climate change scenario of 4 degrees C increase by 2070, these specialists indicated that Fraser sockeye stocks are highly vulnerable (meaning reproductive capacity could be severely impaired) particularly for stocks spawning in the upper third of the Fraser Basin (including the Early Stuart and some of the early summer stocks). Under a 2 degrees C scenario by 2070 these stocks are moderately vulnerable. While there is substantial uncertainty and variability in these estimates, the results show Fraser sockeye stocks are vulnerable to climate induced changes in physiology, habitat and food availability throughout their life cycle, depending on where they spawn and how much warming occurs.

2.4 First Nations rights and salmon harvest patterns

Canada's Fisheries Act places First Nations harvesting for ceremonial and subsistence purposes first in priority if surplus fish stocks are expected beyond what is required for conservation purposes (Boyd 2003). A series of decisions by the courts have recognized concepts of aboriginal title to land, and also granted First Nations the right to consultation on issues affecting natural resources, including fisheries, on their historical territories (Boyd 2003). This has strengthened First Nations rights to resources, including fisheries and habitat.

Management of salmon fisheries and the ways in which the fish are pursued has been a concern among First Nations. Fraser River sockeye salmon are first pursued by troll fisheries off the West coast of Vancouver Island, and then in a series of net fisheries (purse seine and gill net) that grow in intensity as the fish get closer to the Fraser River. There are First Nations people who participate in the commercial salmon fisheries, along with other commercial fishers. These activities are distinct from more direct subsistence fisheries that are pursued by First Nations people who are not commercial fishers. Sockeye are also pursued by sports fishermen, predominantly in-river. Moreover, there have been several instances of large groups of sockeye entering the Fraser River, but not getting to spawning grounds, presumably due to stress caused by warm temperatures, or other reasons (McDaniels et al. 1994). Hence, even though First Nations, such as the St'át'imc, have guaranteed rights under the Fisheries Act, management, and uncertainty over the fate of the Fraser River sockeye lead to concerns about whether those rights are being served.

2.5 Sockeye abundance and harvests since 2005

The potential effects of climate change may accentuate previous changes in ocean productivity habitat changes or other unknown factors that may have caused Fraser River sockeye salmon to plummet since 1996. Since 2005, which is the last year for which comprehensive data are available, the situation for Fraser River sockeye salmon has worsened considerably. While 2006 did have enough sockeye salmon to hold a commercial fishery, virtually no commercial fisheries occurred from 2006 through 2009. Of these years, 2007 had the second lowest returns of sockeye salmon since records were first kept in 1915, 2008 had the fourth lowest, and 2009 had the lowest returns since 1915. Commercial and First Nations fisheries were both closed in 2009, in what was viewed as an ecologically and socially disastrous year for Fraser River sockeye salmon (Hume 2010).

We now turn to the implications of such changes for the St'át'imc people, based on interviews conducted during the 2005 year.

3 St'át'imc fishing

The St'át'imc people consist of 11 communities¹ spread out in the areas surrounding the towns of Lillooet and Pemberton, and along the Lillooet Lake and Harrison Lake, in south central British Columbia (see Fig. 1). The St'át'imc way of life is closely tied to the land, as people continue to use the rivers, mountains, and lakes for hunting, fishing, and harvesting of various foods and medicines² (James 2007).

The major river system in the northern St'át'imc area is the Fraser River, while tributary river systems include the Bridge River, Seton, Yalakom, Cayoosh, and Portage. One of the main fishing areas along the Fraser River is located near the confluence of the Bridge River. The fish are known to slow down in this area, also called 'the rapids', and has been considered one of the best fishing sites on the river. Sockeye heading to the Nechako, Quesnel, and Chilcotin rivers all pass through these rapids (see Fig. 1). Fish are one of the main staple foods—they provide sustenance throughout the year for families in the community. In addition, they are a known source of trade with neighbouring nations. The main fish species include four types of Pacific salmon: the sockeye, and to a more limited extent Chinook (*Oncorhynchus tshawytscha*), coho (*Oncorhynchus kisutch*), and pink (*Oncorhynchus gorbuscha*) (James 2007).

4 Methods

4.1 Data collection

A total of twenty-four interviews were conducted in 2005, comprising of fourteen females and ten males. There were five 'young adults' between the ages of 19 to 29, fifteen 'adults'

¹ The communities include Nxwisten, Ts'kw'aylacw, Sekw'el'was, Lil'wat, Chalath, T'it'q'et, Xaxl'ip, N'quatqua, Xa'xtsa, Skatin and Samahquam.

² Traditional territory extends north to Churn Creek and south to French Bar and northwest to the Bridge River headwaters, and to the northeast towards Hat Creek Valley down to the Big Slide, and south to the island on Harrison Lake. It also includes west of the Fraser River and the headwaters of Lillooet River, Ryan River and Black Tusk mountain.

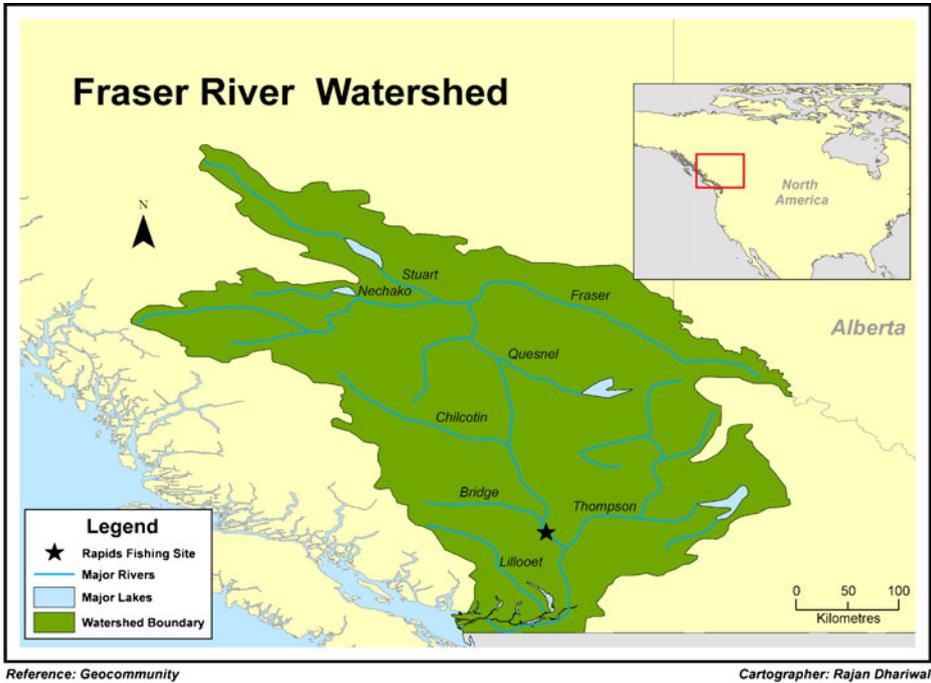


Fig. 1 Fraser river watershed

between the ages 30 to 54, and the remaining four were ‘elders’ above the age 55. The questionnaire used for the interviews is shown in the [Appendix](#).

The people were questioned regarding their participation in traditional fishing activities, and if they have noticed any changes in relation to climate change and the sockeye salmon. They were asked how climate change has been impacting their fishing practices, and what they see themselves and their communities being able to do in response to these changes.

4.2 Data interpretation

The interviews were recorded as written notes to capture the actual words used by the person being interviewed. The results were compiled by summarizing the complete range of viewpoints and perspectives for each question. Jacob (2008) provides the full range of responses using the actual wording used by many of those interviewed. Below we synthesize these results in terms of common themes.

5 Results

The average numbers of years fishing for those interviewed was approximately 33 years. Many have been going down the river since childhood, when they were babies. One person recalls being down the river as young as 3 years old, while many others indicated going down before age 10. One person stated she had been eating fish all her life and she had been going to their fishing camp for as long as she could remember.

Fishing is a seasonal activity that takes place mainly in the summer. One person stressed the importance of giving thanks every year for the return of the salmon, and recalled a story of how and when the salmon first came up the Fraser River. Sockeye salmon is the main fish caught, although a few St'át'imc mentioned they also catch Chinook, also known as spring salmon, and steelhead. Salmon is preserved by wind drying, canning, freezing, salting, and smoking. Fishing methods include dip netting, set netting, and small-sized gill netting along the Fraser River, and some rod fishing at the mouth of the Bridge River. While many people fish for themselves, they also help family members, friends, and elders.

The location and climate in this area provide the St'át'imc, and their aboriginal neighbours with suitable conditions for making *t'swan*, which is salmon in a wind-dried form. At the beginning of the season, people go down the river, set up their fishing camp, and do a general clean up. They ensure their drying rack is sturdy, and make sure the rack is covered securely to keep the salmon dry in case it rains. Each rack is generally shared among families, and depending on each of their schedules, it is common for a few family members to dry at the same time. (See Figs. 2 and 3)

This wind-drying method involves a number of steps. The salmon is first caught at one of the fishing rocks, and packed to the fishing camp. The people then *cwikem*, or cut the salmon to prepare it for the drying process. The salmon is cleaned, the fins and head are taken off, and filleted with the tail still attached. The salmon is cut horizontally into strips from head to tail. It is then stretched and hung by the tail on the drying rack for about a week. It dries faster when it is warm, dry, and windy. The end result is referred to as *t'swan*, which will last throughout the year. Many people camp down the river to acquire their family's winter supply.

In the past, the fishing season usually started in spring, sometime in April to June, when they began catching spring salmon. The Early Stuart run, the first sockeye salmon run, was often used for canning and freezing as they tended to be fatter than salmon caught during later runs. In recent years, many people have chosen not to fish this run due to their low numbers. They are leaving them for their aboriginal neighbours living up north, who also rely on this run for their source of salmon.

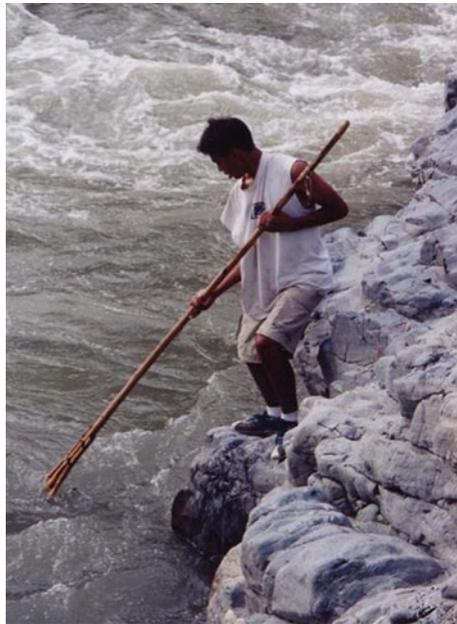
In recent years, the fishing season has generally started later in the summer. While some people start in July and continue on into August, many have noticed the fish are starting even later, mainly in August or sometimes in September. The typical fishing season has changed; as one person said, 'the fish are not there anymore', while others said they are fishing later in the year as the fish are arriving later than usual.³ The number of days that people went fishing depended on how long it would take to acquire his or her family's winter supply.

Fishing has always been a central feature in the lives of those interviewed. Salmon is a basic food source. It ties in with their childhood experience, sense of community, and their way of life. It is a staple food that provides a means of survival throughout the winter months. One person said that she would starve if she didn't have it. Salmon helps cut down on the cost of meat, and it can be traded for wild meat. When families are going through difficult times they can depend on fish for food, and sometimes trade for other things when they or their children require necessities.

Many referred to fishing as a source of fulfilment and an important part of their childhood. Children are exposed to fishing at an early age, they are taught how to fish and preserve salmon.

³ An explanation for the view that the fish are arriving later may be because the early runs are now so small that they may seem to those fishing as if they do not arrive at all. The fish that are arriving later than the historical timing for early stocks are almost certainly late run sockeye, which have been arriving earlier than in the past, since about 1994. See Cooke, et al, (2004).

Fig. 2 A young St'át'imc person using a dip net at the traditional fishing site



One person said she was raised with fish as a traditional food, and when she was younger they ate it three times a day. When people are old enough they carry on these traditions themselves and with their own families. Many wish to pass on these teachings to their children, as they view the experience as a way to give them strength as a people and to stay connected to the land.

At the community level, when families go down the river it becomes a shared experience that brings the people closer together. Responsibilities include gathering firewood, keeping the camps and fishing rocks clean, and ensuring the safety of those who go near the river. It is a place where people share their food and fishing gear, and they help one another while they are fishing. The people have become familiar with the trails and know where many family camps are located. In their down time, it is common for people to visit, talk, and tell stories. Many find the river has a calming effect, as it provides a relaxed atmosphere with no outside disturbances.

Fishing is a fundamental part of the culture; it is something they have been doing for generations and it is a way in which they continue to practice their traditions. Many stressed the practice of ‘taking only what you need’, as a way of respecting the salmon in order for the salmon to return. Others said it was important for people to respect the fish, the river, and other people who are down the river. Families were encouraged to work together and to share with each other. People expressed how happy they and others were when they received a share of dried salmon, especially elders or family members who were unable to go down the river. As cultures change over time with each generation depending on the ways in which people live, one person said, the bottom line is respect and sharing, that these were the roots of their culture.

Many of the people are very concerned with the low numbers of fish. The river is viewed as a source that keeps the people alive, and without the fish the people would no longer exist. First it is their food, and second it provides them with a unique sense of identity of who they are as a people. The St'át'imc are one of the very few groups that are known for making wind dried salmon. It is how their ancestors survived off the land, and it was passed on to them as a way to survive. It is an understanding of how they live their lives— their way of life. Many see fishing



Fig. 3 Traditional drying method for sockeye salmon

as a bit of their true culture that they are struggling to hold onto, similar to the language, plant and berry picking, and hunting practices.

Almost all indicated that they have noticed changes in the abundance of salmon over the last 10 years or so. In earlier years they remember times when the river was thick and black with fish. As a young child, one person said, it looked as if someone could walk across the river on the fish' backs. Recently, they have noticed they have become unpredictable, as some years there are lots of fish, while others there are not that many. On the one hand, many say there has been quite a drop in numbers, and the runs are getting shorter. They are worried that one day the salmon will soon be extinct, and they will have to tell their young people that the river used to be loaded with fish, and that fishing is something the people used to do. On the other hand, others say they still notice a lot of fish, but they are arriving in September and October instead of July.⁴

All those interviewed noticed changes in the quality of fish anywhere from 3 to 10 years ago, and said they were getting worse each year. While sometimes they are fairly large and healthy, other times they are thin, small and appear very unhealthy. Many people noticed sores on the bodies, or they were badly bruised, scarred, and discoloured. The fish were soft to the touch and people sometimes saw worms and hard white lumps in the flesh. Others described them as deformed or diseased, while another reported fish as being shiny or glowing in the dark. Many suspect they were catching hatchery or farmed salmon. People were concerned that the fish seem tired, overstressed, getting red before they were supposed to, and feared they were not making it to their spawning beds.⁵ One person recalls how fortunate they were in the past, as he never experienced these problems while growing up

⁴ See endnote 3 for an explanation of the perceived late arrivals of early stocks. Those are far more likely to be late returning stocks, which are arriving earlier than in the past. See Cooke, et al, (2004). The early stocks are now extremely depressed and in 2009, no fishing occurred by any groups.

⁵ There are no salmon hatcheries on the Fraser River. On the other hand, the comment that the fish seem tired and stressed is directly supported by considerable research. Early migrating late runs are highly physiologically stressed, and in poor condition (Hinch and Gardner, 2009). See Young et al (2006) for a good description of the 'syndrome' found in early returning late run sockeye.

with his grandparents. Back then, the fish were described as ‘nice’, meaning the flesh was firm, and cool to the touch.

The people identified a combination of reasons as associated with these changes. Many expressed concern that the fish are not being respected, and the fish are being taken for granted. One young adult said she was told to give thanks to the deer for giving its life so that people can eat, and it was the same for fish. She said if people are abusing the fish, maybe the fish will no longer give up their lives to the people. Many people said that over-fishing throughout the Fraser River was one of the main reasons why there were fewer salmon. All types of fishing were mentioned, including ocean, commercial, sports, and aboriginal. They were concerned that people were fishing beyond what they need, and that people were selling too many salmon.

Other reasons were in relation to the state of the water, land, and the spawning cycle. People were concerned with the warm temperature levels of the water, and the pollution going into the river from pulp mills, mining, and sewage. One person said one of the biggest contributors was the dams in the river system,⁶ that the water was no longer in its natural state, while another said he noticed changes when the spawning channels were introduced. Others mentioned logging, fish farms, cars, concrete buildings and roads, and global warming. Others stressed that the environment was being interfered with, and that it was not being respected.

When it came to discussing climate change, the most common statement was in terms of how hot the weather was getting in the summer. While some thought summer was getting longer, others thought summer was getting shorter. These same comments were made in reference to the length of winter. One person mentioned there was not as much rainfall, while another noticed that it rained later in the year than when it normally did. As for snow, one person recalled the time when the snow used to reach about ten feet high, and now there was less snow fall. Overall, people didn’t think there was enough rain or snow, and that it was warm for most of the year.

People were also witnessing changes in the planting season. One person, who lived at a higher altitude, said the plants in his garden are growing faster, and he can now grow fruit trees where he wasn’t able to before. As for the berries, they were reported as being ready earlier or later than usual. By mid-august, many of the bushes appeared to be scorched by the heat, and the leaves were getting dry. One person said it seemed summer was just starting, but the leaves were already turning yellow. For some it was hard to explain these changes, as the weather was becoming unpredictable, and they no longer knew what to expect.

A few people associated these changes with a shift in the earth, and believed it was connected with the tsunamis. One person said he noticed a change in climate all over the World, with the droughts, floods, and earthquakes. He said it was something that was happening which was not natural, or normal. With the weather being connected with the water, he believed clear-cut logging was affecting Mother Nature, and it was interfering with the water. One person noticed the streams and lakes are lower than they used to be in the past. He said the land is becoming drier, and if there is not enough snow there will be a period of drought that will not only affect the fish, but the whole human race. He believed people are starting to recognize not to destroy nature, for the sake of money.

Another person said human lifestyles and cars are impacting the environment, and Mother Nature has had enough. He said the people were taught to look after the earth, but

⁶ There are no dams on the main stem of the Fraser River. The Seton River, a tributary of the Fraser, is dammed, and is a major obstacle to upstream migration, even though it has a fishway.

the land is not being looked after— it is being abused. If the people don't look after the earth, he asked how the earth would be able to look after the people. One said he started coming to his senses about the environment a long time ago, whereas before he used to take things for granted. Another said it depended on if we start making changes now towards the environment. If it continues the same way, it was believed that one day the people will not be able to pass on these teachings of how to fish to their children.

Many people mentioned that the heat was ruining the fish and they were not drying properly. The fish were too soft, even when they were recently taken out of the river. As people were attempting to stretch the fish prior to hanging them on the rack, they were finding that the flesh was peeling off the skin, which is something that never happened to them before.⁷ When it gets too hot and there is no wind, it attracts the bees and flies, and the fish were getting wormy fast. More people were realizing that morning was the best time to go fishing when it was cooler.

They believed the heat was influencing the behaviour of the salmon. Many said they knew the fish were there, but it was getting harder to catch them. They said the fish were swimming deeper, going around the nets, or they were staying in certain spots and not going by. A few people said for the last 2 years the fish were holding back and attempting to go up the river later in the year when it was cooler. Others said the salmon were arriving sometime in September, but by then the river was too low. If it were a short summer, and an early winter, it may be too cold to dry salmon. In the past people used to be able to fish for more than 1 month and now with the current conditions they seem to have less time to fish.

Most have indicated that climate change will have an extreme effect on the availability of fish in the upcoming years. The people have noticed that the river isn't as cold as it used to be, and they are worried the river is getting too hot for the salmon to swim through. They seem to be dying in the river, as a few people have spotted fish floating on top of the river. Another concern was with the water levels being too low or too high. When the water is too low it is harder for the fish to get past the rapids. With a combination of the river being too low and too warm, they are concerned that the fish are not making it to the spawning grounds and the fish are getting less and less. Many said there are fewer fish now and they were not sure if they were going to get their winter supply, while one person said there is the same amount, but they are arriving later in the year.

A large majority said they as individuals and as a community would be extremely affected if they were unable to fish due to lower numbers of salmon. One person said fish is a main diet source for her family and extended family. Another said her family would starve during a hard winter. Similarly, another said if she had fish and *t'swan*, she would be able to feed her family. In a rural area where there are not many jobs, there are a lot of people living on low incomes who can't afford to buy store bought food. One person wasn't sure how much it would affect those working at local jobs.

Salmon is a valued trade item, that is traded it for a variety of fruits and vegetables, or other food that could be stored away. Others use it to trade for moose meat, or deer meat, which also helps them get through the winter. A person was often deemed rich by how much fish, deer, canned foods, *tsáqwem*, and *xúsum* they have and if they were willing to share what they have with others. This criterion was used, rather than how much money they had. It was considered just as important now for their survival, as it was for their ancestors who traded salmon for other valuable things.

People said they would be losing something that has always been a part of their lives. One person expressed his love for fishing, as he had been fishing all his life and that it was in his

⁷ See endnote 5 for references regarding distressed fish conditions.

blood. Another said she would starve for fish in the winter, because her body was used to having it. People still eat a lot of fish; they enjoy having *t'swan* soup and fish for supper. Another person said she never ever thought of not having fish; she always had it, she was raised eating it, and she eats a lot in the winter. She said it was something that couldn't be substituted.

At the community level, fishing is viewed as something that they all have in common; it is something that brings them together. A common conversation in the St'át'imc area is to talk about fishing. It is also something that provides them with a sense of uniqueness. One person maintained that since everyone else has fish, people are willing to give it to others who don't have any. Fish is used at gatherings, such as elders' luncheons, ceremonies, weddings, funerals, etc. Without it one person said he would feel hungry and poor, while another said the community would be poor.

One person expressed it as losing a big part of their traditional way of life. With everything that has happened, one person said the changes are taking a toll, and more of their culture is being stripped away. One person said it would be hard for the elders and for those who continue to fish. Some feel it will be the children that would be missing out. Fishing is something they would like to teach them, and not have to say it is something the people used to do. The people would miss the anticipation of going down the river. It brought up some hard feelings, and a few expected the people would get upset or angry. As one person put it, 'I can't imagine it right now, what it would be like not coming down the river to fish— it will hurt our people'.

Many people couldn't see themselves being able to do anything if there were fewer fish. One person said she would preserve what she can, but as it was now she was having difficulty getting her family's supply. Many were finding it difficult to get that little bit extra that they usually give to elders or others. One woman wondered what she would do; beef was considered too expensive. A few suggested cutting the fish into smaller pieces, or turning more towards hunting. Another suggested working around the time when the salmon come, as one person said the salmon are there but they would have to go later in the year when they are there.

At the community level, many couldn't see the people being able to do too much, but to catch what they can. It was suggested to find alternative ways of preserving, and to teach the younger people how to preserve food. It was stressed that people have to help one another, and to ensure elders get what they need. It was stressed not to get greedy by taking more than what a person needs, and to not waste what they have. Others said to stop over-fishing and selling the salmon. Fishing in a respectful manner was a way to ensure that the salmon return for future generations. In addition, people were also asked to respect the land, and to appreciate what they have, because without the land the people wouldn't be able to do anything.

There was a mixed response when asked if they considered not fishing due to the conditions of the salmon. It was hard to imagine the possibility of not fishing because it was always a part of their lives. A few people were already not fishing, which was hurting a lot of people. Some considered the possibility of not fishing for a period of time, or to cut back. On the other hand a dilemma was expressed, as one person stated that he was told by previous elders to never quit fishing. He was told that the fish return every year because there is a need for them, and if the people stop fishing it would be perceived as a no longer needing any fish, and as a result the fish will stop coming. Another recalled his grandfather telling him once the people had to survive a mini ice age, and now people would have to figure out how to survive a heat wave. He usually seeks advice from the elders. The community would need to come together to talk about what is happening and to prepare and adapt to these changes.

The people would like fishing to be the way it was in the past, when the river was respected and kept clean. A time when the runs were longer with higher numbers of springs and wild sockeye salmon, and when the fish were healthier and bigger. One person wanted their

neighbours living up north to have better access to the salmon, and others said they wanted the traditional ways and knowledge revived. They would like to see the temperatures decrease with more rain. They envisioned people respecting the earth, being thankful to the salmon for giving their lives to the people, and for fishermen not to abuse the fish by taking too many.

6 Adaptation prospects

As the previous section indicates, the prospect of being forced to adapt to ever declining sockeye salmon is deeply troubling for the St'át'imc people. Since the interviews were conducted in 2005, the situation has steadily worsened. In this section we build on the views summarized in the previous section, to discuss a range of possibilities. Here we do not speak for the St'át'imc people but rather provide viewpoints based on the interview results. Some of these options could potentially be pursued by individuals, but any substantial efforts for adaptation on a larger scale would require a community-based response.

It may be helpful to view adaptation in terms of services, or the kinds of relationships that exist between the people and the salmon, Fig. 4 indicates there are two major categories of services or relationships: one has to do with the high quality fish protein obtained by the St'át'imc people, while the second is the cultural and traditional significance of the harvest, the drying-salmon method, and exchange process within the community.

We consider the potential loss of high quality protein first. It is a food source that has been an important part of the communities for thousands of years; the loss would be very significant. Like many indigenous people around the world, this traditional harvest activity is the major source of healthy, natural, protein within the diet of people who often have little money to buy food from stores. Some individuals may have more capacity to adapt than others. In simplest terms, one might expect that people with employment income would be better able to adapt by replacing the wild salmon with other store-bought sources of protein, while those without financial resources would be in dire circumstances without the help from others.

Another mentioned the potential to rely more on hunted deer meat. The concern is that deer are also potentially at risk due to climate change. The way in which their populations would respond to a warmer climate is difficult to predict. Hunter cultures further north have indicated great concern over changing access to caribou herds, after population declines led Yukon wildlife officials to limit harvests in the face of declining populations (Yukon Government 2010).

Another alternative would be to seek the involvement of other indigenous fishing people, to engage them in harvesting fish further downstream or on salt water for the St'át'imc people. If the fish do not make it to St'át'imc traditional sites due to warm or low water conditions, they may still be available further out to sea. This would entail a sharing and exchange process on a larger scale, and would likely require a formalized process or agreement among the different groups. However, the ability of those First Nations fishers to continue to harvest sockeye salmon is also in question, particularly after the extraordinary low returns in the last 2 years.

A more straightforward adaptation option, and one that has already been adopted among the St'át'imc, is to delay fishing for sockeye salmon until later in the fall, when the Fraser River cools and some of the fish still make the return journey to the spawning grounds. While this option has considerable appeal and involves the least cost in terms of adaptation, it creates a challenge when using the same drying-salmon method especially as the cooler weather approaches. Again, this option is viable as long as sockeye salmon are still able to mature and return to the Fraser system, even though their returns may be much later in the year.

A final adaptation prospect would be to replace the lost protein by pursuing other fish species. This option is potentially attractive as millions of pink salmon spawn in the Fraser

Service/Relationship Lost	Adaptation Actions	Constraints	Consequences
High quality, healthy protein from sockeye salmon no longer available			
	Hunt for deer to replace fish	Much more difficult to handle and acquire; at risk of loss of abundance of deer	Loss of healthy fish protein; loss of cultural access and significance of historic fishing practices
	Seek cooperation from First Nations further downstream or fishing at sea to acquire sockeye salmon and bring them to the community	Requires coordination among groups on a large scale and sharing of fish formerly sold or used within home communities. Potential loss of all salmon fishing in future	Limited by continued declining stocks of sockeye salmon
	Catch sockeye at other times (late summer, fall) when they are returning	Difficulty to do traditional drying method; Highly likely that such harvests will be greatly curtailed in the future due to shortage of fish	Limited by continued declining stocks of sockeye salmon
	Catch other kinds of salmon, particularly pinks, which are much more abundant	People do not normally prepare this species of (does not work well with the traditional drying method)	Loss of traditional fishing methods by targeting a different species. A new preserving method is required
Cultural significance of sockeye salmon declines affecting the basis for maintaining community ties			
	No adaptation actions identified in terms of maintaining the cultural significance of fishing practices	Drying is not as effective when weather is too hot but not windy	Cultural consequences are vast but not well understood

Fig. 4 Adaptation possibilities for St'át'imc fishing activities

system, although they return at somewhat different times. Pursuing pink salmon has a major drawback in that they only occur in abundance on odd-numbered years; on even numbered years, there are virtually no pinks in the Fraser system. Regardless of this pattern, pinks may be attractive for subsistence fisheries because they are expected to thrive in a warming Fraser system, given their physiological adaptations (MacNutt et al. 2006). While this option does have potential, pink salmon are only pursued by St'át'imc people to a limited degree. Their most prevalent tradition is to pursue sockeye at specific locations and process them in a particular way. Seeking other species would likely mean the fish could not be dried. (Pink salmon are smaller and have less oil content than sockeye and any means of preservation aside from freezing may not be workable).

Turning next to the second relationship between the St'át'imc people and sockeye salmon. It is difficult to see any meaningful adaptation in terms of how traditional fishing practices provide the community with a cultural linkage to the natural world. The summer returns and the usual summer climate have provided the context and opportunity for

conducting these activities over thousands of years. The changing climate may mean fishing for late returning stocks, or different species entirely. Neither of these adaptations allows for the traditional harvest timing, or conducting the drying process as it has been done in the past. In sum, adaptation of these cultural practices to climate change is difficult, since they are connected with summer weather patterns and the timing of salmon runs.

Adaptation to potential losses of culture and identity due to climate change and other biophysical trends is fundamentally different than many other climate change adaptation tasks. The interviews show the ties between the St'át'imc and the sockeye salmon remain strong, especially for those who participate in their fishing activities. Many people have lifelong memories of going down the river to fish and preserve salmon. Fishing is still important to the people as it provides a source of food for the families, and because many of the people are used to having it over the course of their lives. Although it provides as a source of food, it also provides the basis to their culture and identity as a St'át'imc person.

7 Conclusion

Throughout human history, indigenous people around the world have relied on hunting, fishing and gathering plants to provide nutritional subsistence. More recently, these subsistence practices have also become symbolic of how indigenous cultures are markedly different from more dominant, market— oriented cultures, and have helped provide sustenance for those outside the wage economy. The situation of the St'át'imc people, who have fished for sockeye salmon on the Fraser River system for thousands of years, at the same sites, in the same traditional way, is clearly unique to their culture and location. But the implications of climate change for the St'át'imc people in terms of effects on large scale environmental systems that are being altered by climate change, which then affect their food sources and traditional practices, may well be generalizable to many other indigenous contexts. The inability to maintain traditional reliance on an important ecosystem service, due to the effects of climate change, is a grave alteration in the lives of the St'át'imc people.

The interviews suggest that the people are witnessing significant changes to their fishing practices. The salmon are declining noticeably in numbers and are at times very unhealthy. Although it is hard to predict what will happen next, it may prove beneficial for the people to begin considering the possibilities. One way to prepare for these changes is to increase their awareness of what is happening to the salmon, also about climate change, and possible human impacts. Another is to consider planning as a community to identify how these impacts could be minimized. Yet a third is to consider how to take advantage of less traditional species, such as pink salmon. Working together as a people to identify how they could adapt to these changes may provide the community with the foundation that they may need to prepare for any further uncertainties. The message that stood out was to continue practicing their cultural teachings that have been passed on from previous generations, meaning a continued respect for the salmon and the people's ecological surroundings. The values expressed were to take only what they need, not waste what they have, and to share what they have with others.

While the St'át'imc people do have some adaptation options, they will require dramatic changes in practices, possibly including pursuing different stocks or species which return at different times and involve much different handling. These adaptations would provide some of the potential loss in protein, but would not maintain the cultural significance and traditional patterns of the annual sockeye harvest.

More broadly, a great deal of attention has been directed to climate adaptation in man-made systems such as infrastructures (e.g. NAS 2009). But adaptation in large scale human-environmental systems has received much less direct attention in the form of cases and examples. This example should illustrate the severe challenges that may arise when attempting to adapt to changes in highly prized ecological systems that have vast cultural significance for specific people and locations.

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Appendix

Interview Questions

1. Male_Female_
2. Age: 19 – 29_30 – 54_55+_
3. St'át'imc First Nation Member?
4. Do you participate in traditional fishing activities along the Fraser River near the Lillooet area?
5. How long have you been fishing along the Fraser River?
6. What types of fishing activities do you and your family participate in?
7. What time of the year do you go fishing?
8. How many days of the year do you go fishing?
9. Why are traditional fishing practices important to you?
10. Why are traditional fishing practices important to your community?
11. Have you noticed any changes in the abundance of fish over the last few years compared to previous years? Yes_No_If yes, what do you think the reasons are for this change?
12. Have you noticed any changes in the quality of fish over the last few years compared to previous years? Yes_No_If yes, what do you think the reasons are for this change?
13. Have you ever seen those conditions of fish before?
14. In your own words what is “climate change”?
15. What do you think is contributing to “climate change”?
16. In what way(s) do you think climate change is impacting fishing practices?
17. How much of an effect do you think climate change will have on the availability of fish for First Nations fishing in coming years?
18. Have you ever considered the possibility of not fishing due to the poor quality of the fish, and the smaller number of spawning fish? Yes_No_Comments:
19. How much of an impact would it be to you if you were unable to fish because of low availability of fish due to climate change? Rate 1 – 10
20. How would this impact you?
21. How much of an impact would it be to your community if you were unable to fish because of low availability of fish due to climate change? Rate 1 - 10
22. How would this impact your community?
23. How could you respond to the changes in fish abundance and quality due to climate change?

24. What could be done by your community to respond to the changes in fish abundance and quality due to climate change?
25. In 10 years from now, what would you like to see with respect to traditional fishing practices & climate changes?
26. In 10 years from now, what would you not like to see with respect to traditional fishing practices and climate changes?
27. Any additional comments?

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