TRADITIONAL FOODLANDS IN THE FRASER ESTUARY

Impacts of Pollution, Invasive Species, and Climate Change on Indigenous Food Sovereignty

Prepared by: Katharine Baldwin, UBC Sustainability Scholar, 2022
Prepared for: Clare Cullen, Operations Director, Centre for Sustainable Food Systems at UBC Farm

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Cover photo: The Fraser estuary with marsh plants and driftwood in the foreground, a river channel with wooden posts and a bird in the midground, and additional marsh and mountains in the background. By jmv on Flickr.

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Executive Summary

Indigenous peoples have consumed traditional foods for millennia and have developed practices and culture around these foods. Colonial-capitalist policies, such as Indians Reserves, the Pass System, Residential Schools, land privatization, and capitalist resource extraction, have challenged Indigenous peoples' ability to harvest traditional foods; the policies have damaged ecosystems, Indigenous culture, and peoples' health. Through this Sustainability Scholars project, the University of British Columbia Sustainability Hub and the Centre for Sustainable Food Systems at UBC Farm are working towards reconciliation. This project uses a literature review to identify ways to support Indigenous food sovereignty in the Fraser River estuary, and the project will extend to include conversations with Musqueam Knowledge Holders and meaningful supportive action in the future.

The Fraser River estuary is a biodiversity hotspot that spans from Mission, BC to the coast between Point Grey, BC and Point Roberts, Washington, USA. Despite the estuary's ecological, cultural, and economic importance, it is at risk due to lack of unified governance, pollution, wetland destruction, industrial shipping and logging activity, invasive species, climate change, and more. Many traditionally consumed plants and animals no longer live in the estuary or are unsafe to eat.

Cultural keystone species are plants or animals that keep a community in balance, such as through bringing people together for harvest, having many uses, or being heavily consumed. Cultural keystone species in the Fraser River estuary include shellfish, camas, wapato, estuarine root gardens, various berries, bracken fern, cedar, seaweed, salmon, and herring. Pollution, invasive species, and climate change pose barriers to consumption of these species.

Recommendations to improve harvest opportunities for these species include a moratorium on continued environmental degradation, exploring ecosystem services that could be offered by restored shellfish beds, water pollution mitigation legislation, community involvement in traditional root gardens, wetland expansion, control of goose populations, invasive Himalayan blackberry and cross breeding of domesticated blueberry, watering and offering shade to young cedars during heat waves, and supporting fish populations.

Next steps include working with Musqueam to identify their interests and priorities regarding traditional foodlands. Work with Musqueam occurs over an extended timeline and requires a research agreement and funding for honoraria; reflections on this process are included in this report. After interests and priorities are identified, actions can be chosen to meaningfully support Musqueam and Musqueam's foodlands.

Introduction

The Fraser River estuary, near present-day Vancouver, British Columbia, has been home to the Musqueam (xʷməθkʷəy̓əm), Tsleil-Waututh (səl̓ilwətaɬ), Squamish (Skwxwú7mesh), Stó:lō, Stz'uminus, Tsawwassen, Kwantlen, Qayqayt, Semiahmoo, Kwikwetlem, Quw'utsun, W̱SÁNEĆ, Katzie, and Tulalip First Nations since time immemorial (*Native Land Digital*, 2021). The estuary and its shoreline have been a rich source of food for these peoples, providing tubers, berries, shellfish, and more. Careful management of foodlands by First Nations promoted the growth of these food species.

The capital-colonial project has dramatically impacted the abilities of First Nations to access, manage, and harvest foods from their traditional foodlands. Settler policies including, but not limited to, Indians Reserves, the Pass System, Residential Schools, land privatization, and capitalist resource extraction, have prevented Indigenous peoples from accessing their traditional foodlands, and knowledge about resource management, food processing, and uses of various species has been less able to be shared with younger generations. Decreased access to traditional foods and increased reliance on government rations and processed foods has had negative impacts on Indigenous peoples' health, culture, and sovereignty.

Drawing on food sovereignty, this project looks to support Indigenous peoples in the Fraser River estuary, particularly Musqueam, to access healthy, culturally appropriate, and sustainably produced foods and to define their own food systems. A previous study in British Columbia found that top priorities for Indigenous food sovereignty are reforming and redistributing land by returning to treaty agreements, restoring the environment, healing and rebuilding relationships, and addressing social issues, such as poverty, affordable housing, and culture and language, that are negatively impacting the ability of Indigenous peoples to respond to their needs for healthy, culturally adapted Indigenous foods (People's Food Policy Project, 2011). With a focus on the priority of restoring the environment, this project used literature reviews to identify pollution, invasive species, and climate change as key threats to foodlands in the Fraser River estuary.

During the course of this project, literature reviews were completed on Indigenous food sovereignty and traditional foods in the Fraser River estuary, a relationship with Musqueam was strengthened, and requirements for collaboration with Musqueam were determined. This report elaborates on project activities and suggests potential opportunities for supporting Indigenous food sovereignty in the Fraser River estuary.

An Interdepartmental Project Towards Reconciliation

This project was completed as part of the Sustainability Scholars program at the University of British Columbia Sustainability Hub, in partnership with the Centre for Sustainable Food Systems at the UBC Farm. This project supports each department's work toward reconciliation.

The University of British Columbia acknowledges its role in colonial systems and looks to lead implementation of the human rights of Indigenous peoples, as written in the United Nations Declaration of the Rights of Indigenous Peoples. To guide reconciliation efforts and support Indigenous rights, the University has created the Indigenous Strategic Plan. This Sustainability Scholars project works toward the Plan's goals of "Moving research forward" and "Advocating for the truth."

The Centre for Sustainable Food Systems at the UBC Farm is also supporting this Sustainability Scholars project. The Centre researches and produces food using sustainable, climate-friendly practices. The Centre works toward a food-secure future and supports food sovereignty for Indigenous communities.

Positionality

Just as if I was sitting with you, the reader, I introduce myself so that you are aware of my identities, experiences, skills, and motivations. I am a settler woman of Western European descent who grew up on the traditional lands of the Miami, Shawnee, and Kaskasia. The land was part of the 1795 Greenville Treaty. Today, this place is known as Columbus, Ohio. My family has lived uninvited on Indigenous lands for 16 generations. I now live on traditional, ancestral, and unceded Musqueam territory in Vancouver, British Columbia. I am grateful for the caretaking done by the Musqueam and other first peoples of North America.

I am undertaking this project as a Master's student in the Geography Department at the University of British Columbia. Building from prior employment in environmental education and outdoor guiding, my current research centers on feminist environmental and natural histories of Vancouver and the Fraser River. I use my research to connect to place and learn to live meaningfully, sustainably, and grounded in my community. I believe in the value of marginalized perspectives for making the world a better place for all, and I believe in the necessity of Indigenous leadership for addressing climate change.

Background: The Fraser River Estuary

This project focuses on traditional foodlands in the Fraser River estuary. The Fraser River is British Columbia's longest river. The river drains nearly a quarter of the province and is responsible for the creation of the delta on which Metro Vancouver is built (Hall & Schreier, 1996).

An estuary refers to the area where a river reaches the sea. An estuary extends from the furthest upriver area subject to tidal activity, through the area of saltwater intrusion, to the edge of the freshwater plume (Wolanski, 2007). On the Fraser River, the estuary begins 85km upstream of the Salish Sea, in Mission, BC and also extends up the Pitt River into Pitt Lake (McLean et al., 2007). During high river flows, the freshwater plume extends into the entire southern Strait of Georgia (BC Conservation Data Centre, 2006). Since this project is studying foodlands, or terrestrial areas where food is harvested, rather than aquatic food sources, the seaward-edge of the study area will be limited to the coastline from Point Grey, BC to Point Roberts, WA, USA (see *Image 1*).

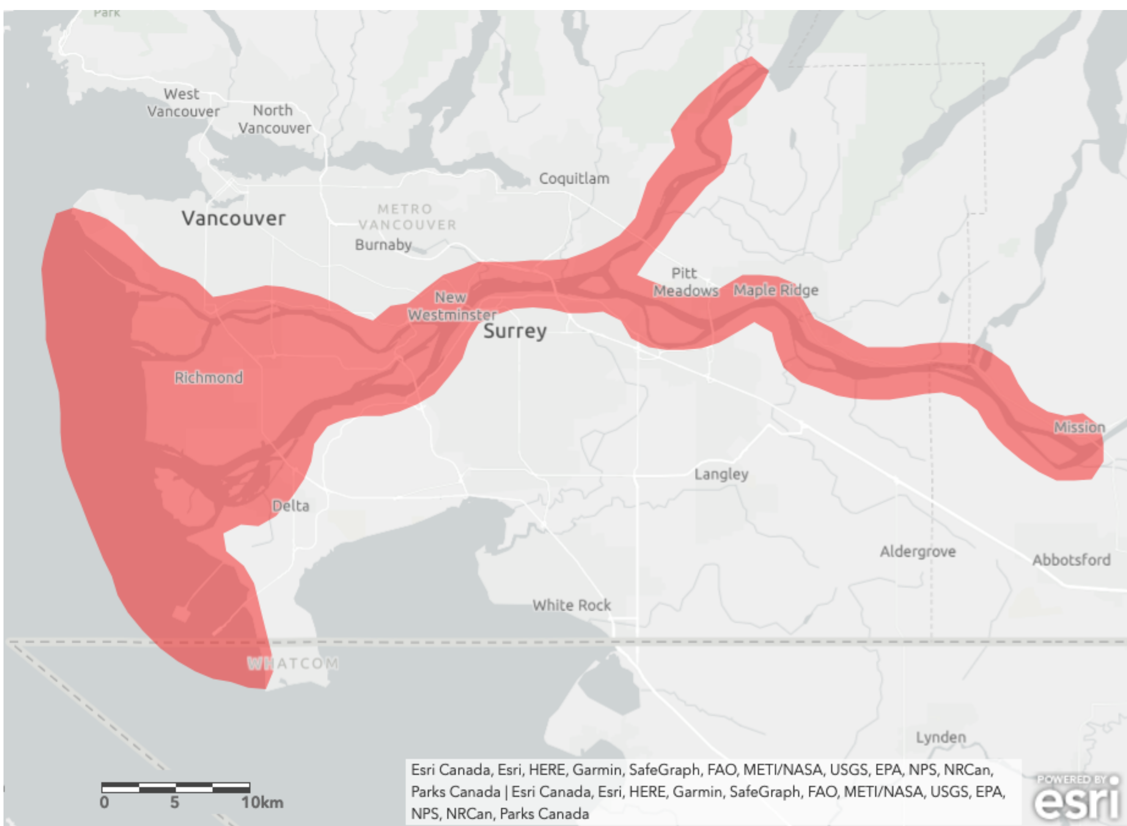

Image 1. Map outlining the Fraser River estuary, as defined in this report. By Katharine Baldwin.

The Fraser River estuary is a biodiversity hotspot that is home to over 300 species of birds, 80 species of fish and shellfish, and 300 species of invertebrates (BC Conservation Data Centre, 2006). 100 species are either provincially or federally “at risk” in the estuary, including the more than two billion juvenile salmon that mature in the estuary each year before entering the ocean (Banwait, 2022; BC Conservation Data Centre, 2006). The estuary is also part of the Pacific flyway and is visited by up to 1.4 million birds during peak migration times (BC Conservation Data Centre, 2006).

The estuary also offers ecosystem services to Metro Vancouver. Wetlands mitigate flooding, clean water, provide habitat for fish and birds that are hunted or fished, and offer opportunities for ecotourism (BC Conservation Data Centre, 2006).

Management and protection of the estuary falls on various regional and local governance organizations including Metro Vancouver, Port Vancouver, and more than a dozen First Nations and city governments. Previous amalgamations, including the Fraser Basin Management Program, Fraser River Estuary Management Plan, and Fraser River Action Plan, have dissolved. Additionally most of the estuary is on unceded Indigenous territory. In this report, representative information is drawn from Metro Vancouver, the City of Vancouver, and Musqueam First Nation with the caveat that the jurisdictions do not align perfectly with the estuary.

Threats to the Estuary

Although the Fraser River estuary offers many environmental, cultural, and economic benefits to Metro Vancouver, the estuary has faced numerous threats from settler communities. 70% of estuary wetlands have been diked, drained, and filled for development (BC Conservation Data Centre, 2006). The estuary wetlands and river passages that remain experience urban, agricultural, and industrial pollution; chemical fertilizers, pesticides, herbicides, livestock wastes, feed additives, runoff and waste from erosion, tannery, cement, asbestos, metal processing, carpet manufacturing, and food processing, oil and petrochemicals, woody debris, and raw sewage all enter the lower Fraser River (Hoos & Packman, 1974).

Pollution negatively impacts the plants and animals in the estuary. The suspended and deposited solids reduce the amount of light in the river, reduce plant growth, clog the gills of invertebrates and other fish, and smother the river bottom, killing fish eggs and bottom-dwelling creatures (Lamothe-Ammerlaan et al., 2017). Wetlands and eelgrass beds trap toxic sediments, and filter-feeding organisms, such as clams, concentrate toxins in their tissues.

In turn, the pollution decreases human enjoyment of and recreation opportunities along the river (Hoos & Packman, 1974).

On top of pollution, native species must compete with invasives, including narrow-leaf cattail and Himalayan blackberry, for resources, and climate change is causing an increasing number of extreme weather events and sea level rise.

Physical river training, pollution, invasives, and climate change are fragments of the settler colonial project that have affected Indigenous foods. The next section of this report uses food sovereignty to present on colonial-capitalist dispossession of Indigenous food sources and the ways food is being used for Indigenous resurgence. The section following considers Indigenous food sovereignty in the Fraser River estuary.

Indigenous Food Sovereignty

Indigenous food sovereignty explores the essential nature of food for Indigenous health, culture, community bonds, worldview, and law. Food sovereignty has been a target of colonial-capitalist policies aiming to separate peoples from their cultures and assimilate them into settler societies and economic systems. Through action around food, such as community gardens, Indigenous cooking, and traditional harvests, Indigenous peoples are reclaiming their culture, health, and sovereignty.

Food Sovereignty

The origin of food sovereignty is most often traced to a statement by La Via Campesina at the 1996 World Food Summit: “Food Sovereignty is the right of peoples to healthy and culturally appropriate food produced through ecologically sound and sustainable methods, and their right to define their own food and agriculture systems” (People’s Food Policy Project, 2011). La Via Campesina’s statement responded to challenges posed to small-scale farmers by neoliberal, globalized policies. Food security discourse dominated food systems, and policy-makers relied on global imports to meet nutrition requirements rather than supporting local farmers. Food sovereignty, as put forth by La Via Campesina, emphasized small-scale farming and sustainability. La Via Campesina’s definition of food sovereignty has been adopted with minor alterations by the United Nations and World Bank (People’s Food Policy Project, 2011).

Food sovereignty has been criticized for reasons that show a misunderstanding of the definition. Many critics mistake food sovereignty as calling for complete food self-sufficiency and cultural autonomy. Specific, although off-point, critiques of food sovereignty also include being unable to meet nutritional demands of a population, uplifting peasant virtues, ignoring remaining demands for tasty nonlocal foods, and relying on oppressive class and gender categories. Food sovereignty does work towards strengthening relationships to food, the land, and food producers, but does not require community independence, and communities are encouraged to create their own visions of food sovereignty (Robin, 2019; Whyte, 2016).

Food Sovereignty and Indigenous Peoples

A subset of scholarship within food sovereignty is dedicated to Indigenous food sovereignty. Indigenous food sovereignty is different from general food sovereignty in its origin, impact on social reproduction, benefits for different groups, reliance on certain foods, and relationships to food.

First, the beginnings of Indigenous food sovereignty are more obscure than those of food sovereignty. Kyle Powys Whyte, a Potawatomi scholar, argues that, although Indigenous food sovereignty was not a term used by Indigenous groups in North America until recently, Indigenous nations have engaged with the concept for hundreds of years; in treaties with settler nations, Indigenous nations retained rights to harvest foods in ceded territories. Language used before and instead of food sovereignty includes inherent sovereignty, self-determination, cultural integrity, subsistence harvesting, and treaty rights (Whyte, 2016).

Second, for Indigenous peoples, food sovereignty extends beyond healthy, culturally-appropriate, and sustainably produced foods to include social reproduction. Charlotte Coté explains, “Beyond nutritional health, Indigenous food sovereignty reinforces familial and social bonds of generosity and reciprocity in harvesting, sharing, and eating our food” (2022, p. 28). The acts of harvesting and preparing foods solidify community bonds, teach communities about their history, connect people to the land, and strengthen cultural identity (Robin, 2019). For example, harvesting a whale requires members of an Indigenous community to work together, the names of various parts of a fish help the Ojibwe remember their relations, and collective health and well-being of the Navajo Nation is indicated by knowledge and growth of sacred crops. Simply providing Indigenous peoples with foods of similar taste, quantity, and nutrient content to traditional foods would not reproduce culture in the same way. Food serves as a hub and a glue. When this hub is disrupted, Indigenous capacity to automatically adapt is limited (Whyte, 2015, 2016).

Jared Qwustenuxun Williams, an Indigenous chef on Vancouver Island, offers a clear visualization of the importance of traditional foods (see *Image 2* below*)*. By placing eating at the tip of a pyramid, Jared Qwustenuxun Williams demonstrates that eating traditional foods is only a small aspect of Indigenous culture. The other levels of the pyramid, in descending order, are cooking, preserving, harvesting, tool making, and teachings. Examples of items within these lower categories include dry pit roasting, jam making, fishing techniques, canoe production, and the teaching, “water is sacred.” Everything in the lower levels could be lost if Indigenous peoples do not eat traditional foods. Traditional food production, not just consumption, fosters culture.

Image 2. "Why is Eating Traditional Foods Important?" pyramid. By [Jared Qwustenuxun Williams] on [Facebook]. Used with permission.

When Indigenous culture, and therefore adaptivity, is limited due to limited access to traditional foods, the adaptivity of setter-industrial state institutions is bolstered. When Indigenous peoples are unable to harvest traditional foods, they must find ways to make money to purchase foods from market. Indigenous peoples can be financially pressured to support extractive industries on their territory, such as oil or mining, despite these operations putting food systems, community cohesiveness, and health at risk. This inadvertently supports settler colonial goals and further undermines Indigenous sovereignty and culture (Whyte, 2015).

Due to the strategic nature of North American Indigenous food sovereignty for decolonization, it follows that prioritizing certain foods that epitomize cultural connection would be most supportive of Indigenous resurgence (Whyte, 2016). In the upper Midwest, wild rice is a species associated with ceremony and community bonding. In the Great Plains, bison bring communities together. In the Pacific Northwest, salmon has been one such food. Ann Garibaldi and Nancy Turner, ethnobotanists who work with Indigenous peoples in British Columbia, draw on the ecological concept of keystone species to describe such plants and animals. In ecology, a keystone species is a species that plays an essential role in the balance and functioning of an ecosystem; popular examples include wolves in Yellowstone National Park and sea otters along the California coast. Extending the definition from ecology to culture, cultural keystone species are those that exhibit a particularly large influence on culture, such as through intense use, role in narrative, ceremony or symbolism, and persistent use despite cultural change - keystone species can be foods, but also be medicines or technology. Garibaldi and Turner identify western red-cedar, red laver seaweed, salmon, abalone, cockles, and wapato as cultural keystone species for coastal British Columbia First Nations (Garibaldi & Turner, 2004).

Another difference between general food sovereignty and Indigenous food sovereignty is Indigenous relationships with and responsibilities for food. The divergence begins with Western notions of land as property, as opposed to land as sacred, an inherent responsibility, and a living being with agency (Norgaard et al., 2011; Robin, 2019). Indigenous peoples enter into a relationship with the land, stewarding it so that it produces food. Foods are traditionally shared, rather than sold, and Indigenous people perform rituals to thank the Earth for the gifts of food (Kimmerer, 2013). Indigenous chef Mariah Gladstone summarizes, “Food takes care of us [and] we can take care of the places where our food comes from” (Ward, 2022).

An example of land stewardship is traditional burning of prairies and forests. Like many Indigenous food management practices, settlers did not recognize traditional burns as the highly-technical agricultural technique that they are. In the prairies, fire breaks the seed coats of plants, like the prairie potato. Fire-blackened grasses are warmed faster by the sun, which encourages the new seeds to grow, and the young shoots attract bison to the area, which are hunted (Ward, 2022).

Traditional burning also promotes the growth of wild blackberries in Coast Salish territory, and settler prohibition of this practice led to a logical decrease in the blackberry crop. Today, instead of only relying on Indigenous burns, Coast Salish peoples note where logging companies are slash-burning and return to these locations to harvest blackberries (Coté, 2022). Blackberries require stewardship that goes beyond Western notions of agriculture, and Charlotte Coté writes, “It almost seems like a misnomer to call qaalqaawi [blackberry] ‘wild’” (2022, p. 4).

Due to these differing inherent relationships and responsibilities with food and the Western notions implicit in “sovereignty,” some scholars find the term “Indigenous food sovereignty” limiting. Sovereignty is a concept based on Western political and legal entitlements and does not translate to Indigenous understandings of place. The singular form of “sovereignty” also does not recognize the diversity of food sovereignty initiatives carried out by Indigenous peoples - perhaps “sovereignties” would be a better fit. That being said, “food sovereignty” does usefully bring Indigenous concerns into international discourse (Daigle, 2015, 2019).

Systemic Erasure of Indigenous Food Systems

Indigenous food systems are less robust today than in the past, as settler nations have systematically targeted and erased Indigenous food systems and food sovereignty through colonial capitalism. Many of these colonial-capital practices continue today. With the arrival of the first settlers, Indigenous peoples across North America began to be forced from their traditional homelands. Settlers burned native crops, fields, and storehouses and killed large numbers of game animals on which Indigenous peoples relied. Indigenous peoples moved west and/or onto small plots of land designated by settlers. Many nomadic hunter-gatherer communities were relocated to arid, unfarmable lands and prevented from living their nomadic lifestyles (Gladstone, 2017).

When Indigenous peoples left their homelands, familiar plants and animals, with which Indigenous peoples had deep cultural relationships, were often left behind, and Indigenous peoples had to create relationships with foreign plants and animals that lived on new lands. Despite treaties that upheld rights to foodlands in many areas, Indigenous interests were repeatedly pushed aside in favor of settler economic interests and land privatization, and Indigenous peoples were prevented from accessing foodlands. Cutting forests eliminated habitat, hydroelectric dams impeded irrigation works and prevented migrating fish from reaching upstream communities, and roads impeded habitat connectivity and animal migrations. Sacred areas, such as Celilo Falls fishery on the Columbia River or Minnesota lakes that were home to wild rice, were submerged, or polluted with industrial, agricultural, and urban wastes, or deforested. Animals essential to all aspects of community life, such as bison and salmon, were nearly hunted, fished, and dammed to extinction (Gladstone, 2017; Norgaard et al., 2011; People’s Food Policy Project, 2011; Ward, 2022; Whyte, 2016).

By the late 1800s, most western tribes in the United States were completely dependent on government rations. The lands on which reserves were located were of limited value for food production; land was often allocated to be a reserve specifically because of its lack of economic or agricultural value to settlers. As rations and as commodity food programming, Indigenous peoples were offered staples of flour, sugar, and lard (Gladstone, 2017). Frybread, or, as Hopi journalist Patty Talahongva calls it, Die Bread, entered Indigenous culture (Talahongva, 2018). In areas where Indigenous peoples continued to have access to wild or traditional foods, permits have often been required to hunt, fish, or collect and such activities have been limited to certain times of year. Extra restrictions for certain species are in place for restoration, especially as a result of commercial overfishing and overhunting by settlers. Permits and harvest windows are often still enforced today, despite treaties that uphold Indigenous rights and excuse Indigenous peoples from such restrictions. Additionally, harassment by law enforcement has led people to further decrease their subsistence and ceremonial activities (Norgaard et al., 2011).

Facilitating the removal of Indigenous peoples and destruction of traditional foodlands were settler ideologies that viewed natural areas as “wilderness”: empty, unused, and wasted space that needed to be developed and put to use. Indigenous agricultural practices were not seen as valid. This ideology offered permission to ignore Indigenous presence and further degrade and pollute lands (Cronon, 1995).

In addition to limited access to traditional foods and means to produce foods, Indigenous nations in Canada faced settler policies, namely the *Indian Act,* that were meant to destroy Indigenous cultural, political, and social institutions. The Pass System, in place in Western Canada from 1882-1935, required Indigenous peoples to acquire settler approval to leave reserves. Conducting traditional ceremonies was forbidden, people were forced into Western land ownership regimes, and children were forcibly removed from their parents and sent to Residential Schools across Canada and the United States where the children suffered emotional, physical, and sexual abuse. Instead of learning traditional skills, such as language and food processing, children learned English and skills for service jobs in the settler economy. Indigenous knowledge was not transmitted from Elders to children as it had been in the past, which devastated knowledge of traditional food systems. The last Residential Schools did not close until 1996 (Daigle, 2015; Truth and Reconciliation Commission of Canada, 2015).

Lack of access to traditional foods and supportive cultural practices has had disastrous health impacts on Indigenous peoples. Indigenous bodies, many of which were adapted to high meat diets, could not quickly transition to the simple carbohydrates provided by the government. Access to healthy foods continues to be a challenge today; obtaining healthy, culturally-appropriate, and affordable food on reserves can require driving several hours to the nearest grocery store. The Blackfeet reservation in northern Montana is one example of a food desert: there are two grocery stores for an area the size of the state of Delaware.

High exposure to natural and industrial toxins and mental health challenges due to historical and personal trauma exacerbate diet’s impact on health. Half of Indigenous children born in the United States today will develop type 2 diabetes in their lifespan, and the life expectancy for

Indigenous peoples in the United States is 20 years less than the general population (Gladstone, 2017; Whyte, 2016).

Indigenous Resurgence Through Food Sovereignty

Many of the challenges faced by Indigenous food systems can be addressed through Indigenous food sovereignty. Indigenous food sovereignty enables Indigenous peoples to revitalize their cultural, political, and social institutions, and in doing so, resist colonial-capitalism. This section includes examples of food sovereignty initiatives. The initiatives are broad in scope, ranging from gardens, restaurants, cookbooks, seed saving, education, research, biomonitoring, and food cooperatives. Such everyday actions as gardening, cooking, and sharing food are as essential for Indigenous resurgence as political or legal action (Daigle, 2015; Robin, 2019; Simpson, 2017).

Food sovereignty can help revitalize language. Collecting or processing foods can be a reason to learn and use traditional language (Coté, 2022).

Indigenous cooking is becoming more popular across North America. Sean Sherman, also known as the Sioux Chef, in Minneapolis is a leader in revitalizing Indigenous cooking in the United States, and in Ottawa, Algonquin College offers an Indigenous cooking certification. The Vancouver Island Traditional Foods Conference was held annually in the mid 2010s, but no longer continues. In Vancouver, Coast Salish foods are becoming more common commercially, but remain exceedingly limited. Several Coast Salish cookbooks are in publication, including Salish Country Cookbook by Rudolph C. Rÿser and Feeding Seven Generations by Elise Krohn. (Neither the Vancouver Public Library nor the University of British Columbia Library have either book.) There is currently one Indigenous restaurant in Vancouver, Salmon and Bannock, and one Indigenous food truck, Mr. Bannock. Indigenous restaurants in British Columbia face challenges due to municipal health inspector regulations on certified meat producers, types of wild game that can be sold in restaurants, and food safety laws that do not align with traditional Indigenous preparation techniques (Dumpys Woolever, 2019).

Within Canada, national and provincial organizations have developed guidelines to support Indigenous food sovereignty. The People’s Food Policy Project has created a list of priorities for Indigenous food sovereignty in Canada: reforming and redistributing land by returning to treaty agreements, restoring the environment, healing and rebuilding relationships, and addressing social issues, such as poverty, affordable housing, and culture and language, that are negatively impacting the ability of Indigenous peoples to respond to their needs for healthy, culturally adapted Indigenous foods (People’s Food Policy Project, 2011).

Provincially, within British Columbia, the Indigenous Food Systems Network and the Working Group on Indigenous Food Sovereignty took the initiative to redefine Indigenous food sovereignty from a Western, rights-based discourse to a responsibilities-based discourse. The responsibilities-based language emphasizes cultural responsibilities and relationships that Indigenous peoples have with land, water, plants, and animals (Coté, 2022). This led to a set of four guiding principles: sacred or divine sovereignty, participatory, self-determination, and policy (Working Group on Indigenous Food Sovereignty, n.d.).

The priorities and principles from the People’s Food Policy Project and the Working Group on Indigenous Food Sovereignty are used to guide the research in this report. The second half of the report focuses on the priority of environmental restoration, as a small-scale, settler-approachable opportunity for research and action.

Foodlands in the Fraser Estuary

Coast Salish peoples have tended and harvested a wealth of foods from the Fraser River estuary. This section elaborates on specific foods harvested from the estuary, impacts of settler river management on food species, and First Nations relationships around foodlands with Metro Vancouver and the City of Vancouver. Due to the project's completion on Musqueam territory, a discussion of Musqueam culture and food sovereignty is also included.

Traditional Foods in Coast Salish Territory

Because the Fraser River estuary ranges from Mission, BC, 85km upstream, to the Salish Sea, the estuary hosts brackish marshes, mud and sand flats, rocky shorelines, and splash zones that, in turn, host various food species. The diversity in ecosystem types, and therefore food species, is partially attributable to tidal impacts on the Fraser River. Upstream of New Westminster, the estuary is completely freshwater, but still tidal. Downstream of New Westminster, the estuary is brackish. The salt wedge moves downstream from New Westminster during high flows, such as during spring freshet, and can reach Sand Heads at the coast. Therefore the estuary from New Westminster to Sand Heads can be completely freshwater at times (Tamburi & Hay, 1978). Some species are adapted to both freshwater and saltwater, but many can survive in only one or the other. Different species are also unique to different intertidal zones; certain adaptations are required for an aquatic organism to live out of water or a terrestrial organism to live in or on the water for several hours every day.

Defining food species to be included in this study was complicated, due to the fact that an estuary is, by definition, a body of water, but this study focuses on terrestrial foodlands in the estuary. For a food species to be included in this study, two requirements must be met. First, the species must be found above the waterline, on land, for at least part of the day. This allows various species in the intertidal zone to be included, as well as birds. Fish are notably excluded by this requirement, as many other studies have been completed, and are currently being completed, on fish. Second, for land-based species that are found ubiquitously in the region, estuary waters or habitats must be for some reason significant in the harvest.

Foods are harvested from each of these ecosystem types seasonally. Food species include bivalves (clams, mussels, and oysters), barnacles, crabs, fish, fish eggs, seaweed, small mammals (beaver, muskrat, otter), birds and their eggs, berries, roots, trees, and a variety of other plants.

The traditional foods consumed today are similar to those consumed in the past, based on archaeological and ethnographic sources. In Coast Salish territory, shell mounds offer dietary evidence that goes back 10,000 years; these mounds contain shells, bones, pollen, and other leftover fragments of people's meals and environment. Archaeological studies can remind elders of foods they hadn't thought about in years and facilitate the return of additional memories (Hoover, 2012). The species found in shell mounds align with ethnographic findings, and most of the foods found in shell mounds continue to be consumed, although in limited qualities or from different locales, today.

It is important to note that Indigenous stewardship is required to foster growth of food species; landscapes do not produce large quantities of food on their own. For example, camas root, which grows in rocky forest meadows, is cared for through burning, transplanting, and selective harvesting (Thom & Fediuk, 2009; Turner et al., 2013). Clam gardens increase the length of the intertidal zone to provide more habitat for clams (Pynn, 2019). Because managing foodlands has not been possible in many areas and pollutants have contaminated estuarine ecosystems, past foodlands now produce much less food.

Impacts of Limited Traditional Food Access on Coast Salish Society

Similar to broader trends in traditional Indigenous foods across North America, many Coast Salish people no longer obtain their foods from their lands, despite wanting to. A study of Coast Salish food insecurity in the southeast portion of Vancouver Island found that people had less access to wild foods than they desired, and that "Coast Salish people equate their own food security with access and consumption of a broad range of wild foods" (Thom & Fediuk, 2009, p. 11). About one quarter of people in Thom and Fediuk's (2009) study regularly harvested foods, but the diversity of foods was limited; of the more than 200 desired species, only two, salmon and clams, were of adequate supply.

This lack of traditional foods in Coast Salish diets has had negative impacts. Before colonization, 90% of the protein in a traditional Coast Salish diet was from marine sources. A person would consume 1-2kg of marine foods every day. Today, government regulation, poverty, environment, issues related to private land, loss of traditional knowledge, various personal reasons, and high costs of traditional foods at market are key barriers. More than half of Coast Salish peoples in the southeast portion of Vancouver Island live below the poverty line, and accessing traditional foods would improve their quality of life. The change in diet has had negative health impacts; infant mortality is more than four times that of the general population, people have a high risk of anemia, and rates of obesity are increasing. These numbers are potentially worsening, as a significant portion of people's marine foods had been coming from Indian Band governments through the federally funded Aboriginal Fisheries Strategy program, but the distribution decreased from 50 salmon per year in 2001 to 5 salmon per year in 2009 (Thom & Fediuk, 2009).

Knowledge and harvest of traditional foods is also intimately tied with language - both language loss and revival. Many Coast Salish peoples only learn plants by their First Nation's names (Charlie & Turner, 2021; Coté, 2022). Elders hold a patchwork of knowledge about foods and medicines found on the land, often from childhood experiences with family, that few today know. While some names and uses of plants have been lost, new names are also being granted and information is being shared with future generations (Charlie & Turner, 2021).

River Management and Traditional Foodlands

Settler management of the Fraser River has had a major impact on Indigenous access to traditional foods in the estuary. Beginning in the late 1880s, settlers dredged, diked, and removed natural debris from the river, and these changes altered ecosystems, including traditional foodlands.

Annual dredging in the South Arm, from New Westminster to Sand Heads, began in the 1880s, and dredging in the North Arm began in 1918 (McLean et al., 2006; *The North Arm of the Fraser, Its Industries, Its Possibilities*, 1918). Dredging removes sediment from the bottom of a river channel or harbour either by vacuum or bucket and crane (clamshell dredge). The dredged material can be pumped to storage locations onshore or onto a nearby boat for future use or disposal (BIEAP & FREMP, 2006).

Dredging impacts ecosystems by disturbing sediments and bottom-dwelling communities, stirring up or moving pollutants, increasing sediment in suspension, smothering at disposal sites, and increasing erosion of sand flats and marshes.

The majority of studies regarding dredging's impact on wildlife have been related to fish. Sediment removal can entrain juvenile salmon, eulachon, and other fish, effectively killing them. Increased suspended sediments erode a fish's skin and gills, decrease vision and food consumption, and suffocate eggs laid in stream beds. Sediment can also disturb intertidal vegetation by reducing light and burying plants; this can lead to a decline in catchable fish for up to four months after dredging (BIEAP & FREMP, 2006; Lamothe-Ammerlaan et al., 2017).

Regarding pollutants, dredging can be either harmful or beneficial. Pollutants can reenter the water column during dredging, but removal of polluted sediments and trash can improve the health of aquatic ecosystems and reduce the risk of eutrophication. Pollution is especially of concern in the North Arm of the Fraser River; the river has received, and continues to receive, many industrial wastes (BIEAP & FREMP, 2006).

Disposal of the sediment removed from the river poses another risk to ecosystems. Dredge spoils from the Fraser are most commonly dumped at sea or along the shore. Sometimes, dredged material is coveted as infill at construction sites. Spoils are rarely deposited along the shore today, but past instances include dumping of dredge spoils on the upper intertidal zone between the Iona Causeway and the North Arm Jetty prior to 1966, along Wreck Beach from Trail 6 to Point Grey in 1977, and behind the west end of the bend in the Steveston North Jetty in 1987. A marsh-building project requesting dredge spoils has been proposed on the north side of the Steveston North Jetty, with the aim of reversing the retreat of tidal marshes (Hales, 2000; Hemsing, 2005; Maxwell, 2021).

Since dredging removes sand-sized sediments from the river, sediment naturally deposited in sand and tidal flats at the mouth of the river is decreased. This could lead to increased wave erosion of marshes. River training structures, which transport sediment further offshore, and removal of woody debris exacerbate the situation. The debris protects marshes by acting as a breakwater; the debris can also create habitat for young plants when old plants are uprooted as debris is dragged across the surface of tidal flats or marshes during storms or high seas (Hales, 2000).

River training structures have been a second impactful settler river management technique. Almost all the major river training structures in the lower Fraser, which include dikes, jetties, breakwaters, and walls, were built between 1910 and 1945. During this period, wetlands along the river were replaced with rocky barriers, reducing foreshore habitat essential for fish, ducks, bivalves, and plants.

River training structures had unexpected ecological benefits. Although wetlands were destroyed, brackish marshes expanded as sediment collected in lee areas behind jetties. Between 1930 and 1954, marsh area in the delta increased 16%, including losses due to land reclamation. Marshes in the newly-protected booming grounds on the North Arm expanded rapidly and protected the shoreline from additional erosion. Sand waves also developed on tidal flats as a result of wave refraction from the jetties (Hales, 2000).

In addition to marsh growth, the hydraulic conditions created by the river training structures stabilized existing marshes. Previously, marshes had previously been subject to frequent migration; islands would slowly march downstream, and marshes thrived at their margins. When islands were stabilized with rocky dikes, the islands stopped moving downstream and vegetation patterns shifted. Trees grew for the first time on some river islands, and marsh species that once thrived in new, open habitat were outcompeted (Hales, 2000; UBC Campus Planning, 2000).

The river continues to be managed today, although with greater emphasis on environment and less emphasis on engineering. Wetlands are recognized as essential salmon habitat and flood mitigation tools, dead-end river corridors that trap juvenile salmon are being reopened, and the public demands greater degrees of sewage treatment. There continues to be push and pull, as humans desire to live alongside the water, while at the same time desire public water-side greenspace and adaptability to rising water levels with climate change. Reconstruction of the Iona Island Wastewater Treatment Plant and the associated Regional Park provides one opportunity for habitat reconstruction. Yet overall, the trend of declining natural habitat prevails: in the Greater Vancouver area, in the 5 years from 2009 to 2014, there was a decrease of 3.4% in the sensitive and modified ecosystems (such as forests and wetlands) in the regional core due to human impacts (Clark & Meidinger, 2020).

First Nations Relationships with Regional Park Management

Parklands are some of the last areas in the Fraser River estuary where traditional species can be found and safely harvested. That being said, First Nations' relationships with Regional Parks have not always been positive. This section looks to the creation of Pacific Spirit Regional Park to illuminate ongoing green colonialism and disrespect of Musqueam land claims. An interview with Metro Vancouver staff suggests improvements to the relationship since the park was created.

In the 1980s, Musqueam was vocal in asserting land claims in the Vancouver area, and Musqueam was particularly interested in the University Endowment Lands (UEL). The UEL are the last major forested area on the Vancouver peninsula and the only major undeveloped tract of land in traditional Musqueam territory in Vancouver. The lands are also adjacent to Musqueam's main reserve and are regularly used by Musqueam for spiritual purposes, berry picking, medicine gathering, dye collecting, and gathering wood for carving. A regional park was proposed for the same lands, and the park idea was popular with settlers. In an act of green colonialism, in which colonial acts such as land grabs occur under the guise of environmental protection, Musqueam was dispossessed of the land. The transfer of the UEL from Crown Land to the Greater Vancouver Regional District (now known as Metro Vancouver) in 1989 directly ignored Musqueam's claims to the land and created new land use restrictions in the forest (Glavin, 1989).

Today, Pacific Spirit Regional Park, as well as the 11 other regional parks in the Fraser River estuary, are managed by Metro Vancouver. Enhancing relationships with Indigenous communities who have an interest in natural resource management is part of Metro Vancouver's Regional Parks Natural Resource Management Framework:

> "Regional Parks recognizes the importance of Indigenous traditional knowledge for the management of regional parks. Natural resource management in parks is based in science and will be enhanced by honouring and incorporating traditional ways of knowing. Engaging local First Nations to better understand past and future uses of park lands and waters will improve planning and operations, provide better management and support healthier communities." (Metro Vancouver, 2020, p. 11)

Different parks have different levels of engagement with local Indigenous groups; Pacific Spirit Regional Park and Iona Island Regional Park have a 20-plus year informal relationship with Musqueam, and Metro Vancouver hopes to develop and strengthen relationships with other First Nations in other parks (R. Worcester, personal communication, May 13, 2022).

As part of this relationship, Musqueam is able to use parkland for harvests and is consulted about restoration projects. Although the general public is prohibited from harvesting in Regional Parks, the Indigenous need for limited, sustainable harvesting is respected when Regional Park staff are informed. Prior to this, Musqueam was expected to go through the same "research permit" system used by scientists to obtain permission to harvest from the park.

Restoration projects within Regional Parks tend to be opportunistic, due to low staff and resources, but First Nations are included in the decision-making process and First Nations' suggestions are heeded. For example, Musqueam suggested specific habitat elements for a restoration project, and Metro Vancouver contracted with a nursery to grow the plant species not commercially available. When a culturally significant site overlaps with an area needing restoration or public safety work, work at that site is likely to be prioritized (R. Worcester, personal communication, May 13, 2022).

"What is the City's Role in It?"

The City of Vancouver also manages natural areas in the Fraser River estuary and is orienting towards First Nations and food sovereignty. As Food Policy Planner, Caitlin Dorward, summarizes, the City of Vancouver is asking, "What is the City's role in [supporting Indigenous food systems]?" (C. Dorward, personal communication, June 9, 2022).

The City of Vancouver is ambitious in its goals to engage with Indigenous peoples, such as in the Vancouver Park Board's Local Food System Action Plan. The first of four goals is to centre

Indigenous voices by improving access to Park Board land for Indigenous peoples to harvest food and medicine and funding Indigenous-centered food spaces and initiatives. Additionally, one of the six objectives of the Local Food System Action Plan is to “Identify opportunities to remove barriers and support Indigenous ways of relating to the land and food systems, in alignment with the Park Board’s decolonization goals and commitment to Reconciliation” (Vancouver Board of Parks and Recreation, 2021). The Park Board’s document identifies the City’s responsibility to support Indigenous food sovereignty, but the Park Board has yet to take significant action for change (C. Dorward, personal communication, June 9, 2022).

As of June 2022, the City of Vancouver is not working directly with any First Nations around food policy, but has supported Indigenous individuals and groups through initiatives such as giving them access to funding and space for community gardens and residencies (C. Dorward, personal communication, June 9, 2022). Additionally, the City of Vancouver does have a volunteer-based Food Policy Council, which reserves two seats for Indigenous members (*Members*, 2022).

Musqueam First Nation

Because this project takes place on Musqueam territory, a discussion of Musqueam culture and food sovereignty is included. Musqueam is a Coast Salish nation whose traditional territory includes almost the entire estuary and neighboring lands: Musqueam lands include all of Vancouver and extend up Howe Sound and into the Fraser Valley (see *Image 3*). (Note that Musqueam territory also extends to the centre of the Salish Sea.) Musqueam people have lived on their traditional territory since time immemorial, and artifacts found in Musqueam territory are more than 9,000 years old (Musqueam, 2011).

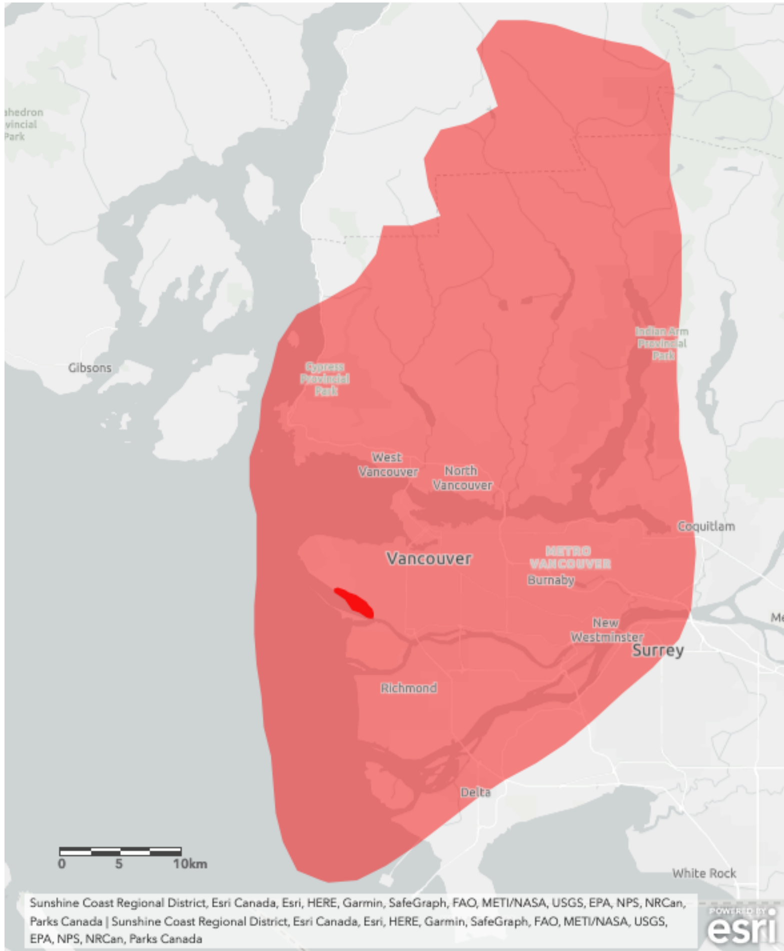

Image 3. Transparent area approximates Musqueam terrestrial territory and solid area approximates Musqueam Indian Reserve 2. By Katharine Baldwin, adapted from Musqueam Statement of Intent Boundary.

The name, Musqueam (xʷməθkʷəy̓əm), means People of the River Grass. The grass (məθkʷəy̓) grows on the tidal flats and marshes within the estuary. Musqueam people are closely aligned with the Fraser River; Musqueam people live along the river's banks and fish in its waters, and the people's rhythms, stories, and culture stem from the river. The origin of Musqueam's name shows deep connection to and relationship with place (Musqueam, 2011).

Today, Musqueam First Nation's land holdings are 0.2% of their traditional territory. Indian Reserve 2 (IR2), today's main reserve and population centre, has been Musqueam's main winter village for over 3,500 years. Musqueam has approximately 1,300 members, half of which live on reserve. The population is young: people under 20 represent almost 40% of the population, compared to 23% for the rest of Vancouver. The population is also aging, with the number of elders expected to double in the next 10 years (Musqueam, 2011).

In 2001, the Aboriginal Peoples Survey queried residents at Musqueam IR2 about topics including traditional foods, residential school attendance, health, and language. The responses offer insight into Musqueam people's values and the challenges (Statistics Canada, 2009).

Some residents of IR2 harvest traditional foods, medicines, and technologies. In the past 12 months, 13% of residents hunted, 34% fished, and 16% gathered wild plants. The vast majority of the hunting and fishing, and half of the gathering, was done for food (Statistics Canada, 2009). The mouth of the Main Arm of the Fraser River and Roberts Bank are Musqueam's primary fishing, prawn, and crabbing areas, as well as areas used for hunting wildfowl and gathering plants (Government of Canada, 2015).

The percentage of people harvesting traditional species is hopeful, given that Musqueam residents have been highly impacted by colonial policies, partially due to their location in a now-urban area. Musqueam residents were affected by residential schools more than other Indigenous peoples in Vancouver. A quarter of adults at Musqueam attended a federal residential or industrial school, and nearly all adults have a family member(s) who attended such a school. This compares to 6% personal attendance and 63% family attendance across Vancouver. Residential school attendance, as well as various other colonial policies, have had a negative health impact on Musqueam adults; adults at Musqueam are in slightly poorer health than Indigenous adults across Vancouver, with over a quarter reporting their health as only fair or poor, and more than half having at least one long term health condition (Statistics Canada, 2009).

Musqueam people value reclaiming their cultural heritage through language. Survey responses show that the Hən̓q̓əmin̓əm̓ language is important to Musqueam respondents. One third can speak or understand Hən̓q̓əmin̓əm̓, and 84% say keeping, learning, or relearning the language is either important or somewhat important (Statistics Canada, 2009).

Musqueam and Food Sovereignty

The importance of food sovereignty for Musqueam is apparent through litigation, conservation activities, and planning documents.

Musqueam has been key in litigating for Aboriginal rights across Canada, especially in regards to access to traditional and healthy foods. The 1976 Musqueam Declaration laid the groundwork for Musqueam rights, and two influential supreme court cases followed: the 1984 Guerin case and the 1990 Sparrow case.

In the 1984 Guerin case, the Department of Indian Affairs leased land on the Musqueam reserve to Shaughnessy Golf and Country Club with terms different from those to which Musqueam had agreed. Instead of being paid fair market rent for the land, Musqueam received only 10% of that amount. The Supreme Court ruled that the government must act in the best interests of First Nations (First Nations Studies Program, 2009).

The 1990 Sparrow case began when Musqueam band member Ronald Sparrow was arrested for fishing with a net longer than his permit allowed. The Supreme Court ruled in favor of Musqueam: Aboriginal rights to fish had not been extinguished, and the government bears the burden of justifying regulations with a negative effect on Aboriginal rights (First Nations Studies Program, 2009). Both this case and the Guerin case assert the Canadian government's responsibility to protect the rights of Indigenous peoples, including Indigenous rights to food.

Musqueam has also taken smaller-scale actions towards food sovereignty. Musqueam's Fisheries Department assists the federal Department of Fisheries and Oceans to enforce fishing regulations and monitor salmon stocks (Musqueam, n.d.). Also, since 1997, the Musqueam Ecosystem Conservation Society, (originally the Musqueam Watershed Restoration Project) has partnered with the David Suzuki Foundation to conserve and restore the Musqueam Creek watershed.

Access to traditional foods continues to be a priority for planning at Musqueam. In the 2018 Comprehensive Sustainable Community Development Plan Update, Musqueam prioritizes increasing access to traditional and healthy foods as Action #8. Subgoals include increasing access to foods through habitat restoration and asserting rights, educating around nutrition and cooking, exploring options for a community garden and food bank or donation centre, and creating partnerships, such as with UBC Farm. Rationale for prioritizing foodlands is that "Harvesting and consuming our traditional resources gives our community members a way to establish connections with our culture and improves health and wellbeing" (Musqueam, 2018).

Barriers to Food Harvest: Pollution, Invasives, and Climate Change

This section begins with a history of pollution in the estuary, describes impacts of invasive species, discusses local effects of climate change, and then explores the impacts of these factors on cultural keystone species.

History of Pollution in the Estuary

The Fraser River and Salish Sea have been subject to high levels of pollution since the early 1900s, which have affected ecological and recreational activities in the estuary. Since settlement, the waters surrounding Vancouver have served as Greater Vancouver's waste disposal system. The river acted as an open sewer draining the Fraser Valley, and both sewage and industrial waste were once deposited unfiltered into its waters.

For many years, the river and ocean were able to dilute the young city's wastes, but at the turn of the 20th century, as Vancouver's population grew and the city industrialized, the river and tides became insufficient. A Greater Vancouver regional sewerage committee undertook a series of projects that moved the sewage further from Vancouver's popular beaches, while undertaking minimal treatment. Even with additional treatment and sewer lines, pollution killed aquatic life, closed shellfish bed harvests, caused eutrophication, facilitated disease outbreaks amongst humans, threatened the health of fishermen, tugboat operators, and other water users, and detracted from public enjoyment of the water. Public frustration peaked in the 1970s, and conversations over the necessary extent of water treatment continue to this day (Keeling, 2005; Stewart, 2017; Waldichuk, 1983).

Lack of unified governance has challenged management of water quality in the lower Fraser. Although beyond the scope of this project, water quality has been managed in both short-term projects and long-term governance by the Fraser Basin Management Program, the Fraser River Estuary Management Plan, the Fraser River Action Plan, the Greater Vancouver Regional District (now Metro Vancouver), and various municipalities (Hall & Schreier, 1996).

Sewage

Prior to the 1910s, sewage flowed in small streams and underground pipes into the Fraser River and Burrard Inlet, near to where the waste was produced. For many years, the amount of waste produced by Vancouver's small population was able to be assimilated into the river's flow and the ocean's tides. Sewage planners tracked the water's ability to disperse waste and created measures of "assimilative capacity" to guide city planning (Keeling, 2005).

As the waste from Vancouver's population exceeded the natural assimilative capacity of the river and ocean, Vancouver's engineers needed a new approach to mitigate pollution. In 1911, R.S. Lea, a sanitary engineer from Montreal, was hired to address the polluted river, creeks, and shorelines. For Lea, the most beneficial use of the river and estuary was disposal of sewage, and not taking advantage of the assimilative capacity of the river would be an unethical waste of a natural resource. Lea designed a plan that transported untreated sewage in underground pipes to outfalls, which deposited the waste into the surrounding waters. These pipes followed the natural drainage patterns of the region. At outfalls where waste could potentially stagnate, the waste would be released deep underwater, where it would be carried away by currents. (These underwater outfalls were common along the Fraser River.) Because the North Arm was especially polluted, Lea proposed an additional interceptor sewer to collect waste from outfalls along the riverbank and divert the waste to the mouth of the river at Point Grey - at Musqueam's village near the present log booming grounds. Despite concerns from Musqueam and sawmill owners about sewage backing up in the river and contaminating log booms, Lea was confident his plan would overcome the complexities and variability of tides and river discharge (Keeling, 2005).

Lea's plan mitigated excessive pollution until the 1950s, when population growth strained the system. Beaches were frequently closed due to high bacteria counts, and officials worried about illnesses, including typhoid, spreading through the contaminated water. City officials hired A. M. Rawn, a sanitary engineer from Los Angeles County, California, who employed a "zoned" approach to sewage management. Under the Rawn Plan, some areas, such as English Bay, would be protected for recreation and public enjoyment, while other areas, such as the mouth of the Fraser River, were designated as sacrifice zones. To transport sewage to sacrifice zones, Rawn conceptualized a "giant flushing machine:" all sewage flowing northbound to Burrard Inlet (a recreation zone) and southbound into the North Arm Fraser River (already too polluted for safe industrial use) would be redirected to a sewage treatment plant at Iona Island, at the mouth of the North Arm. After primary treatment, where solids would be strained from liquids, the liquid sewage would be piped three miles into the ocean at Sturgeon Bank. Raw sewage would still enter the Main Arm of the Fraser River from New Westminster, Richmond, and parts of Burnaby. Rawn's proposal was adopted, and the Iona Island Wastewater Treatment Plant opened in 1963 (Keeling, 2005; Stewart, 2017; Waldichuk, 1983).

Soon, even Rawn's plan was not enough to manage the growing urban waste of Vancouver. A 1970 Vancouver Health Board reported unpleasant smells, black-brown foreshores, and gas bubbles along the Fraser River. Lumber mills described large buildups of fecal matter on log booms. Residents displayed samples of slimy sewage collected near the Iona Wastewater Treatment Plant on the floor of the BC legislature. Concern over human illness was the primary motivator for change. Two more sewage plants with primary treatment were proposed (Keeling, 2005; Stewart, 2017).

Residents of Greater Vancouver supported construction of additional sewage treatment plants, but were frustrated that the government proposed only primary treatment. In December 1971, a flotilla of dozens of fishermen and environmentalists protested the primary treatment proposed for an Annacis Island treatment plant, in favor of secondary treatment. Secondary treatment uses biological processes to remove 90% or more of material remaining after primary treatment. At the protest, fishermen worried that sewage in fishing nets was a health risk to workers and complained that there were no fish to be caught in the North Arm Fraser due to pollution (Waldichuk, 1983). Conservationists united with the laborers, and in 1975, an upgrade to secondary treatment at Annacis Island was approved (Keeling, 2005).

By the 1980s, wastewater treatment plants operated at Iona Island, Annacis Island, Lulu Island, and near Lion's Gate Bridge, yet pollution problems continued. In 1980, a major fish kill occurred near the mouth of the Fraser River due to oxygen depletion. Under the Fisheries Act, regional sewage officials were fined $5000 each (Keeling, 2005). Investigations showed sediments at the outfall from the Iona Island Wastewater Treatment Plant were contaminated, water lacked oxygen, and the habitat was not suitable for bottom-dwelling organisms. Options for diffusing waste deeper across Sturgeon Bank were studied, and the Iona Island Wastewater Treatment Plant was forced to disinfect treated water with chlorine when bacteria counts were too high along Spanish Banks, i.e. during most of the summer (Waldichuk, 1983). In the following years, more water treatment plants were built and upgraded to keep up with increasing demand.

Today, Metro Vancouver operates five wastewater treatment plants, two of which provide primary treatment and three of which provide secondary treatment. Primary treatment removes materials that either settle or float, which account for 30-40% of biological oxygen demand. Secondary treatment uses biological processes to remove 90% or more of remaining material. The Lion's Gate Treatment Plant is being replaced with the North Shore Treatment Plant, which will provide tertiary treatment. Tertiary treatment removes ammonia, nitrates, and additional organic matter. The Iona Island Treatment Plant, the only other primary treatment facility, is also being upgraded. In the past, the benefits from upgrades to secondary sewage treatment have been offset by population growth. Tertiary treatment will remove additional pollutants from the water, in addition to facilitating continued urban expansion (Hall & Schreier, 1996; Metro Vancouver, 2022).

Industrial Pollution

In addition to sewage, the Fraser River has been receiving effluent from various point and nonpoint sources. Industrial waste is point-source pollution, because there is a single identifiable source that pollutants come from, such as a smokestack or water pipe. Industrial waste is not easily treated in standard water treatment plants and is instead addressed at the source (Waldichuk, 1983).

In 1996, approximately 140 businesses along the lower Fraser had permits to discharge industrial waste directly into the river. The permits fell into 29 different waste categories, but little detail regarding the particulars of the waste is known (Hall & Schreier, 1996). Permitted businesses included Dow Chemical Canada, which produced highly toxic phenolic resins, metal recycling facilities, and sawmills, which released leachates from wood and bark in log booms (Waldichuk, 1983).

In contrast to arguments for controlling sewage that revolved around mitigating transmission of disease to and between humans, arguments for controlling industrial pollution revolved around reducing harm to fish (Stewart, 2017). Fisheries scientists and ecologists raised concerns about toxic chemicals in the water that they had the technology to begin measuring in the 1950s and 1960s, and biochemical oxygen demand was primary in the conversations (Waldichuk, 1983).

Conflicts over ecological harm to fish can clearly be seen in relation to pulp and paper mills. Pulp and paper mills have been a major source of industrial waste into the Fraser River and Salish Sea. In the 1960s, mills were built along the Fraser in Prince George and Kamloops, and by the 1980s, several mills also operated along the lower Fraser. The waste from pulp mills had high biochemical oxygen demand (BOD), large volumes of suspended solids, an unnatural color, an odor, foam, and chemicals from either sulfite or kraft processes. The high BOD of pulp effluent was especially concerning for fisheries, as fish require oxygen for survival; BOD for a 500 ton per day kraft mill was equivalent to the sewage of a city of 236,000 people. Effluent from a sulfite mill had an even greater BOD, equivalent to 1.9 million people. The effects of BOD on fish were mostly localized, but the chemicals released from the mills upriver also affected organisms in the lower river. Discharge requirements were established for the various mills, which were primarily enforced by the Department of Fisheries. Mills now had holding ponds and completed at least some level of water treatment. In an environmental win, assimilative capacity was rejected in favor of biological and chemical waste treatment to protect spawning salmon (Hall & Schreier, 1996; Keeling, 2005).

Nonpoint Source Pollution

While industrial wastes, including those from pulp and paper mills, are point sources of pollution, nonpoint sources also challenge water quality in the Fraser River and Salish Sea. Nonpoint sources are harder to address, as the source of the waste is a large area, rather than a single factory or mill. Agricultural runoff is a nonpoint source of pollution that contributes to algae blooms, which cause shellfish poisoning. Forestry runoff can add significant sediment and contaminates to streams. Urban runoff, only some of which is eventually collected by storm sewers and piped to wastewater treatment plants for treatment, is another challenge. The first storm after dry periods tends to be especially problematic, because the rainwater washes large amounts of urban pollutants from rooftops, streets, and lawns. These pollutants include spills and leaks of automobile fluids, pesticides, animal and bird excrement, deicing salts, and trace metals such as copper from brake lining and zinc from rubber tires. Levels of many pollutants in Vancouver's waters exceeded safe levels for protection of aquatic life in the 1990s (Hall & Schreier, 1996; Waldichuk, 1983).

Much of Vancouver's urban runoff enters combined storm sewer pipes (as opposed to separate pipes for stormwater and sewage) and is carried to wastewater treatment plants for treatment. While treatment of urban runoff is beneficial, combined storm sewers can increase pollution during large rain events; when too much rain falls, the pipes overflow or exceed the capacity of the water treatment plant, and some rainwater and sewage is released untreated. This happens frequently in Vancouver (Conger et al., 2019).

To combat combined storm sewer overflows, the City of Vancouver is both separating sewage and rainwater pipes and building green water infrastructure. The city has been separating the sewer lines since the 1970s, but even with separate lines, the pollution in urban rainwater runoff remains and still must be treated. The City of Vancouver's current Rain City Strategy aims to capture and treat 90% of rainwater at the source by 2050, rather than permitting the water to run off. The strategy relies heavily on green water infrastructure, such as rain gardens, absorbent landscapes, living roofs, permeable pavement, downspout disconnection, and non-potable water reuse. Pollutants contained in the rainwater may concentrate in the gardens, which may need to be eventually decontaminated. That being said, green water infrastructure is still an economically preferred way to treat and reuse urban rainwater, as well as create additional green spaces for human use (Conger et al., 2019).

Invasive Species in the Estuary

Invasive species are another threat to estuary foodlands that impact our environment, economy, and health. An invasive species is a species that has been introduced to an area and has taken over. Invasives outcompete native species for water, light, nutrients, and space, and can reduce soil and water quality, change wildfire regimes, degrade resources, introduce disease, and threaten biodiversity (*What's the Big Deal?*, n.d.).

Key invasives affecting Fraser River estuary foodlands include narrow-leaf cattail, Asian clam, yellow flag iris, European green crab, Eurasian watermilfoil, English ivy, non-migratory Canada goose, and Himalayan blackberry. A particular challenge with Himalayan blackberry is that the plant's thick growth and thorns physically block access to food harvest sites (Banwait, 2022). Additional information about non-migratory Canada goose and Himalayan blackberry can be found in the sections on edible roots and berries.

To briefly touch on climate change before a deeper discussion in the next section, climate change impacts are exacerbated by invasive species. Some invasive species, such as scotch broom, have oily branches that accelerate the spread of fires. Out-competition of native species means native species' deep roots no longer stabilize banks in areas prone to erosion. The added weight of invasives, such as English ivy, on trees makes the trees more likely to topple in storms. Hand in hand, invasive species also exacerbate climate change; ecosystems altered by wildfires, floods, disease, and extreme weather are aggressively colonized by invasives (*What's the Big Deal?*, n.d.).

Primary origins of introduced species in the Fraser River estuary are international shipping and the aquarium trade. Shipping is a major challenge, as organisms travel in ballast waters, burrowed into or attached to hulls, or ride aboard ships. The Atlantic teredo and the New Zealand mudsnail both arrived via shipping, as well as many other species (*New Zealand Mudsnail*, n.d.; Waldichuck et al., 1994). A detailed study of exotic marine invertebrates has not been completed for British Columbia, but a study found almost 100 exotic marine invertebrates in the San Francisco harbour (Waldichuck et al., 1994). Shipping volume to Port Vancouver continues to increase, thereby increasing the transportation of non-native species. To reduce the risk of colonization by additional invasive organisms, ships are now required to dump their ballast in the open ocean rather than in the inlet or harbour (BC Conservation Data Centre, 2006).

Several organizations manage invasives in the estuary. The Invasive Species Council of BC tracks and manages invasive species in the province. The council hosts webinars, which are recorded and have been posted online since 2019, and collaborates with Indigenous land and water stewards. Metro Vancouver and the Invasive Species Council of Metro Vancouver host web pages about best-management practices for dozens of invasive species and work with practitioners and residents to eliminate invasives across Metro Vancouver.

Key actions that residents can take to minimize the spread of invasives include planting non-invasive species in gardens and landscaping, removing and/or trimming invasive plants, cleaning boats, clothing, and gear between uses, not transporting soil or firewood, and reporting sightings of invasive species. Sightings can be reported on the BC Invasives website, as well as through the Report Invasives BC and iNaturalist apps.

Climate Change in the Estuary

Climate change, and the associated rise in sea level, pose threats to the Fraser River estuary. Greater Vancouver is already seeing the effects of climate change. Various governance organizations within the estuary have proposed methods to address the threats, ranging from coastal armouring to retreating. First Nations are at higher risk of climate-related impacts, due to the low-lying locations of reserves and reliance on local ecosystems for food, culture, and well-being.

Projected Changes to Local Climate and Sea Level

The Government of British Columbia, as well as various sub-governance agencies including Metro Vancouver, have compiled data about projected impacts of climate change on the province and Greater Vancouver. Vancouver will be 3°C warmer by the 2050s, with an increased number of hot days; this will make Vancouver warmer than present-day San Diego. Annual precipitation is predicted to increase 5% by 2050, and the additional precipitation will increasingly fall during extreme weather events. Annual snowpack, which Metro Vancouver relies on for drinking water during the dry summer months, will decrease by 56% (Metro Vancouver, 2016).

These changing conditions will tax ecosystems. Data suggests a 20% increase in the length of the growing season, a 45% increase in growing degree days, and a 60% decrease in the number of frost days. Scientists expect to see more pests and invasive species, increased wildfire risk, reduced soil moisture, and high flood risk. Despite an increase in the length of the growing season, hotter summers may mean decreased plant growth, heat stress, water scarcity, and increased resource competition. Aquatic species in particular will experience decreased streamflow, warmer water, and an earlier freshet. Many native species will not be able to adapt to changing conditions quickly enough to maintain widespread populations; this will affect traditional foods (Metro Vancouver, 2016).

Greater Vancouver's location on the Salish Sea means the region is also subject to sea level rise. 80% of British Columbia's population lives within 5km of the coast, suggesting sea level changes will have a significant impact on human populations, and coastal ecosystems will be squeezed between the rising sea and human development. Additionally, most Musqueam, Tsawwassen, Semiahmoo, Tsleil-Waututh and Squamish lands are close to sea level, meaning climate change will greatly impact Indigenous nations' reserves, culture, and lifeways (Arlington Group Planning and Architecture Inc. et al., 2013; City of Vancouver, 2018).

Average sea level rise globally is estimated at 17cm per 100 years, but sea level rise will not occur uniformly around the world, nor uniformly along the B.C. coast. Tectonic change, subsidence, and post-glacial rebound affect the height of the land, and thermal expansion, melting glaciers and ice caps, and the melting of the Greenland and Antarctic ice sheets affect the volume of water in oceans (Arlington Group Planning and Architecture Inc. et al., 2013).

In Greater Vancouver, land in the Fraser River delta is subsiding (i.e. compressing) and the volume of water in the ocean is increasing. Post-glacial rebound and tectonic uplift are working in the opposite direction to raise the level of the land, mitigating sea level rise. Sea level in the City of Vancouver (which is not on delta sediments) is rising at a rate of 2cm every 50 years. Sea level rise in delta areas, including Richmond, Delta, and Queensborough, will be an additional 5-10cm every 50 years (Arlington Group Planning and Architecture Inc. et al., 2013).

The rate of global level rise is exponentially increasing. The predictions in the last paragraph rely on data from the latter part of the 19th century and the 20th century; since 1993, rates of sea level rise have nearly doubled. Thermal expansion is the largest contributor. The British Columbia government commissioned a study in 2011 that recommended planning for a half meter of sea level rise by 2050, 1.0m by 2100, and 2.0m by 2200, plus adjustments for local rates of land height change. The distant projections are not for scenarios where humans continue to pump carbon into the atmosphere - even if carbon emissions stopped today, sea level will continue to rise for centuries as ocean temperatures reach an equilibrium with air temperatures (Arlington Group Planning and Architecture Inc. et al., 2013).

When calculating sea level rise for Greater Vancouver, the authors of the government reports focused on built rather than natural environments and did not consider the impacts of continued sediment deposition in the estuary by the Fraser River. Since most residential areas are diked, those areas will continue to sink, but areas outside the dikes, such as sand flats and marshes, will receive additional sediment: sedimentation is estimated at 1.18cm/year. Hales (2000) calculates this sedimentation rate to be sufficient to maintain the delta and brackish marshes in the face of otherwise rising sea levels and subsisting sediments. Marshes and sand flats may continue to provide natural habitat and offer ecosystem services, despite worrisome provincial and local predictions for adjacent built environments.

While long-term rising in sea level poses many challenges, the more immediate concern is when slightly higher sea levels coincide with king tides and storm surges; flood events will be devastating. Homes will flood, and much of Musqueam IR2 could be underwater. High water levels could release contaminants into the environment and damage or destroy intertidal habitats, such as mud flats and brackish marshes. Traditional use areas and archaeological sites could also be damaged or lost (City of Vancouver, 2018).

Adapting to a Changing Climate

To adapt to a changing climate, governance organizations are planning for change, research is being conducted on natural ecosystems, and First Nations, including Musqueam, are anticipating their upcoming needs.

Metro Vancouver, the City of Vancouver, BC Ministry of the Environment, and Musqueam have created planning documents that touch upon adapting human land use to rising sea levels. The various approaches include: 1) protecting current development through coastal armouring, such as dikes; 2) accommodating rising seas and flooding through actions such as retrofitting buildings and either relocating or elevating lifeline infrastructure; 3) moving or retreating from flooded areas; 4) avoiding risks by limiting new development in high risk areas. Adaptations span planning and regulatory tools and structural and soft-armouring measures. Impacts on foodlands were not a focus of the planning documents, although the documents do mention environmental impacts in passing, such as coastal squeeze and minimizing the impacts of flood management strategies on habitats (Arlington Group Planning and Architecture Inc. et al., 2013; Barron et al., 2012; City of Vancouver, 2018; Musqueam, 2014).

Beyond the reports, action is being taken to help ecosystems adapt to the changing climate: biologists are studying tolerance and movement potential of various species. For example, Metro Vancouver Regional Parks is taking climate change into account when replanting disturbed areas. By studying which tree species are thriving in already changing conditions and which are not, staff are able to predict which species will thrive in the future. Because cedars in drier areas are already dying, cedar is now only being planted at wet sites, whereas cedar was commonly planted in all locations in the past. Regional Parks are also monitoring other climate-related impacts in forests; the pest, hemlock looper, is killing trees, and maples are dying back due to disease (R. Worcester, personal communication, May 13, 2022).

Indigenous Peoples and Climate Change

Indigenous voices around climate change have regularly been ignored, despite Indigenous peoples having looked after these lands for millennia and being positioned to lead climate action. Indigenous-managed lands, including those in Canada, contain equal or higher levels of biodiversity than other protected areas (Schuster et al., 2019). Indigenous-managed forests also store more carbon; a 2021 UN report focusing on Latin America and the Caribbean found that reduced deforestation in Indigenous-managed forests has prevented 59.7 million metric tons of carbon dioxide from entering the atmosphere each year from Brazil, Bolivia, and Columbia alone. This report also recognized that Indigenous peoples are the best guardians of world forests (FAO & FILAC, 2021).

Indigenous peoples are typically highly aware of current climate change impacts, as peoples are familiar with local ecosystems and Indigenous communities often are the most heavily impacted by climate change. Indigenous peoples have been forced to live on the least desirable lands, which are now becoming uninhabitable, and Indigenous peoples experience higher socioeconomic vulnerability, due to factors such as poverty and chronic health conditions (Chakraborty et al., 2021). Additionally, climate impacts, including changing ice and permafrost conditions, increased number and intensity of wildfires, warmer water temperatures, changes in precipitation, and extreme weather events, are affecting the ecosystems that Indigenous peoples rely on for food. Already, peoples are reporting large reductions in the amount of food they are able to harvest, and harvesting foods is becoming more difficult and more dangerous. This leads people to rely more heavily on less nutritious and culturally inappropriate store-bought foods (“Canada,” 2020). Indigenous peoples are aware of climate impacts and have long been seeking solutions to the climate crisis.

Musqueam is one Indigenous community taking action to adapt to the changing climate. Musqueam IR2 contains low-lying areas that are at high risk of flooding and climate impacts, especially the Musqueam Golf Course. In 2018, the City of Vancouver worked with Musqueam on concerns and values around flooding on IR2 for the 2018 Coastal Adaptation Plan, and Musqueam is also taking independent action (City of Vancouver, 2018; Musqueam, 2014). A community park is being developed along the Fraser, which will maintain access to the river for community members and provide a low-impact flood zone (Musqueam, 2014). Additionally, the First Nation is working with First Nations Emergency Services and Indian and Northern Affairs Canada to upgrade and repair the dikes near the main reserve using environmentally friendly materials (Musqueam, n.d.). An additional concern is losing potable water sources due to shifts in weather and precipitation patterns, and Musqueam must anticipate using alternate water sources (Musqueam, 2014).

Impacts of Pollution, Invasives, and Climate Change on Food Species

Pollution, invasive species, and climate change compound the challenges already present for Indigenous food sovereignty. Locally, many traditional harvest sites and food populations have already been reduced or lost - these losses are a result of pollution, invasive species, and climate change and laws impacting Indigenous culture, health, movement and agriculture. The majority of food species require cultivation and tending to promote growth. Seasonal village sites once allowed people to temporarily live near species that needed care or to be harvested. Settler policy did and does not permit or facilitate these seasonal villages. Increasing Indigenous access to and engagement in traditional food harvest is predicated on being able to safely access and consume foods. In turn, engagement will increase the abundance of foods. This section of the report examines the needs of various cultural keystone species, including the impacts of pollution, invasive species, and climate change on each species as applicable.

Shellfish

Shellfish, including clams, mussels, and oysters, have been a staple food of First Nations along the BC coast. Shellfish can be harvested year-round and are both consumed fresh and dried in large quantities. Sometimes, dried shellfish were strung on necklaces to be eaten as snacks (First Nations Health Authority, n.d.). In Musqueam territory, clams were the most abundant of bivalve species and were a heavily harvested dietary staple (Government of Canada, 2015).

To facilitate shellfish growth, First Nations would build clam gardens (see *Image 4*). In a clam garden, a stone wall is constructed at the low tide level. With each tidal cycle, the wall collects sediment on its upslope side. As the area above the wall fills in, the length of the intertidal zone and the amount of optimal clam habitat extends. The walls also collect nutrients and warm the cool ocean water, which helps baby clams grow faster (Isabella & Henry, 2017).

Image 4. Overhead view of a shoreline with an extended intertidal zone clam garden. By SFU - Communications & Marketing on Flickr.

Shellfish harvesting today is limited due to pollution, toxins, development, logging impacts, climate change, over-harvesting, and license requirements (Thom & Fediuk, 2009). This section will focus on sanitary and biotoxin closures and the impacts of climate change. The section concludes with an optimistic discussion of recent Tsleil-Waututh shellfish harvests in Burrard Inlet and ecosystem services offered by restored shellfish beds.

Of all the food species in the Fraser River estuary, the effects of pollution have been most strongly documented on shellfish. Shellfish are especially sensitive to pollution because they are filter feeders; in the process of sifting food particles from the water, they also sift and bioaccumulate metals and toxins, and shellfish tissues can host concentrated numbers of bacteria, viruses, and phytoplankton. Shellfish are so pollution-sensitive that they are even used by some cities to monitor water quality - the shellfish are held in tanks, and if they close their shells, the water is too polluted for human consumption (Micu, 2020).

Shellfish harvesting closures due to pollution are common in the Salish Sea. The closures are categorized as either sanitary closures, stemming from high coliform counts, or shorter-term biotoxin closures, caused by harmful algal blooms. Climate change is increasing the frequency and extent of both types of closures.

Due to high coliform counts, all shellfish harvesting in the Fraser estuary, as well as most of the southern Salish Sea, has been subject to sanitary closure for decades. The coliform enters waterways via sewage outfalls, septic tank leaks, urban and agricultural runoff, and sewage discharge from boats. Agriculturally sourced coliform is prolific and difficult to manage and limits the impact that upgraded or additional urban wastewater treatment plants could have on potentially opening shellfish harvesting areas (Waldichuk, 1983).

While some shellfish harvesting areas are annually assessed for sanitary closure, many other areas are permanently closed. This includes areas within 300 meters of outfalls, within 125 meters of marinas, floating structures, or docks that could be sources of contamination, and in areas where water pollution is especially bad. In certain areas, shellfish are not safe to be eaten directly from the waters, but can be consumed after purification - this involves moving the shellfish to pure water for a period of time, so the shellfish can expel contaminants (Canadian Food Inspection Agency, 2022).

The second reason for a shellfish harvesting closure is biotoxins from toxic algal blooms. Some algae produce toxins that accumulate in shellfish. When contaminated shellfish are consumed, the toxins can kill marine mammals and seabirds, as well as cause illness or death from paralytic, amnesic, or diarrhetic shellfish poisoning in humans. Other algal blooms are non-toxic and do not typically cause closures, but are still harmful because they deplete water oxygen levels, irritate and clog gills, block light to seagrasses, produce foam that damages feathers, and stop larval fish, shellfish, and copepods from feeding. Such non-toxin harmful algal blooms do not necessarily lead to shellfish harvesting closures, but still damage ecosystems and prevent human use of the environment and its resources (First Nations Health Authority, 2021; Perry, 2016).

Harmful algal blooms have always occurred along the BC coast, and First Nations have traditional knowledge about how to identify safe times to harvest shellfish; unfortunately, climate change is reducing the reliability of traditional safety identification methods. For example, people would traditionally observe whether gulls and otters were consuming shellfish, and if so assume the shellfish to be safe for human consumption. Another example is that shellfish were once safe to harvest in months with an “r” in the name (i.e. the cooler months of the year). Because climate change is increasing the frequency of harmful algae blooms at all times of year and animals have different tolerances than humans, traditional knowledge around shellfish safety is no longer sufficient (First Nations Health Authority, n.d., 2022).

Scientific monitoring for harmful algal blooms began in BC in 1942 and continues today (Harbo, 1997). Testing for safety is a multi-step process that requires specialized lab equipment and live mice. First, scientists sample the water in or near a shellfish bed and use a microscope to look for toxic cells inside plankton. If toxins are seen, a rapid test on both the water and shellfish tissue is conducted to determine whether a dangerous concentration of toxins are present. If this is positive, shellfish are taken to health department labs for a mouse bioassay - if the mouse is affected, the shellfish cannot be safely consumed by humans (Trainer, 2016). The toxin limit for paralytic shellfish poisoning (saxitoxin equivalents) is ≥80 ug/100g, amnesic shellfish poisoning (domoic acid) is ≥20 ug/g, and diarrhetic shellfish poisoning (okadaic acid and/or dinophysis toxins, singly or in combination, or pectenotoxin) is ≥0.20 ug/g. The standard for reopening a closed area is three consecutive samples over 14 days within acceptable levels and showing a downward trend in toxicity (Canadian Food Inspection Agency, 2022).

Indigenous needs are not met with current monitoring schemes. The majority of monitoring occurs at commercial harvest sites, rather than personal harvest sites where most Indigenous peoples harvest (Afshari, 2016). Because samples must be sent to distant labs, wait times are increased and closures last longer than necessary (First Nations Health Authority, 2022). Some First Nations members will not share their harvest locations, even with other First Nations members, so those sites are never tested (Marine Biotoxin Workshop Committee, 2016).

Additionally, the limits for safe shellfish consumption for the non-Indigenous population may not be sufficient for Indigenous peoples, who consume greater-than-average amounts of shellfish. Toxin limits are based on a standard serving size and do not take into account continuous low dose exposure or carry-over effects of previous meals. Research on chronic domoic acid exposure in mice and zebrafish suggests impacts on gene transcription, mitochondrial function, pregnancy, and neurologic sensitivity. Indigenous peoples who frequently eat shellfish are at additional risk for disease, even if the shellfish eaten contain acceptable levels of toxins. Additional guidelines must be developed to guide safety around chronic toxin exposure from shellfish (Afshari, 2016).

Climate change is increasing the frequency and extent of both sanitary and biotoxin closures, as well as impacting the ability to harvest shellfish in other ways. Sea level rise and coastal squeeze reduce bivalve habitat. Extreme precipitation events cause a greater number and greater scale of combined sewer overflows, releasing additional untreated sewage into waterways. Extreme precipitation events also add large volumes of freshwater to estuaries, which salt-water adapted, marine organisms are unable to handle. Forest fires increase erosion and runoff. Heatwaves can cook marine organisms in the intertidal zone; during the 2021 heat wave, temperatures along rocky shorelines reached 57 degrees and killed billions of organisms. Ocean acidification is weakening shells of crabs and clams. The warmer temperatures associated with climate change increase the risk of harmful algal blooms; the 2015 Blob, a long-lasting algal bloom extending from California to Alaska, simulated the effects of warmer temperatures on algal blooms along the west coast. Such events suggest a future with near-constant shellfish closures (Cruickshank, 2022; First Nations Health Authority, 2022; Government of Canada, 2018; Thom & Fediuk, 2009; Trainer, 2016).

Traditional Indigenous knowledge may be helpful for mitigating the effects of climate change on shellfish beds. For example, protecting areas with cool spots, such as boulder fields and uneven terrain, could protect intertidal species from heat waves. The traditional process of adding shell hash could reduce acidification, and tending clams and gardens could allow dormant cysts of harmful plankton to be washed out with the tide before conditions create a bloom (First Nations Health Authority, 2022).

Various clam garden restoration projects are taking place throughout coastal British Columbia, including in W̱SÁNEĆ, Hul’q’umi’num Nations, and Tsleil-Waututh territories (Isabella & Henry, 2017). Tsleil-Waututh’s clam garden restoration in Burrard Inlet and Indian Arm offers hope of once again harvesting shellfish in previously polluted, urban-adjacent areas.

After a 44 year closure, Tsleil-Waututh conducted its first sanctioned harvest in October 2016. Some clams beds are being restored for consumption, and others for their ecosystem services (Doyle, 2018). These ecosystem services include protecting shorelines from storm surges, creating substrates that offer habitat to other species, and filtering substantial amounts of nitrogen and phosphorus from the water to reduce eutrophication and algal blooms (van der Schatte Olivier et al., 2020). Tsleil-Waututh continues to address additional priorities related to restoring shellfish beds, such as monitoring water quality, reducing pollution from stormwater runoff, and mapping and conserving critical habitats (Beddall, 2016). Research specific to climate change is also being conducted by Tsleil-Waututh on the impact of shell hash for buffering increasingly acidic ocean waters in Burrard Inlet (Doyle, 2018).

Within the Fraser River estuary, Musqueam IR2 and Point Grey have traditionally been productive shellfish habitats, but proximity to the Iona Wastewater Treatment Plant, in addition to general river pollution, have eliminated most shellfish populations and potential for safe harvest. Nowadays, Musqueam trade for shellfish from other First Nations or purchase shellfish from stores (Government of Canada, 2015). Shellfish restoration in the Fraser estuary is likely to be more challenging than in Burrard Inlet, due to the complexity of Fraser River flows, ocean tides, and urban runoff. That being said, restoring shellfish beds will offer cultural value to Musqueam, in addition to a potential food source, aid shoreline stability during storm surges, increase biodiversity and ecological productivity of the area, and improve water quality. Shellfish beds should be considered in plans for ecological restoration near the new Iona Wastewater Treatment Plant, even if the likelihood of safe consumption is near zero.

Edible Roots

Before colonization, roots were the primary source of carbohydrates in traditional coastal BC diets. Camas meadows and wapato patches were frequently cultivated, as well as estuarine root gardens that produced springbank clover, Pacific silverweed, northern riceroot lily, and Nootka lupine. Many roots were pit-cooked with other foods such as clams, then dried, pounded, and sometimes made into cakes to be stored. Research in this section relies on sources from outside the Fraser River estuary, but likely also applies to practices within the estuary. Notes regarding plant prevalence are the author’s personal observations only, and do not necessarily reflect sufficient quantity or quality for harvest (Joseph & Turner, 2020).

Camas

Two species of camas are cultivated in coastal BC: common blue camas and great blue camas. Camas is a member of the lily family that grows like an onion, with an underground bulb; people eat the bulb (see *Image 5*). Camas grows in seasonally-wet meadow sites, which are often, but not always, near estuaries. Camas meadows are most common on southern Vancouver Island and the adjacent Gulf Islands. These meadows are burnt every couple years to prevent surrounding forests from encroaching and to provide nutrients for camas and other food species. The meadows are also weeded and tilled, and camas is selectively harvested and transplanted. Harvests take place in early summer, after seeds have matured (Charlie & Turner, 2021; Joseph & Turner, 2020; Turner et al., 2013).

Camas is a culturally important trade good in the Pacific Northwest. Except for dried salmon, no item has been more widely traded by Washington peoples than camas. It would often be exchanged between coastal and interior regions, and Hul’q’umi’num’ peoples on Vancouver Island would trade camas to Fraser River peoples in exchange for keeping watch over wapato plots in the estuary (Charlie & Turner, 2021; Joseph & Turner, 2020). This suggests limited historical cultivation of camas within the Fraser River estuary, although it does speak to the importance of camas as a food source for Fraser River peoples.

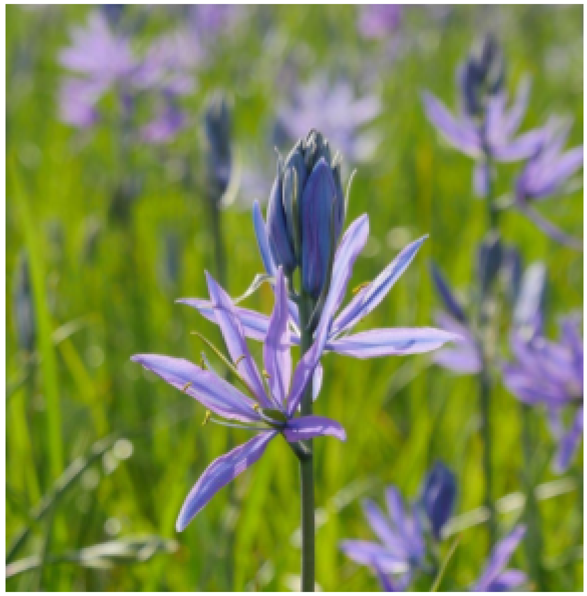

Image 5. A field of green with six-petaled, purple camas flowers. By Aaron Cloward on Unsplash.

Lack of Indigenous caretaking and ignorant settler use of camas meadows for urban development, other agriculture, and livestock grazing has decimated camas populations (Stucki et al., 2021). Climate change is also a threat to camas; studies of camas have shown that increased temperature and decreased precipitation, as expected in the Fraser River estuary with climate change, lead to decreased camas density and growth (Stucki, 2018).

Wapato

Wapato is a semi-aquatic, freshwater plant with above-water, arrowhead-shaped leaves (see *Image 6*). Wapato was formerly very common in the Fraser Valley and the Fraser River estuary and was a cultural keystone species for Katzie First Nation. Wapato patches, typically in wetlands, were filled by settlers for development and agriculture. Additionally, some wapato patches were selectively converted by First Nations to grow imported potatoes, which were larger and easier to harvest than wapato (Charlie & Turner, 2021; Garibaldi, 2003; Garibaldi & Turner, 2004).

In 2014-2015, Katzie First Nation initiated a wapato restoration project in the Pitt River watershed, at the head of the Fraser River estuary. Wapato was once common here, but is now restricted to remnant patches due to wetland loss. Restoration of wapato patches will facilitate Katzie members learning about and participating in traditional harvests (Government of Canada, 2017).

Image 6. Large, yellow and green, arrowhead-shaped wapato leaves with small, three-petaled white flowers. By born1945 on Flickr.

Estuarine Root Gardens

Beyond camas and wapato, additional edible roots were grown in estuarine root gardens. Estuarine root gardens were created and tended by First Nations along the BC coast, including Nuu-chah-nulth, on the west side of Vancouver Island, and Kwakwaka'wakw, on northern Vancouver Island and the adjacent islands and mainland. People would backfill salt marsh areas, such as with fish traps or clam gardens, to extend the length of the upper intertidal zone. Within this zone, people would cultivate edible roots, including springbank clover, Pacific silverweed, northern riceroot lily, and Nootka lupine (see *Image 7*). The root gardens were weeded, fertilized, and tilled with specialized digging tools, species were transplanted and propagules replanted, and rocks and debris were removed. Only optimal sized roots were harvested. Family plots would be delineated with logs or cedar marking posts. The harvested roots would be a primary source of carbohydrates throughout the year and were often gifted and exchanged for other foods. Additionally, the gardens would attract ducks and geese, which would be hunted (Joseph & Turner, 2020; Turner et al., 2013). Some restoration work on estuarine root gardens was completed a decade ago in the Squamish River estuary (Leigh, 2012). The author does not know the status of current or past cultivation of estuarine root gardens in the Fraser River estuary.

Due to the importance of cultivation for edible root populations, loss of traditional harvest areas and lack of active participation in stewardship practices pose the most immediate challenges to harvest of edible roots. That being said, pollution, climate change, and invasive species are also significantly affecting the roots. Pollutants may kill plants or accumulate within plant tissues, putting healthful human consumption at risk and affecting flavor.

Image 7. Nootka lupine bush with conical clusters of purple flowers. By Forest Service Alaska Region, USDA on Flickr.

As sea levels rise, low-lying marsh and wetland areas will be inundated and no longer suitable habitat for edible roots. Coastal squeeze will compound the problem, as human development will limit migration of marshes and wetlands towards previously dry land.

Marshes that currently exist are retreating due to year-round foraging by the invasive non-migratory Canada goose (see *Image 8*). (Migratory Canada geese are native, but their non-migratory, introduced relatives are invasive). The geese eat the roots of estuarine plants, which destabilizes marsh sediments and facilitates erosion. High numbers of snow geese are compounding marsh retreat, as they forage in ever-shrinking habitat each winter (Chu & Jenkins, 2022).

K'ómoks First Nation is using traditional knowledge to address goose-caused marsh retreat. By fencing sections of their estuary and harvesting geese, K'ómoks is restoring habitat for juvenile salmon and other native species. K'ómoks Guardians are also training other First Nations to process and cook harvested geese in traditional ways to support Indigenous food security

(Auger, 2021). Further north, where snow geese breed in summer, Innu peoples are doing the same (Bennett, 2018).

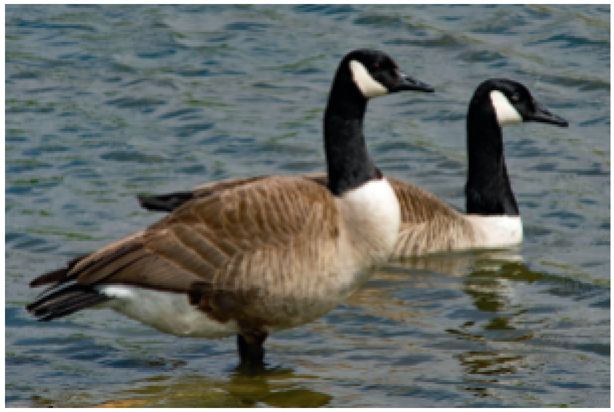

Image 8. Two Canada geese with black heads and brown bodies in water. By Raymond Eichelberger on Unsplash.

Berries

Berries were a primary source of sugar and fiber in northwest Indigenous diets and provided essential vitamins and minerals year-round. Over 30 species of berries are harvested in coastal BC (First Nations Health Authority, n.d.); frequently harvested berries include salmonberry, thimbleberry, trailing wild blackberry, and various huckleberries. Most berries are collected in spring or summer, and the berries can be dried or preserved in cakes to be consumed the rest of the year. Many berries grow along forest edges or in clearings, where they receive plenty of sunlight.

Image 9. Toothed, trifolate salmonberry leaves with red, raspberry-like berries. By Stella de Smit on Unsplash.

Salmonberry

Salmonberry displays pink flowers in spring that develop into golden-to-red, raspberry-looking berries (see *Image 9*). The ripening of salmonberries indicates the return of sockeye salmon for the Nuu-chah-nulth, and the size of the berry harvest is traditionally related to the size of the salmon run; salmon fertilize the berry plants, both through natural stream-side decay and through purposeful fertilization of salmonberry plants by humans. In addition to consuming the berries, salmonberry has many other uses, including using the leaves as a tonic during pregnancy and eating shoots in the spring (Houtsy, 2021).

Salmonberry is an indicator species for climate change and ecosystem health, and changes in salmonberry phenology have cascading effects. When winter temperatures are warmer, the first salmonberries bloom sooner. Other animals, such as the rufous hummingbird, return from their migration at the time when salmonberry usually flowers; if salmonberry blooms early, hummingbirds arrive after nectar is available, and the birds could go hungry and the salmonberry flowers may not be effectively pollinated. This would mean no berries or smaller berries later in the season. Other species rely on salmonberry to meet their needs, and if salmonberry changes the timing of its life-cycle events, other species will be affected (*Salmonberry Monitoring Directions*, n.d.).

Climate change is also affecting the range of salmonberry. Warmer temperatures are allowing salmonberry to spread to higher elevations, which in turn reduces habitat for higher-elevation species such as mountain heather and sage (Zouhar, 2019). At the same time, low-elevation salmonberry habitat is being overrun by the invasive Himalayan blackberry, which spreads rapidly and competes for similar habitat (see *Image 10*). Habitat loss to Himalayan blackberry is especially problematic in the Fraser River estuary.

Image 10. Toothed Himalayan blackberry leaves with blackberries. By Elizabeth George on Unsplash.

Thimbleberry

Thimbleberry is a white-flowered plant with large, maple-like leaves that produce red, raspberry-like berries (see *Image 11*). Thimbleberries grow in similar habitat to salmonberry and Himalayan blackberry and are common in the Fraser River estuary. Both berries and shoots are eaten. Ripe thimbleberries are an indicator that it is the best time to cut cedar poles, which are peeled and split to be used to create the foundation in cedar-root basketry. Thimbleberry has a wide species range, which will aid in climate resilience (Charlie & Turner, 2021).

Image 11. Palmate thimbleberry leaves with red, raspberry-like berries. By yooperann on Flickr.

Trailing Wild Blackberry

The native, trailing wild blackberry, is smaller, earlier-ripening, and sweeter than its invasive cousin, the Himalayan blackberry. The leaves can also be used to make a medicinal tea (Charlie & Turner, 2021). Trailing wild blackberry can be found in the Fraser River estuary, but is outnumbered by the invasive Himalayan blackberry.

Image 12. Oval huckleberry leaves with one blue berry. By Nathan Raikman on Unsplash.

Huckleberry

Many varieties of huckleberries, including several blueberry and cranberry species, are harvested by First Nations in coastal BC (see *Image 12*). Huckleberries grow in many environments: peat bogs to rocky outcrops, low-to-high elevations, and open to forested areas (Charlie & Turner, 2021). Huckleberries are found in the Fraser River estuary. Native species are experiencing competition from domesticated blueberries grown on farms in the upper estuary.

Bracken Fern

According to Garibaldi and Turner (2004), BC ethnobotanists, Musqueam's primary source of carbohydrates before colonization was bracken fern. Bracken fern is a large fern that grows in well-lit areas, such as prairies, clearings, road edges, and open woods (see *Image 13*). The root is harvested to make flour, and the fronds have a variety of cultural uses including something to lay on, cleaning game, and flavoring for cooking (Charlie & Turner, 2021). Bracken fern has responded well to increased temperatures in scientific experiments, and potential die off of overstory species could increase availability of sunny habitats; therefore bracken fern may do well in the face of climate change (Werkman et al., 1996). Bracken fern remains common in the Fraser River estuary.

Image 13. Bracken fern growing in the understory of a young forest. By [Crispin Jones](#) on [Unsplash](#).

Cedar

Western red-cedar is one of the most important trees to Coast Salish peoples. The tree grows in moist soils at low to medium elevations, and Indigenous peoples harvest the wood, inner bark, boughs, and roots (see *Image 14*). Cedar is used for canoes, house posts, baskets, medicine, cooking, and more. Trees from different habitats are used for different purposes; for example, cedar that grows near swamps has a high resin content, while cedar at higher elevations is very light. Due to the importance of the tree, there are many names in Hul'q'umi'num' for cedar, parts of the cedar, and uses of the cedar. Although the author did not find any examples of the cedar being consumed as food, cedar is used as medicine and is used in the cooking process (Charlie & Turner, 2021).

Image 14. Bough and striated trunk of western red-cedar in a forest. By Baha'i Views / Flitzy Phoebie on Flickr.

Pollution may have an impact on western red-cedar, although limited research has been completed. A study in West Virginia on eastern red-cedar, a related species, found a distinct acceleration of growth around 1980, a decade after the Clean Air Act was enacted. This corresponded with a decrease in sulfur dioxide emissions and acid rain (Kansas State University, 2013). Because western red-cedar also relies on surface water, improvements in both air and water quality, especially in stream-side, river-side and ocean-side trees, could improve the health of the trees.

Climate change appears to be a bigger threat to western red-cedar than pollution. For over a decade, western red-cedar has been dying back (Seebacher, 2007). Dead trees, which stand out from the green forest with their orange foliage, are not unusual across Metro Vancouver. Recurrent summer droughts prevent trees from recovering from the stress of dry years; while a tree can survive one or two dry summers, year after year of drought kills the tree. Trees that grow in well-drained, rocky soil and on south-facing slopes are particularly at risk due to less moisture and greater sun exposure (Vikander, 2019). These observations align with Metro Vancouver Regional Parks' staff comments that cedar isn't surviving in dry sites any longer, and cedar is now planted exclusively in moist areas in Regional Parks (R. Worcester, personal communication, May 12, 2022).

Seaweed

Several species of seaweed are edible and have cultural uses for BC First Nations: bladderwrack/rockweed, bull kelp, membranous seaweeds such as red laver, and sea lettuce. Bladderwrack/rockweed is a shoreline species with air pockets. The seaweed can be consumed, used as soap, or applied to the skin as medicine. Bull kelp grows in kelp forests 30m deep and can be used to tie up a boat, provide protection from rough waters, as a toy, to cure wooden bows, to identify prime habitat for other food species, as fishing line, to store liquids, and as food in an emergency (see *Image 15*). Membranous seaweeds and sea lettuce are intertidal species that can be eaten (Charlie & Turner, 2021; Turner, 2003).

Image 15. Thick strands of yellow-green bull kelp seaweed with a bulbous top. By [Ingrid Taylar] on [Flickr].

Red laver (Porphyra sp.), a membranous seaweed, was identified by Garibaldi and Turner (2004) as a cultural keystone species for coastal British Columbia First Nations. The seaweed is also heavily consumed in Japan, where it is known as nori (Turner, 2003). Red laver is gathered from rocky shorelines by canoe in the spring and dried or smoked. The seaweed is continuously harvested each year - like a garden, it must be tended to grow strong and healthy (Turner, 2003). The seaweed is a good source of Vitamin A, Vitamin C, iron, and protein (First Nations Health Authority, n.d.).

Seaweeds are sensitive to pollution and are used to monitor for toxins, heavy metals, and radioactive isotopes in many places. Until the 1980s, red laver was harvested in large amounts from the coast of Wales, but concerns of pollution from nuclear power plants reduced the harvest. In British Columbia, pollution from pulp mills decreases the abundance of seaweed that grows in the vicinity, and locals no longer harvest the seaweed that grows nearby due to toxins

(Turner, 2003). Due to pollution in the Fraser River estuary, seaweed is no longer harvested. Kelp and other seaweeds once collected by Musqueam are now either not found or avoided locally due to contamination concerns and are received through trade instead (Government of Canada, 2015).

Seaweed has entered the climate conversation as an option for carbon sequestration, regenerating ecosystems, biofuel, methane-reducing cattle feed, and a sustainable food source (Godin, 2020). In response to public interest, First Nations in coastal British Columbia have expressed several concerns. One concern regards settlers entering Indigenous territories and commercializing seaweed without Indigenous consent. Aquaculture of seaweed could bring jobs to Indigenous communities, but Indigenous management and agreement are essential. Another concern around aquaculture is the possibility that exotic seaweeds could be introduced that outcompete local types, as has happened elsewhere (Turner, 2003).

Fish

Although fish are not a focus of this report, this brief section discusses risks to herring and salmon mentioned in other literature referenced - such risks may also extend to or relate to species discussed above.

Image 16. Small, white balls of herring roe covering seaweed. By FolioRoad on Flickr.

Salmon and herring are both migratory fish. Herring eggs, or roe, are harvested on kelp and conifer boughs when the herring spawn (see *Image 16*). Musqueam still fishes for salmon, and salmon forms the basis of Musqueam trade with other First Nations. In contrast, Musqueam trades for herring roe now due to conservation and contamination concerns (Government of Canada, 2015).

Pollution in an estuary is particularly harmful for young fish. For example, juvenile salmon feed for an extended time in estuaries, including the Fraser River estuary, before they swim out to sea. Toxins from urban, industrial, and algal sources and low dissolved oxygen levels all impact fish in the estuary. Furthermore, although the levels of individual pollutants may be within ranges deemed acceptable, the cumulative impacts of multiple pollutants are likely harmful to fish and other organisms (Waldichuk, 1983).

In addition to pollution in the estuary, spawning salmon and herring face increasing water temperatures due to climate change. Salmon only spawn at certain temperatures, and this could be true for other fish and shellfish species. During the 2021 heat wave, salmon backed out of inlets to get away from heat and low oxygen levels (First Nations Health Authority, 2022). Salmon migration routes were also affected (First Nations Health Authority, 2021). The timing of herring spawning is based on water temperatures, and climate change could cause a disconnect between the timing of the spawn and the bloom of plankton that herring eat (First Nations Health Authority, 2022).

The warmer water temperatures are also affecting traditional food processing. Foods must now be processed in new ways to neutralize toxins and bacteria. For example, salmon must be frozen before smoking to kill bacteria. Herring roe, crab, and oysters have also been linked to illnesses, and various precautions are required before safe consumption of these foods. This impacts how traditional knowledge can be applied to present-day harvests (First Nations Health Authority, 2022).

Lack of wetland environments in the Fraser estuary also limit both salmon and herring's ability to find shelter and food. Populations of both species are dangerously low, and consumption is limited to aid conservation. Increasing population levels should be a top priority for Indigenous food sovereignty, especially given the keystone nature of salmon and herring.

Other Species

Beyond the cultural keystone species listed above, many other plants and animals have traditionally been harvested from the Fraser River estuary. Many of these species are currently unavailable, yet Musqueam desires to harvest these species again. Death by a thousand cuts continues, as industrial development, such as Port Metro Vancouver's Roberts Bank Terminal, increased vessel traffic, fishing and hunting restrictions, conservation issues, contamination, invasive species, and climate change continue to chip away at the habitat that remains.

Additional species harvested from the estuary within living memory include, but are not limited to, prawn, crab, all five species of Pacific salmon, steelhead, rockfish (rock cod, red snapper), herring and herring spawn, smelt, halibut, eulachon, trout, sturgeon, harbour seal, sea lion, porpoise, chitons, crayfish, cockles, scallops, abalone, barnacles, octopus, sea urchins, sea cucumber, mallard, wigeon, pintail, teal, murres, grebes, loons, scooters, scaups, harlequins, Canada geese, snow geese, and swans, the eggs of ducks and gulls, deer, elk, bear, mountain goat, mink, muskrat, otter, beaver, rabbit, grouse, elderberry, bog cranberry, salal berries, Pacific crabapple, horsetail, wild rose, thistle, broad-leaf plantain, stinging nettle, Indian consumption plant (bare-stem desert parsley), and hardhack (Government of Canada, 2015).

Recommendations

Recommendations include ways to mitigate the impacts of pollution, invasive species, and climate change on cultural keystone species and protocols for working with Musqueam.

Supporting Cultural Keystone Species

Barriers to food harvest in the Fraser River estuary are plentiful and solutions must be multi-scalar. On a macro scale, reducing greenhouse gas emissions will reduce temperature change, frequency and intensity of extreme weather events, and sea level rise. Mid-scale solutions include upgrading sewer pipes, wastewater treatment plants, and environmental protection policies. Policy change has the potential to drastically alter Indigenous relationships with traditional foods in the estuary. Current settler policies continue to permit trade of natural areas for jobs and immediate economic benefits. As natural areas slowly disappear, traditional foods and Indigenous relationships with place are suffering from death by a thousand cuts. Governments must decide that enough is enough, and it’s time to protect and see the benefits offered by our natural places in the face of climate change and colonial-capitalist growth.

The remaining solutions discussed in this section are small-scale; these solutions could be completed by the Centre for Sustainable Food Systems at UBC Farm in collaboration with Musqueam and are potential avenues for continuation of this project. Listed below are the cultural keystone species discussed above and top recommendations for addressing barriers to harvest of each species in the Fraser River estuary. Keep in mind that these are ideas brainstormed solely by the author. The ideas have not been approved by Musqueam and may not be of interest to the Musqueam community.

1. Shellfish: Pollution from the Fraser River must be addressed before consumption can be considered. Instead of waiting to restore shellfish beds until pollution is fully controlled, we should explore ecosystem services that shellfish could offer, with Indigenous consent and under Indigenous management. Potentially, shellfish could help clean the water and give First Nations the opportunity to continue cultural caretaking practices. Redesign of the Iona Wastewater Treatment Plant and adjacent park could be an opportunity to restore shellfish beds. Safe shellfish consumption should be the long-term goal.
2. Roots: Root gardens require frequent maintenance, so fostering community involvement in traditional root gardens would help increase root populations. As with shellfish, community engagement may be stronger if roots are safe to eat. Expanding and preserving wetland habitat and minimizing pollutants will also support root populations.

This will include research of the impacts of geese on marsh retreat and taking action, such as hunting and fencing, to control goose populations.

3. Berries: The invasive Himalayan blackberry dominates many habitats in the estuary where native berry species once thrived. Himalayan blackberry should be removed, and native berry growth promoted. Attention should also be paid to domesticated blueberry escape and crossbreeding with native species.
4. Cedar: Cedar is challenged by high temperatures and limited summer precipitation. On a small scale, ensuring shade for and watering young cedars may help keep trees alive during hot, dry spells.
5. Seaweed: Pollution effects seaweed growth and safety of harvest. Similar to shellfish, seaweed consumption should be an eventual goal, but ecosystem services such as carbon capture, biofuel, and ecosystem regeneration should be explored. If pursuit of ecosystem services is deemed feasible, it should proceed under Indigenous consent and management.
6. Fish: Salmon and herring populations are both at risk and require immediate action to maintain and increase populations. Pollution and climate change are both damaging fish communities. Small-scale actions include wetland restoration and reduced harvests to enable populations to rebound.

Strengthening a Relationship with Musqueam: Experiences and Recommendations

This summer project was originally proposed to be of greater scope, but administrative barriers required reconceptualization of the project. Instead of interviewing Musqueam Knowledge Holders and visiting foodlands, the project became a literature review. Throughout the changes to the project, much was learned about the various approvals and requirements for working with Musqueam, as well as the timeline over which a project must be completed.

The originally conceived project will continue with two additional phases. The next phase will be working directly with Musqueam Knowledge Holders to identify priorities for restoring traditional foodlands. Documents and studies internal to Musqueam may also inform this work. The phase after that will be choosing a top priority and acting on it.

Prior to future work with Musqueam and before hiring additional student workers for this project, the following approvals/funding should be in place.

1. Musqueam Research Agreement - this agreement is a simple, one-page document, plus an attached research proposal, researcher CV, and terms and conditions page. The agreement must be signed by a supervisor at UBC; according to staff at the UBC

Indigenous Research Support Initiative (IRSI), the UBC signature must be from an official UBC signatory. Most likely, this person would be J.P. Heale from the University-Industry Liaison Office[1]. After receiving preliminary permission to submit a research agreement from Leona Sparrow at Musqueam, the agreement and required documents are submitted to Leona Sparrow. The agreement must be signed by several committees at Musqueam.

2. UBC Research Ethics Board (REB) review - Ethics review may or may not be required for additional phases of this project, depending on how the project is framed and what action project is chosen. Preliminary work to determine details of a project to be completed can be done prior to ethics review, and if the project is not a "research" project it may be able to avoid ethics review altogether. There is a checklist that helps to determine whether the project is "research"[2], i.e. whether the project extends knowledge. Ethics review is required for all UBC "research" projects that are not quality assurance and improvement studies (QA/QI, "program improvement project"). Given the historical context of UBC and settler interactions with Musqueam, REB approval would be best practice for this project, regardless of whether it is deemed preliminary outreach, research, or QA/QA. Ethics review cannot begin until after a Musqueam Research Agreement has been approved, although the application can be prepared in advance. REB approval requires support from a faculty member, completion of online trainings by all researchers, a detailed project plan including the research questions to be asked, other paperwork, and a minimum of three weeks processing time. This study is higher risk because it includes Indigenous participants. Expect to make amendments before initial approval and be required to resubmit at least once.
3. Research funding - Knowledge Holders expect to receive honoraria for their participation. According to UBC research guidelines, a Knowledge Holder who shares between zero hours and a half-day should be gifted $400. An "Indigenous Finance Guidelines" document can be found on the UBC IRSI website[3], and Musqueam has their own document with guidelines, which the author has not seen. Check for funding with the Director of Development at UBC Land and Food Systems. Various other funding sources to consider include UTown@UBC, Vancity, Pacific Institute for Climate Solutions Fast Track program, the Partnership Recognition Fund at UBC Community Engagement, and Open Educational Resources Rapid Innovation Grants. Grant search pages are also

[1] https://uilo.ubc.ca/about-us/contact-us

[2] https://ethics.research.ubc.ca/sites/ore.ubc.ca/files/documents/BREB_ChecklistForResearchRequiringEthicsReview.pdf

[3] https://irsi.ubc.ca/news/ubc-launches-indigenous-finance-guidelines

hosted by UBC Community Engagement[4], UBC IRSI[5], and the UBC Office of Research Services[6]. The Director of Development at UBC Land and Food Systems must approve applications for external grants prior to application.

Relationship-building is important in Musqueam culture. Consider volunteering at the UBC Farm Musqueam Garden and attending Indigenous events on campus, and accept invitations to visit the Musqueam Reserve. COVID protocols have limited in-person relationship-building over the past two years, which has added a barrier to working with Musqueam. Frequent turnover of students conducting research and the short-term nature of Sustainability Scholars programs also pose challenges to building meaningful relationships.

Reaching out early in the conceptualization of the project and frequently checking in helps to avoid miscommunication and protocol breaches; that being said, due to limited capacity at Musqueam, emails may not receive (prompt) responses, which can indefinitely delay a project. Musqueam staff frequently cc other staff members in their correspondence to keep all parties updated on the status of projects.

When working with Knowledge Holders, consider decolonizing the interview. Frame interactions as conversations. Group conversations that include a (home-made) meal can minimize community burnout and allow Knowledge Holders to build off one another's comments. Conversations should be approached as though there is an abundance of time, and the initial conversation may be mostly about listening rather than pushing one's agenda. Building feedback into the project design provides a good reason to follow up with Knowledge Holders and invite them into future conversations.

In discussions with Musqueam regarding this project, it is important to Musqueam that they be the only First Nation participating in the project. In initial conversations, Musqueam staff suggested interviewing various staff members to identify priorities around foodlands. A possible project idea could be making an interactive map for Musqueam that shows the locations of past village sites and the foods tended and harvested at each site. The scope of a project could also be expanded to include traditional medicines. No matter the final project, it should be of value to Musqueam - although the intention may not be to "take" information, research can come across this way if something of value is not returned to the community from the project.

[4] https://communityengagement.ubc.ca/engage-with-ubc/awards-funding/
[5] https://irsi.ubc.ca/indigenous-communities/resources#funding
[6] https://ors.ubc.ca/funding-sources

Musqueam has many internal resources and studies. Relationship-building and a research agreement are required to access these documents.

For support internal to UBC for engaging with First Nations, contact the Indigenous Research Support Initiative. Staff was especially helpful in brainstorming ways to minimize engagement fatigue, wording to use in outreach emails, and connecting me to other resources at UBC. Reaching out to staff directly, and through phone rather than email, is more likely to receive a response than an email to the general information email.

Conclusion

Can you imagine a Fraser River estuary where the water carves canals through marsh grasses, foreshores are home to octopus, and you can harvest dinner at low tide? This used to be the estuary, and it could be the estuary again.

Indigenous peoples obtained food from the estuary for millennia, and despite large barriers created by the colonial-capitalist state, continue to do so. In addition to the calories and nutrients obtained from the foods, the foods bring Indigenous communities together to solidify bonds, practice traditions, and enact connection to place. These cultural values make traditional foods essential for sovereignty, decolonization, sustainable living, and addressing climate change and social justice.

On top of the historic injustices and continued legacies of the Indian Act and settler river management, pollution, invasive species, and climate change challenge the harvest of traditional foods today. Pollution limits the safe consumption of estuarine species such as shellfish, and invasives are especially damaging the habitat of berries and roots. Climate change is already causing heat waves, summer drought, atmospheric rivers, and flooding.

As more attention is given to the Fraser River estuary, such as through the *Soul of the Fraser* (2022) documentary, Fraser Estuary Research Collaborative of the UBC Sustainability Scholars program, and breaches in the Steveston and North Arm jetties, the public will hopefully realize that ecological and cultural values of the estuary outweigh economic incentives for unsustainable development. Settlers bear responsibility for destruction of the estuary and loss of traditional foodlands, and settlers are therefore responsible for their restoration. Restoration will benefit not only Indigenous peoples, but everyone.

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