Exploring the Alignment of Human Health and Environmental Health in Canadian Fish and Seafood Policy

By

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Abbreviations

AI- Adequate Intake
CBSA- Canadian Border Services Agency
CFG- Canada's Food Guide
CFIA- Canadian Food Inspection Agency
CPI- Consumer Price Index
DFO- Fisheries and Oceans Canada
DHA- Docosahexaenoic acid
DRI- Dietary Reference Intakes
EPA- Eicosapentaenoic Acid
FAO- Food and Agriculture Organization of the United Nations
OW- Ocean Wise
RDA- Recommended Dietary Allowance
TAC- Total Allowable Catch
TSN- Taxonomic Serial Number

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Abstract

Many people around the world rely on fish and seafood as a source of protein, fatty acids and micronutrients, but nearly a third of global fish stocks are overfished, and overfishing remains a sustainability concern. Furthermore, the global population continues to increase, and human health recommendations suggest that fish and seafood consumption is important to health. With many people already relying on fisheries to provide important nutrients, and a likely increase in fish and seafood demand in the future, it is important to ask: In what ways can seafood sustainability support human health needs? Focusing on Canada, we can begin to assess how human health and environmental health recommendations for fish and seafood intake align, and where there are opportunities for alignment of these guidelines. This question is timely given that Canada recently launched an updated Food Guide and new national food policy, boasting environmental considerations. In this research project a problem-oriented approach is used to explore the alignment of four areas of interest regarding fish and seafood consumption: human health recommendations, environmental health considerations, provenance of Canada's seafood supply, and affordability of fish and seafood. Results demonstrate little alignment between all four areas of interest; however, species commonly satisfy one or two criteria. Clams are the only group of species that satisfies all criteria. Recommendations include ensuring the availability of species level information in food labelling and in fisheries management, adapting health recommendations to emerging health concerns regarding seafood, and considering the sustainability of species listed in health recommendations.

Chapter 1 Introduction

Humans are surrounded by, and embedded in, environments, experiences and influences that impact our health and wellbeing. One of the most influential considerations for human health is the resources available to nourish our bodies, support growth, promote healthy individuals and a healthy population. We depend on our food system to provide the nutrients to support human health, but it is important to recognize that our food system exists within, and is dependent upon, the broader social-ecological system. This recognition allows us to think more broadly about the role of food and food systems in supporting human wellbeing. Given that the (physical, cultural, emotional) health of our population depends upon a healthy food system and healthy environment, it is prudent to explore the relationships between these considerations.

The global population is projected to reach 9.8 billion by 2050 (United Nations Department of Economic and Social Affairs, 2017), with accompanying estimates that global food production will have to increase by around 70% to meet rising demand (Food and Agriculture Organization of the United Nations (FAO), 2009). It is thus imperative to consider how we will meet this demand while supporting the health of our food system and environment. Global food insecurity already impacts millions of people around the world. Starvation, wasting, stunting, and illness are all consequences of inadequate quality and/or quantity of food, in addition to the psychological stress of struggling to meet nutritional needs. At the same time, an increasing reliance on highly refined foods has led to higher rates of food-related illnesses globally (Tilman & Clark, 2014). How can we ensure that we have an adequate food supply to support a healthy global population in the future, when we are already falling short today?

Sustainable food systems have been positioned as a way to produce an adequate quantity and quality of food to feed the growing world. Framed as a tool for building food security and ensuring that sustainable production continues, they are seen as an improvement upon conventional food production practices that cause environmental degradation through poor water and soil management practices, intensive production, monoculture and reduced

biodiversity (Godfray & Garnett, 2014). Research that addresses the connection between human and environmental health tends to explore dietary patterns and whether the dietary pattern is sustainable based on the environmental impact (Chen, Chaudhary & Mathys, 2019; González-García, Esteve-Llorens, Moreira & Feijoo, 2018; Tilman & Clark, 2014). However, some research has reached beyond the foods chosen to consider the broader social-ecological aspects that influence the connection between health and sustainable food systems. Considerations such as purchasing locally produced and seasonal foods, a culture of enjoying foods (rather than rushed and distracted eating), incorporating ethical considerations into purchasing decisions (Koerber, Bader & Leitzmann, 2017), and considering health and economic circumstances have all been identified as factors impacting the sustainability of a food system (Fiorella et al., 2017). By considering food systems as a part of broader environmental and human systems we can begin to see that aligning human health and environmental health is necessary to support sustainable food production for years to come. There has been international recognition of the need to consider the interconnectedness of human health and environmental health on all levels policy making that impact food systems (Environment and Climate Change Canada, 2016; UNDP, 2016a; UNDP, 2016b), however, the extent to which this has been meaningfully considered in the context of food policy in Canada is questionable.

Fish and seafood consumption provides an opportunity to explore a food with specific nutritional qualities that benefit human health and have been incorporated into Canadian nutrition guidelines for that reason. While the evidence behind encouraging the consumption of fish, fish oils and seafood has been questioned by some (Jenkins et al., 2009; Weylandt et al., 2015), the presence of fish and seafood in health guidelines around the world, including in Canada, suggests that current evidence indicates that these foods are beneficial for human health. Recent changes to *Canada's Food Guide for Healthy Living* raise the profile of fish and seafood through reordering the appearance of proteins and suggesting fish and seafood as sources of protein (Health Canada, 2019a). Given that these foods are being promoted, it becomes important to explore whether their consumption is sustainable and/or attainable, or how best to support sustainable sourcing of these foods more broadly. Related to this is the risk that should seafood systems collapse because of overfishing and overconsumption, the

implications for human health could range from minor shifts in nutrient intake to an inability to meet nutritional needs depending on the stability and diversity in the food system.

Unfortunately, many fisheries around the world are overfished and overfishing continues. Canada is no exception, with a number of freshwater and sea fisheries assessed by Fisheries and Oceans Canada (DFO) as being in critical, cautious or an uncertain state (DFO, 2017). DFO's Sustainability Survey for Fisheries selects a variety of Canada's fisheries based on their social, environmental, and economic significance, and assesses them for sustainability and stock health. In 2017, 10% of fish stocks included in the Sustainability Survey for Fisheries were considered to be in the critical zone, 14% were in the cautious zone, and 41% had uncertain status, leaving just 35% in the healthy zone. Of the stocks assessed in the survey, 43 fish stocks have no management plan in place (DFO, 2017). Fisheries mismanagement in Canada, such as the infamous collapse of the northern cod fishery and more recent concerns around Pacific mackerel (Fox, Jacob, Darimont & Paquet, 2016) and Atlantic mackerel stocks (DFO, 2019c; World Wildlife Fund Canada, 2019), has raised concerns about the effectiveness of fisheries management. Concerns around the uncertainty of fisheries management and decision-making that is not driven by science, and that which does not adequately incorporate the precautionary approach have been cited as obstacles to effective fisheries management in Canada (Fox, Jacob, Darimont & Paquet, 2016). Ensuring that Canada's fisheries are sustainably managed should be a top priority. With the knowledge that only 35% of Canada's fisheries are in healthy status it becomes important to explore whether it is wise, sustainable, or in line with a precautionary approach to be harvesting and consuming these species, and more so, to continue actively promoting their consumption.

Some research has been done to date to explore shifting human health recommendations to more closely align with and support environmental health, particularly focusing on the theoretical capacity of the planet to meet food production needs and the diets that are most sustainable (Bahadur et al., 2018; Willet et al., 2019). With the revision of *Canada's Food Guide* (Health Canada, 2019a) there was a call to incorporate environmental considerations, given public awareness of climate change and our environmental footprint. With the release of the

Food Guide, Health Canada touted the incorporation of environmental considerations in Canada's dietary guidelines for the first time. With dietary guidance supporting fish and seafood consumption, fish stocks that are overfished and overfishing occurring, it becomes important to explore if and where Canada's human health recommendations for fish and seafood intake and environmental recommendations for seafood sustainability align, and whether there are opportunities to better align these guidelines to support human and environmental health.

Research Objectives

To that end, this research explores what Canadians should be eating with regards to fish and seafood, keeping in mind human health recommendations and environmental sustainability. Additionally, the attributes of affordability and provenance are considered. These are additional elements of sustainability when viewed through a food systems lens. See *Figure 1* for a graphical representation of the study design. The main research questions are:

1. Where do Canada's human health recommendations and environmental health recommendations for fish and seafood consumption align or diverge, and what are the opportunities for aligning human health and environmental health?
2. In line with sustainable food systems, how can the interconnected areas of human health, environmental health, provenance and affordability be considered together to support a healthy Canadian population as well as healthy, sustainable marine ecosystems?

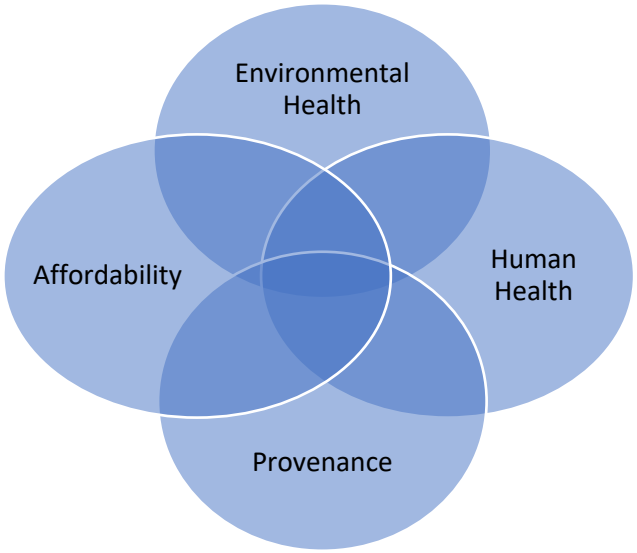

Figure 1 Environmental health, human health, provenance and affordability of species were assessed against pre-established criteria to determine which species satisfied the criteria for multiple areas of interest. Ideally, a species would satisfy all four areas of interest.

This research is presented in five chapters. In this introductory chapter a background on human health, the connection between human health and our food systems and the current state of Canada's fisheries is outlined. Chapter 2 will discuss the methods used to guide the research, including the data sources and criteria used for each area of interest. The results of the research follow in Chapter 3. Chapter 4 explores some discussion points around the research process and results. Finally, recommendations and conclusions are found in Chapter 5.

Background

Exploring the Alignment of Human Health and Environmental Health

Several different aspects of the alignment of human and environmental health may be considered. Here, the environmental impact of dietary patterns, the environmental impact of food production and consumption and finally, the consideration of human health and environmental health together will be discussed. Additionally, some research exploring the alignment of human and environmental health, specifically regarding seafood, will be briefly reviewed.

The alignment of human and environmental health has been explored in various studies around the world. Some studies have predominantly focused on dietary patterns, whether based on a model diet (Tilman & Clark, 2014), actual reports of purchasing and food consumption behaviours (Clonan, Wilson, Swift, Leibovici & Holdsworth, 2015), or both (Chen, Chaudhary & Mathys, 2019). At present, the literature suggests that plant-based diets, the Mediterranean diet, and diets with less red and processed meats are more environmentally sustainable. While there has been some research to explore the connection between meat and dairy consumption and environmental impact (Clonan, Wilson, Swift, Leibovici & Holdsworth, 2015), there is a paucity of research to draw connections between other food items and their environmental implications.

Studies have employed a variety of tools to quantify the environmental impact of food production, processing, transportation, consumption and disposal. Greenhouse gas emissions, ecological footprints, consumer attitudes and purchasing behaviours have been used as proxies for the sustainability of dietary patterns and the factors that influence the choice of dietary patterns for individuals (Chen, Chaudhary & Mathys, 2019; Clonan, Wilson, Swift, Leibovici & Holdsworth, 2015; Gardner et al., 2019; Koerber, Bader, & Leitzmann, 2017; Tilman & Clark, 2014). However, there has yet to be a thorough evaluation of how shifting human health recommendations may influence eating patterns, markets, food systems and the broader environment.

Canadian health and food policy is beginning to acknowledge the connection between human health and the environment. The new food guide acknowledges that “food choices can have an impact on the environment” (Health Canada, 2019a, p.9). The 2019 release of Agriculture and Agri-food Canada’s *A Food Policy for Canada* marks the first national food policy for the country (Agriculture and Agri-Food Canada, 2019). In addition to incorporating considerations for the social, economic, and cultural components of our food system, the policy addresses the importance of supporting a sustainable food system as well as recognizing the linkages between human and environmental health. However, the acknowledgement of these interconnected

domains of health must be practically implemented in policy domains, which remains a difficult challenge.

The alignment of human and environmental health, specifically regarding seafood has emerged in the literature. Some research has explored the potential to align human health through general guidelines and associations of the ecological characteristics, health benefits and risks of seafood species consumed, however results have been challenged by others (Gerber, Karimi & Fitzgerald, 2012; Tlusty, 2013). Other research has focused on the role of sustainable fisheries in supporting food security around the world (Belton, Van Asseldonk & Thilsted, 2014; Beveridge, Thilsted, Phillips, Metian, Troell, & Hall, 2013). However, the complexity of fisheries management, the seafood supply chain and human health research create great complexity in considering the alignment of human and environmental health as it relates to seafood consumption, leaving much to be explored.

Canada's Health Recommendations

Canada has several government agencies, under the purview of the Minister of Health, who are responsible for various aspects of supporting the health of Canadians. Health Canada is the Canadian government department responsible for protecting and promoting the health of Canadians. In this capacity, the department uses various policies, regulations and recommendations to provide guidance on health-related topics such as food choices, nutrient intake and dietary patterns. *Canada's Food Guide for Healthy Living* is perhaps the best publicly known source for dietary recommendations in Canada. However, Health Canada also maintains Dietary Reference Intakes, food labelling regulations related to health, and other efforts that relate to the health of the Canadian population.

It is important to note that Health Canada and other government agencies under the health portfolio, as well as other departments, have overlapping responsibilities that address trade, agriculture and agri-food, fisheries and aquaculture and other activities that shape our food systems. For example, both Health Canada and the Canadian Food Inspection Agency (CFIA) set food labelling regulations that address health and safety, respectively. Accordingly, the

ministerial mandate letter to the Minister of Health includes explicit direction to work with the Minister of Agriculture and Agri-food on aligning food labelling regulations and food policy (Trudeau, 2017). The mandate letter to the Minister of Fisheries, Oceans and the Canadian Coast Guard calls for cooperation with the Minister of Science and Sport to consider climate change in decisions that may impact fisheries and aquaculture (Trudeau, 2018). This overlap can also be seen in the role of the Canadian Border Services Agency (CBSA) to enforce the import requirements set by the CFIA at border crossings and to collect trade data, which is then communicated to Statistics Canada, and back to the relevant government agency. Thus, the governmental potential for influencing the health of Canadians is broader than publishing a food guide every decade or so, but rather extends into other sectors and reaches beyond influencing health on an individual level.

Canada's health guidelines include explicit guidance on specific nutrients that are of benefit to human health and how to meet recommended intake levels, including for several nutrients derived from seafood. Very long chain n-3 fatty acids, specifically eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA), are included in Canada's health recommendations for a number of reasons. The role of n-3 and n-6 fatty acids in human growth and development are well supported in the literature. *Table 1* provides an overview of the human health benefits of EPA and DHA. Given the known health benefits of these fatty acids, and that they are exclusively marine derived, it follows that Canadian food and nutrition recommendations include guidance specifically related to foods that contain these fatty acids, fish and seafood.

Table 1 Health benefits of EPA and DHA. (Food and Agriculture Organization of the United Nations, 2010)

Health Benefits of EPA & DHA
• Fetal growth and development • Neurological health • Cardiovascular health • Anti-inflammatory effects • Immune health effects

The Adequate Intakes (AIs) for n-3 fatty acids at various life cycle stages are listed in Table 1. Throughout the lifecycle, Health Canada recommends that 0.6-1.2% of energy be consumed from n-3 fatty acids, with up to 10% of that as EPA and DHA (Health Canada, 2010).

Table 2 Dietary Reference Intakes for n-3 fatty acids throughout the lifecycle. (Health Canada, 2010)

Age	Males (g/day n-3 fatty acids)	Females (g/day n-3 fatty acids)
0-12 months	0.5	
1-3 years	0.7	
4-8 years	0.9	
9-13 years	1.2	1.0
Adult	1.6	1.1
Pregnancy		1.4
Lactation		1.3

Global Fisheries Health

With about 33% of global fish stocks being fished unsustainably and another 60% considered to be fished to their sustainable limits (FAO, 2018), it is clear that there is current strain, and likely to be future strain, on our global fisheries resources. Only 7% of (assessed) global fish stocks are estimated to be in a healthy condition, with a buffer to account for uncertainty in assessing factors that impact stock status. Capture fisheries production has been relatively stagnant for the past four decades, even possibly declining (Pauly & Zeller, 2016), however the expansion of aquaculture has accounted for significant growth in fish and seafood production, nearly matching capture fisheries production volume. With global population growth and increasing global food fish consumption (FAO, 2018), it is challenging to see how we can continue to sustainably, and even increasingly, exploit these resources. Management and governance efforts to date have been unable to ensure a sea full of fish for future generations.

The connection between fish and seafood production and depleting fish stocks is multifaceted. While the removal of species for direct human consumption is perhaps the most immediate cause, additional impacts of fisheries and aquaculture must be considered. Forage fish provide important food sources in ocean ecosystems. This significance is exploited by fisheries where forage fish are caught in large volumes for bait and aquaculture feeds. Aquaculture is often criticized for poor feed conversion ratios, indicating that a large volume of fish is used in the feed compared to the product that is ultimately produced (Tschirner & Kloas, 2017). Progress

has been made in reducing feed conversion ratios, notably in Norway (Ytrestøyl, Aas & Åsgård, 2015) and globally (Tacon & Metian, 2008), however the question remains whether it is sustainable to remove forage fish from ocean ecosystems to feed farmed crops, and furthermore whether seafood products are being used as efficiently as possible (Tlusty et al., 2019). Adding to the complexity of the sustainability conversation, there are some concerns that shifting aquaculture feeds to land-based alternatives may ease pressure in the ocean but does not negate sustainability concerns associated with terrestrial food production (Fry et al., 2016). Capture fisheries are not without their own sustainability concerns. Bycatch, discards and destructive fishing methods threaten non-target species, juveniles, ecosystem trophic balance and habitat destruction. The numerous considerations of the sustainability of fish and seafood production complicate sustainability assessments and speak to the potential for fisheries impacts to ripple throughout ocean ecosystems.

Canadian Fisheries Health

Bound by the ocean on three sides, Canada has an extraordinary expanse of coastline and an equally impressive variety of fisheries activities including freshwater fisheries, sea fisheries, aquaculture as well as recreational, sport and indigenous fisheries. Some of the earliest explorers remarked on the incredible productivity of the Grand Banks, and coastal Indigenous peoples have been harvesting fish for over 10,000 years (Canadian Museum of History, n.d.). This history of fishing supported the development of a strong fishing and more recently aquaculture industry. Over 600 Canadian communities and Indigenous communities depend upon fisheries resources for livelihood and wellbeing (Auditor General of Canada, 2016). The importance of fisheries in Canada cannot be ignored.

Marine fisheries are regulated by the federal Department of Fisheries and Oceans (DFO), with designated regional offices and even differing regulations throughout the Atlantic, Arctic and Central and Pacific regions. DFO often works in collaboration with other government groups, provinces and territories to manage freshwater fisheries, aquaculture, and recreational and sport fisheries. As rightsholders, Indigenous people have the right to self-determination and

management of their food, social and ceremonial fisheries (R. v. Sparrow, 1990) as well as fishing to secure a moderate livelihood (R. v. Marshall, 1999).

Much of the fisheries regulatory environment is governed by the *Fisheries Act,* which came into law in 1868, and is one of Canada's oldest pieces of legislation. Bill C-68, an amendment to modernize the *Fisheries Act* passed on June 21, 2019. Amendments to the *Act* are intended to protect fish and fish habitat and to address outdated pieces of the legislation, or pieces which had been 'watered down' in recent years (Bailey et al., 2016).

Fisheries Management in Canada

Canada's fisheries management has been criticized for lacking the relevant information to effectively manage fishing activity on our coasts (Oceana, 2018). The most recent Sustainability Survey for Fisheries (2017), carried out by DFO itself, reported that 40% of Canada's fish stocks assessed lacked sufficient information to assign a health status, and were therefore considered to be of "uncertain" status. Only 35% were considered to be in a 'healthy' status. In order to support the sustainable use of our marine resources, it is important that we know the status of fish stocks, the sustainable rate of exploitation, the current exploitation, and the life history characteristics of the fish. Many stocks lack information about the biomass of the stock, nearly a third lack a limit reference point and many lack fishing and natural mortality estimates (DFO, 2017). Others, like tuna, may have rough estimates that are often treated as actual counts of the fish. Additionally, there are some influences upon marine resources that we are not certain of, such as the impacts of climate change and shifts in species distribution that may follow (Nye, Link, Hare & Overholtz, 2009). Bycatch, discards and illegal, unregulated and unreported fishing introduce further uncertainty about the volume of fish leaving the water. It should be noted that some fisheries do not operate with well managed quantitative reference points, and therefore the actual catch of a fishery may still be unknown, for example the Atlantic Mackerel recreational fishery in Atlantic Canada does not require licenses or enforce a bag limit, but does enforce a 26.8cm minimum size (DFO, 2019a). In order to support the health of Canadian and global fisheries we require adequate information to inform management to protect and

prevent degradation of stocks that are currently healthy, support the recovery of stocks that are overfished, and prevent overfishing from continuing.

Fisheries management in Canada has also been criticized for a lack of proactive, or even reactive, management action to support sustainable fisheries. In the 2017 Sustainability Survey for Fisheries, DFO reported that of the 18 critically depleted stocks, 4 had rebuilding plans, and an additional 7 had plans in the works. Leaving a number of critically depleted stocks with no rebuilding plan in place or in progress (Auditor General of Canada, 2016). To date, many stocks still lack a rebuilding plan or are awaiting action to proceed (DFO, n.d.). Oceana Canada has criticized the plans that do exist for failing to incorporate globally recognized best practices (2018). Additionally, the 2016 Auditor General's report cited that of the 154 fish stocks that DFO manages, only 110 had up to date Integrated Fisheries Management Plans (known as IFMPs) in place, and some of those lacked clear objectives for management (Auditor General of Canada, 2016). The concept of ministerial discretion has also been criticized for enabling disregard for scientific assessments and recommendations (see for example Snook et al., 2019). While it should be acknowledged that ministerial discretion also includes the discretion to be more precautionary than the science suggests, recent examples such as the use of ministerial decision to exceed scientific advice in setting the catch limit for the Atlantic Mackerel fishery (DFO, 2019b; 2019c) and premature re-opening of the Atlantic cod fishery (Miel, 2019), suggest that it may be disadvantageous for those stocks with economic and political significance.

The economic and biological benefits of rebuilding fisheries are well-known and embraced within fisheries literature. However, the approaches that are required in order to rebuild fish stocks lack the lustre of the eventual returns. In many cases rebuilding of fisheries requires removing pressure on the fishery through reducing effort in directed and related fisheries, regulating and preventing bycatch and discards, or other management measures. However, rebuilding may require two or three life cycles of a species (FAO, 2018) or longer depending on the life history characteristics of the target species and other pressures on the population. In some contexts, these measures may be feasible, and rebuilding may be possible. However, in

other contexts the removal of effort from the fishery may result in a loss of livelihood, food security and economic capital. In such cases the longer-term benefits of improved fish stocks and higher catches promised by rebuilding may be out of reach given the dependence on the depleted resource.

Addressing Food Security

Food security is recognized as a public health issue globally and is addressed in the United Nations Sustainable Development Goal Two- Zero Hunger. Food security is key to human health for numerous reasons, including through ensuring a sustainable supply of sufficient quality and quantity of fish and seafood that meets the health, social and cultural needs of people. Thereby, the absence of food security- food insecurity, negatively impacts the wellbeing of Canadians through negatively influencing the quality and/or quantity of food available to individuals, families and communities. The highest rates of food insecurity are seen in the Atlantic Provinces and northern territories (Tarasuk, St-Germain & Mitchell, 2019).

Economic circumstances are an important variable in achieving food security. Higher income has been associated with greater levels of food security at marginal, moderate and severe levels of food security (Tarasuk, St-Germain & Mitchell, 2019). These levels correspond to concern about meeting food needs, compromising quality and compromising quantity of foods, respectively. In the budget of an individual or family there are fixed and flexible expenses. In cases of limited income, food presents one of the few budget lines that can be shrunk and shifted if necessary. By contrast, items such as rent, transit passes, and power are less flexible. The cost of food is an important determinant of consumers' purchasing and dietary habits, with affordable foods more likely to be consumed than more expensive alternatives and higher incomes associated with more nutritious diets (Lee et al., 2013). With the knowledge that income is associated with food security, and thereby health, it becomes relevant to explore the affordability of fish and seafood options in considering the best options for Canadians to meet human health needs.

So, in addition to thinking about fish and seafood consumption from the lens of environmental health, economic health becomes an additional lens of importance, where affordability may be the determining factor in the contribution of fish to food security and human health.

Affordability of a healthy diet is challenging to assess given the complexities of healthy diets and food prices. Internationally, a Consumer Price Index (CPI) is used to assess and compare the cost of an established set of goods. Canada maintains a monthly CPI across the country that provides a general overview of the categorical price fluctuations of various forms of fish and seafood products (fresh and frozen). However, knowledge of such fluctuations does not assist in determining which products are most affordable (See *Figure 2*). Statistics Canada also maintains a *Monthly average retail price for food and other selected products* database (See *Figure 3*); however, the selection of items includes only one fish/seafood item: a can of salmon. Neither database provides sufficient detail to build a useful understanding of the affordability of fish and seafood.

	Canada (map)				
Products and product groups[3]	**September 2018**	**August 2019**	**September 2019**	**August 2019 to September 2019**	**September 2018 to September 2019**
	2002=100			Percentage change	
Food [4]	144.9	151.1	150.2	-0.6	3.7
Food purchased from stores	141.4	148.4	147.2	-0.8	4.1
Meat	159.4	167.3	168.2	0.5	5.5
Fresh or frozen meat (excluding poultry)	169.1	171.8	175.3	2.0	3.7
Fresh or frozen beef	179.6	184.8	188.1	1.8	4.7
Fresh or frozen pork	144.0	142.5	146.5	2.8	1.7
Fresh or frozen poultry	156.9	166.9	169.2	1.4	7.8
Fresh or frozen chicken	161.2	171.6	173.0	0.8	7.3
Processed meat	147.9	159.0	156.4	-1.6	5.7
Ham and bacon	149.4	150.9	151.4	0.3	1.3
Other processed meat	152.5	165.9	162.5	-2.0	6.6
Fish, seafood and other marine products	136.4	142.1	141.9	-0.1	4.0
Fish	147.2	158.2	157.4	-0.5	6.9
Fresh or frozen fish (including portions and fish sticks)	146.6	154.6	154.5	-0.1	5.4
Canned and other preserved fish	144.5	164.6	161.5	-1.9	11.8
Dairy products and eggs	134.6	137.9	138.0	0.1	2.5
Dairy products	132.8	136.2	136.2	0.0	2.6
Fresh milk	143.5	144.1	144.0	-0.1	0.3
Butter	139.3	145.1	146.2	0.8	5.0
Cheese	126.7	128.2	128.2	0.0	1.2

Figure 2 Categories of food items included in the Consumer Price Index, with percentage change in $ CAD. Categories of seafood items included in Canada's Consumer Price Index cannot be effectively used to assess affordability. (Statistics Canada, 2019a)

Products	Canada (map)				
	May 2019	June 2019	July 2019	August 2019	September 2019
	Dollars				
Round steak, 1 kilogram	17.75	17.88	17.59	17.16	17.07
Sirloin steak, 1 kilogram	22.65	23.38	22.17	22.17	22.42
Prime rib roast, 1 kilogram	32.60	32.81	32.97	32.94	32.61
Blade roast, 1 kilogram	16.15	16.66	15.34	15.75	15.62
Stewing beef, 1 kilogram	15.68	16.02	15.50	15.55	15.58
Ground beef, 1 kilogram	11.30	11.41	10.86	11.23	11.67
Pork chops, 1 kilogram	12.20	12.26	12.02	11.72	12.07
Chicken, 1 kilogram	7.52	7.52	7.72	7.39	7.44
Bacon, 500 grams	6.96	7.07	7.14	6.99	7.04
Wieners, 450 grams	4.28	4.33	4.34	4.34	4.28
Canned salmon, 213 grams	5.67	5.57	5.84	5.89	5.81
Homogenized milk, 4 litres	5.81	5.78	5.80	5.77	5.76
Partly skimmed milk, 4 litres	5.19	5.17	5.14	5.15	5.16
Butter, 454 grams	4.97	4.85	5.16	5.03	4.97
Processed cheese slices					

Figure 3 A sample of the items included in Statistics Canada's monthly retail price database with prices in $ CAD. Canned salmon is the only seafood item included. (Statistics Canada, 2019b)

Alternatively, affordability of a healthful diet has been assessed through considering the cost of a “food basket”, a preselected group of grocery store items that would most likely be available in stores across the country (Fan, Baylis, Gundersen & Ploeg, 2018; Power, Belyea & Collins, 2019; Williams et al., 2012). The items are costed at predetermined time intervals and the total cost of the basket is compared across the nation or area of interest. However, like the CPI, these studies lack a variety of fish and seafood items, if they are included at all. Other approaches to assessing the affordability of dietary choices depend up on the intention of the study. Foods can be assessed by the nutrient content, energy or mass relative to cost, or by the cost relative to a similar food item. However, each of these evaluations will provide an incomplete picture of the affordability of that food item in the context of a healthy, balanced diet. It is important to note that Canada is by far not the only jurisdiction to lump fish and seafood into one commodity category and calls for the dismantling of this convention have been made (Tlusty et al., 2019).

Considering the Broader Food System

With a focus on supporting the health of Canadians and the health of the ocean, it is fitting to explore how Canada's food system, specifically fisheries and aquaculture as a sub-system, have potential to support the Canadian population through domestic production, rather than through the export focused system that we presently rely on. Through prioritizing local, domestic production we can begin to support additional dimensions of health and wellbeing such as the economic sustainability and cultural richness of fishing communities, supporting consumption of nutritious, local species, reducing environmental impacts associated with global fish and seafood trade, and finally, supporting food security and food sovereignty within Canada's food system. As such, a fourth dimension of interest in this paper is the provenance of seafood. If the assumption that local food systems also contribute to community health and wellbeing is accepted (see Amos and Bailey, 2019 for a discussion of this related to Canada's northern cod fishery), then the provenance of seafood may also be a determinant in the extent to which fisheries and seafood can support human health.

Chapter 2 Research Methodology

This research is a problem-oriented study with an interdisciplinary approach combining the fields of human and environmental health and relying on sustainable food systems scholarship for its theoretical grounding. The focus is on exploring opportunities for aligning different dimensions of health in the context of fish and seafood consumption in Canada. Four areas of interest are assessed: human health, environmental health, affordability, and provenance (See *Figure 1*). The method of assessment for each area is explained below.

While the objective of this research is to identify species that satisfy all four areas of interest, it should be acknowledged that in some cases the information available is not specific to the scientifically named species level. In some instances, such as trade data, landings data and health guidelines, species are grouped (i.e. clams, mussels). Given the lack of specificity, the lowest level of species identification possible may be a grouping of species.

Assessing Human Health Recommendations

Human health data sources were explored for the content of health recommendations related to fish and seafood, evidence for these recommendations, species and quantities that are explicitly identified in health guidance documents. Key data sources included Canada's Food Guide, related healthy eating publications and the background documents, as well as cautionary guidance regarding fish and seafood intake.

In Canada, Health Canada is the government department responsible for safeguarding and promoting the health of Canadians. In this capacity Health Canada develops and supports the implementation of food and nutrition recommendations such as *Canada's Food Guide,* accompanying documents and other food and nutrition related recommendations. *Canada's Food Guide* was most recently updated in 2019 following a lengthy revision process that involved evidence reviews, public and expert consultation.

Health Canada establishes Dietary Reference Intakes (DRIs) for nutrients that are known to be related to human health. Within DRIs there are values that specify a variety of levels of

confidence and reference limits. For n-3 fatty acids there is insufficient evidence available to support the development of any Upper Limit or Recommended Daily Allowance (RDA), however there is an n-3 fatty acid Adequate Intake (AI) established. AIs are established when there is insufficient evidence to state with confidence that the recommendation will meet the needs of a certain proportion of the population, however it is likely to meet the needs of most (Health Canada, 2010). In the case of n-3 fatty acids, fish and seafood species included in human health recommendations are those that that are explicitly named in guidance and recommendation documents as supportive of human health, as well as those species named in precautionary guidelines to avoid or limit due to high mercury content.

Assessing Environmental Health

Assessing the environmental sustainability of fish and seafood species is complicated by the production location, method (farmed or wild), gear used, and stock status of wild populations. Each of these factors has the potential to shift a species along a sustainability continuum. Additionally, there are numerous indicators of sustainability that can be used to assess the environmental impact of fish and seafood production and consumption. Each potential indicator has benefits and challenges, given the focus of the assessment. Fish are a public resource and therefore in Canada, management and sustainability assessments fall in part to the federal government, as discussed in Chapter 1. Third party certification is often boasted as the gold standard for ensuring the sustainability of fish/seafood production. However, it should be noted that the market leverage intention of the certification, and only recent introduction of cumulative impacts assessment, present challenges when looking to compare the sustainability of a variety of fisheries which are in varying states of compliance and certification. In this study, both national, specifically, the 2017 DFO Sustainability Survey for Fisheries, and third-party assessment, specifically Ocean Wise, are used to assess sustainability.

Fisheries and Oceans Canada selects a variety of wild fish stocks for assessment in the Sustainability Survey of Fisheries based on cultural, economic, and environmental importance to provide a healthy, cautious, critical or uncertain ranking of sustainability. As discussed above, many stocks are assessed as “uncertain” due to the absence of important data to accurately

assess the stock. Analysis was complicated by the range of rankings that some species received, spanning uncertain to healthy to critical. At this time there is no government-based assessment of aquaculture species sustainability.

Ocean Wise assesses fisheries and provides an external recommendation on the sustainability of the fishery. Like the DFO Sustainability Survey, gear, fish stock, production method and location all influence the Ocean Wise recommendation, or lack thereof. Similarly, the Ocean Wise rankings of species ranged from being recommended to not recommended. Some fisheries, particularly those that are very small (i.e. Alewife) have not been assessed by Ocean Wise (personal communication).

The environmental health dimension was assessed depending on whether the species had been assessed in the 2017 DFO Sustainability Survey for Fisheries and the resulting rating of sustainability, as well as whether the stock is recommended by Ocean Wise both domestically and internationally. In DFO's Sustainability Survey the absence of an assessment or uncertain status was considered to be an indicator that the stock cannot currently be said to be sustainably exploited due to a lack of data. Species that have multiple Ocean Wise stock assessments (i.e. multiple gear types, geographic locations) have been considered in a worst-case scenario in line with the precautionary approach intention to avoid harm if uncertainty exists. In fact, throughout the analysis species have been considered from a precautionary perspective. Where a species may have multiple stocks that are in varying states of compliance or recommendation, the lowest ranking has been used. This is in alignment with the precautionary approach, and with consideration that Canada's food labelling regulations do not provide sufficient information to determine whether a purchased product is from the healthy/unhealthy/uncertain, recommended/not recommended stock. For example, in the event that some shrimp species are recommended because they are trap caught and some other shrimp species are not recommended because they are harvested by bottom trawling the species would be deemed not recommended in order to be precautionary.

Ultimately, sustainable fisheries management would necessitate supporting stocks to be in healthy status, fished sustainably with gear that is minimally harmful for the environment. If these conditions were satisfied the fishery should receive positive rankings from both the Sustainability Survey for Fisheries and from Ocean Wise, assuming it was assessed by both.

Assessing Affordability

Assessing the affordability of food items is complex and there is no standard formula to reach a conclusive value. Various methods exist for assessing how affordable a food item is, such as considering cost based on the energy density, nutrient density, mass, or relative to alternative food items. Each approach has its respective merits and challenges. In order to assess the relative affordability of fish and seafood options in this project, the median cost per pound of fish and seafood on the Canadian market ($8.99) was determined, and items that fell at or below the median were considered to be “affordable”. This allowed for some safeguarding against skewing due to the outliers of very expensive cuts and species of fish and seafood that can be triple or even quadruple the cost of more cost-efficient alternatives.

Affordability was determined based on pricing provided by a confidential national seafood retailer. The retailer provided the researcher with daily price per pound selling amounts for fresh and frozen seafood. Additional pricing information was obtained from publicly available retail prices from major retailers across Canada via their online shopping portals and catalogues. Cost was calculated on a per 90g raw (75g cooked) portion in line with Health Canada guidance that cites 75g as a meat/fish serving size. The less expensive half of the products, those at and below the median price, were classified as affordable fish and seafood options.

Assessing Provenance

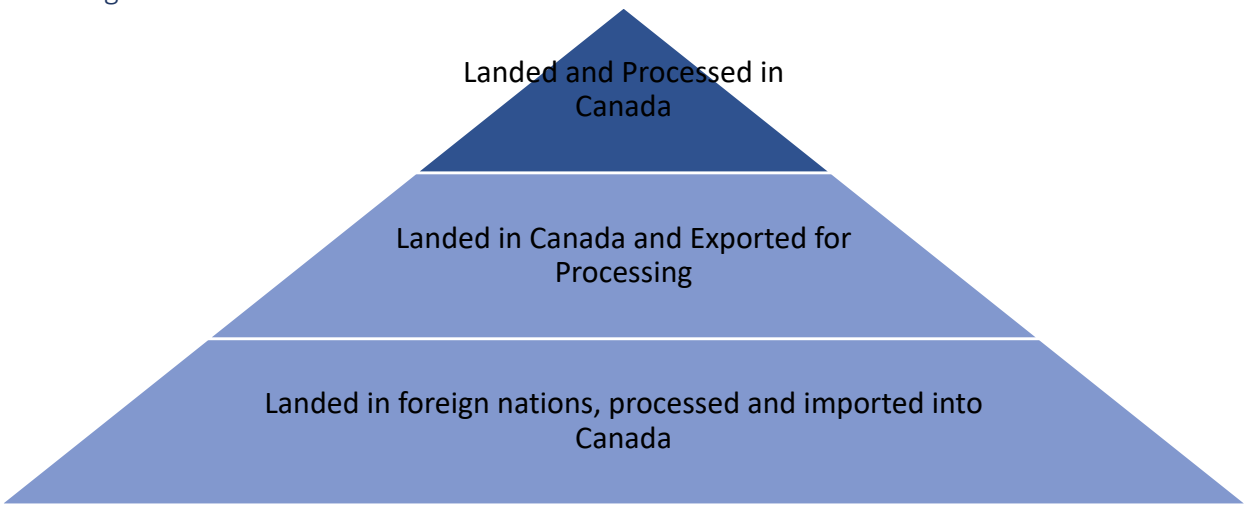

Figure 4 Provenance analysis considered three tiers. Tier 1 includes domestically produced and processed seafood. Tier 2 includes tier 1 and domestically produced seafood processed elsewhere and re-imported. Tier 3 includes tiers 1,2 and imported seafood.

Provenance was employed as a dimension to identify Canadian production in order to support the social, cultural and economic benefits of domestic and local food production. Canadian production volumes for seafood were determined based on DFO freshwater fishery and seafishery landings, as well as aquaculture production statistics for 2017. While other species may be available in Canada through recreational or sport fishing they have not been considered in this analysis. Trade statistics for 2017 were obtained from DFO through personal communication with a DFO employee at an @dfo-mpo.gc.ca e-mail address. Fisheries landings and aquaculture production volumes were combined, and exports were deducted to obtain the approximate Canadian production volume available on the market for the top provenance category. Re-imports were considered the second-best provenance category and finally imported fish and seafood were considered the least desirable provenance option, but still indicated that at least the product was available in, if not sourced from, Canada (See *Figure 4*). Species for which it could be calculated that at least ten 75g (cooked) servings per Canadian per year were available are recommended for consumption, given the prevalence of health recommendations that encourage consumption of a variety of foods.

Finally, a scan of the relevant literature for each area of interest was used to inform any gaps in the literature. A comparative analysis was used to identify species that satisfy the criteria established for each, or multiple, areas of interest.

Table 3 Areas of interest and respective data sources and criteria for assessment.

Area of Interest	Data Sources	Criteria
Human Health Eg. "Char" is listed as a recommended species of fish in Canada's guidelines, meeting the assessment criterion.	• Government of Canada publications • Literature cited in Government of Canada publications • Contradictory literature identified through EBSCO host database search	Is the species identified (recommended or cautioned against) in health guidelines or recommendations?
Environmental Health Eg. Hake is assessed by DFO as unhealthy, uncertain and healthy and as both recommended and not recommended by Ocean Wise. Hake does not satisfy this criterion.	• DFO Sustainability Survey for Fisheries (2017) • Ocean Wise assessments for domestic and international production	Does the species have favourable sustainability assessments from both Ocean Wise and DFO?
Affordability Eg. Fresh, whole flounder is $5.49/lb, below the median of $8.99/lb, meeting this criterion.	• Confidential Seafood Retailer national pricing list • Publicly available fish and seafood pricing information from major retailers • Less expensive 50% of choices ranked as "more affordable"	Is the species at or below the median seafood price per pound ($8.99) of pricing available?
Provenance Eg. Domestic production of clams produces 11.5 75g (cooked) servings per Canadian, meeting this criterion.	• DFO Seafishery and Freshwater Fishery Landings (2018) • DFO Aquaculture Production (2018) • Canadian International Merchandise Trade Database Import, Export data 2018 • Trade and production data from DFO personal communication from @dfo-mpo.gc.ca e-mail address	Does supply meet the threshold of 10 annual 75g (cooked) servings per Canadian?

Chapter 3 Results

In the following chapter, the results of which fish and seafood species and species group met one or more of the areas of interest are provided.

Health Recommendations

Fish and seafood are recognized as an important source of n-3 fatty acids (EPA and DHA) and high-quality protein, as well as vitamin D and micronutrients such as selenium, iron, copper, zinc and iodine (Health Canada, 2017). From the document analysis of a variety of Canada's fish and seafood recommendations, there are two focal messages that stand out regarding fish and seafood intake. Firstly, the revision of *Canada's Food Guide* saw an elevated profile for fish and seafood, following plant-based proteins and preceding other animal-based proteins. While the previous iterations of Canada's food guide provided explicit guidance on the frequency and size of servings of the foods to consume based on the food groups (grains, meat and alternatives, vegetables and fruit, milk and alternatives) or specific foods (such as "choose fish such as char, herring, mackerel, salmon, sardines and trout" (Health Canada, 2011a)), there is no longer explicit messaging around how often to consume fish and seafood or the portion sizes that should be consumed in the food guide. It is possible that the listing of proteins may be interpreted by the public as a hierarchy of which to choose, thereby encouraging the consumption of fish and seafood. Other guidance from Health Canada still maintains the previously suggested two 75g fish/seafood servings per week and focuses on limiting exposure to mercury in fish (Health Canada, 2017). Large predatory fish are known to have higher levels of mercury (tuna, swordfish, shark, orange roughy, escolar) and therefore are recommended only in limited amounts, especially for children and pregnant women (Health Canada, 2017). Guidance documents offer lists of lower mercury fish and seafood alternatives to meet people's needs. See *Table 4* and *5*.

There is an important distinction to be made between species that are recommended, cautioned to limit, and those that simply don't appear in health guidelines. Those that are recommended for consumption can be assumed to contribute positively to meeting human

health needs. Those that are cautioned to limit are understood to possess compounds that may be harmful If ingested in specific life stages and/or quantities, such as mercury. However, species that do not appear in health guidelines are not necessarily recommended or cautioned against, but rather have simply not been listed. In the Canadian context, halibut can be used as an example. It is not specifically listed in human health recommendations; however it has similar, and in some cases more, omega 3 fatty acids than some species listed (such as shrimp and crab) (Health Canada, personal communication, 2019) and less mercury than some species included in cautionary guidance (United States Food and Drug Administration, n.d.). However, it is not listed because Canada's recommendations do not include exhaustive lists of species, but rather a selection.

Table 4 Fish and seafood species recommended for intake for human health reasons

Species Recommended by Health Canada
• Anchovy[A] • Atlantic Mackerel[AB] • Blue crab[AB] • Capelin[A] • Char[A] • Clam[AB] • Crab[B] • Flounder[B] • Haddock[B] • Hake[B] • Herring[AB] • Lake whitefish[AB] • Lobster[B] • Mackerel* • Mullet (sucker) [A] • Mussel[AB] • Oyster[AB] • Pollock (Boston bluefish) [AB] • Rainbow trout[A] • Salmon*[AB] • Sardines* • Scallops*[B] • Shrimp*[B] • Smelt[A] • Sole[B] • Trout*[B] *- listed in CFG accompanying documents (Health Canada, 2019b) [A]-(Health Canada, 2017) [B]-(Health Canada, 2011b)

Table 5 Recommended Species to Limit Due to High Mercury Content

Species Listed Under Cautionary Guidance due to Mercury Content
• Barracuda[C] • Escolar[A] • Marlin[A, C] • Orange roughy[A] • Seabass[C] • Shark[A,C] • Swordfish[A, C] • Tuna, specifically Bigeye and canned Albacore[A, C]
[A]-Health Canada, 2017
[c]-Health Canada, 2007

Across all recommendations, a total of twenty-six (26) species or species groups were recommended as contributing to human health. Ten (10) species or groups of species were included in cautionary guidance. While this demonstrates a wide diversity of options for Canadian consumers, as can be seen in subsequent sections, when viewed with consideration of the other areas of interest, this variety diminishes quickly leaving few options that are favourably assessed in all areas of interest.

Environmental Health

Table 6 presents the results of the environmental analysis. Notably, only four species or species groups, that is farmed clams, geoduck, Pacific halibut and sablefish, satisfied the environmental health criteria. However, as Canada does not have an abalone fishery, the Ocean Wise (OW) global assessment was considered adequate to achieve compliance. Many species have a variety of rankings from both DFO and Ocean Wise. Canada's fish and seafood labelling regulations do not require information about stocks or fishing method, and do not provide scientific names for species. Therefore, the consumer would be unable to discern whether the fish purchased was from a sustainable or not sustainable population, according to DFO and Ocean Wise. As such, the overall assessment has considered the worst-case scenario in line with a precautionary approach.

*Table 6 Environmental health results. Species with multiple assessments show the variety of results for species within a group or stocks. * indicates a species that has a Canadian fishery according to DFO fisheries management resources and listings of commercial, recreational and sport fisheries, but was not included in DFO's 2017 Sustainability Survey for Fisheries. Blank assessment results indicate that there was no assessment available through DFO or Ocean Wise, respectively.*

Species	Sustainability Survey for Fisheries (2017)	OW Ranking CAD	OW Ranking Global	**Environmental Assessment Overall**
Abalone			Y	**Y**
Alewife	*			**N**
Anchovy			N	**N**
Arctic Char	Healthy/Uncertain	Y	Y	**N**
Atlantic Cod	Critical/Cautious	N	Y/N	**N**
Burbot	*			**N**
Capelin	Uncertain	Y/N	Y	**N**
Carp	*		Y	**N**
Catfish	*	Y	Y/N	**N**
Clams / quahaug	Cautious/Healthy/Uncertain	Y	Y/N	**N, Y (farmed)**
Cockles			Y/N	**N**
Cod	Critical/Cautious	Y/N	Y/N	**N**
Crab Dungeness	Healthy	Y	Y/N	**N**
Crab, Other	Uncertain	Y/N	Y/N	**N**
Crab, Queen	Cautious/Healthy/Uncertain	Y/N	Y/N	**N**
Crayfish			Y/N	**N**
Cusk				**N**
Cuttlefish				**N**
Dogfish	Uncertain	N	Y/N	**N**
Eel	Uncertain		N	**N**
Flounders	Critical/Cautious/Healthy/Uncertain	Y/N	Y/N	**N**
Geoducks	Healthy	Y	Y	**Y**
Greenland turbot	Cautious/ Healthy/ Uncertain		Y/N	**N**
Haddock	Healthy/Uncertain	Y	Y/N	**N**
Hake	Critical/Healthy/Uncertain	Y/N	Y/N	**N**
Halibut	Cautious/Healthy/Uncertain	Y	Y/N	**N**
Halibut (Atlantic)	Healthy	Y	Y/N	**N**
Halibut (Pacific)	Healthy	Y	Y	**Y**
Herring	Critical/Cautious/Healthy/Uncertain	Y/N	Y/N	**N**
Lake trout	Uncertain	Y/N	Y/N	**N**
Lingcod	Healthy	Y/N	Y	**N**
Lobster	Healthy/Uncertain	N	Y/N	**N**
Lobster, Rock			Y/N	**N**
Lumpfish roe				**N**
Mackerel	Critical	Y	Y/N	**N**
Monkfish			N	**N**
Mussel		Y	Y/N	**N**
Ocean Catfish			Y/N	**N**
Ocean perch	Healthy			**N**
Octopus		Y	Y/N	**N**
Oyster	Uncertain	Y	Y/N	**N**
Patagonian toothfish			Y/N	**N**

Perch	*	Y/N	Y/N	**N**
Pickerel		Y/N	Y/N	**N**
Pike	*	N	N	**N**
Plaice	Critical		Y/N	**N**
Pollock	Cautious	N	Y/N	**N**
Redfish spp.	Cautious/Healthy/Uncertain	Y	Y	**N**
Rock bass	*	Y	Y	**N**
Sablefish	Healthy	Y	Y	**Y**
Salmon	Critical/Cautious/Healthy/Uncertain			**N**
Salmon (Atlantic)	Critical/Uncertain	Y/N	Y/N	**N**
Salmon, Chinook	Cautious/Uncertain	Y/N	Y/N	**N**
Salmon, Chum	Healthy	Y	Y/N	**N**
Salmon, Coho	Uncertain	Y/N	Y/N	**N**
Salmon, Pink	Uncertain	Y	Y/N	**N**
Salmon, Sockeye	Critical/Cautious/Healthy	Y	Y/N	**N**
Sardine	Uncertain		Y/N	**N**
Sauger	*			**N**
Scallop	Cautious/Healthy/Uncertain	Y	Y/N	**N**
Sea bass			Y/N	**N**
Sea cucumber	Healthy/Uncertain	Y/N		**N**
Sea urchin	Healthy	Y/N	Y/N	**N**
Shad	*			**N**
Shark		N	N	**N**
Shrimp	Critical/Cautious/Healthy/Uncertain	Y/N	Y/N	**N**
Silversides	*			**N**
Skate	Uncertain	Y/N	Y/N	**N**
Smelt	*	Y/N	Y/N	**N**
Snails				**N**
Sole		Y/N	Y/N	**N**
Squid	*		Y/N	**N**
Sturgeon	*	Y/N	Y/N	**N**
Sucker (Mullet)	*		Y/N	**N**
Sunfish	*			**N**
Swordfish	Healthy	Y/N	Y/N	**N**
Tilapia		Y	Y/N	**N**
Tomcod	*			**N**
Trout		Y	Y/N	**N**
Tullibee	*			**N**
Tuna	Healthy/Uncertain			**N**
Tuna, Albacore	Healthy	Y/N	Y/N	**N**
Tuna, Bigeye		N	Y/N	**N**
Tuna, Bluefin	Uncertain	N	N	**N**
Tuna, Bonito				**N**
Tuna, Skipjack/Bonito		Y/N	Y/N	**N**
Tuna, Yellowfin		Y/N	Y/N	**N**
Whelks	Uncertain		Y	**N**
White bass	*			**N**
Whitefish	Uncertain	Y/N	Y/N	**N**
Yellow Pickerel	*	Y/N	Y/N	**N**

Some species that emerged in other areas of interest throughout the research do not have rankings for sustainability in the DFO survey, Ocean Wise, or both. This inhibits the assessment of which species may be sustainably consumed.

Provenance

Tier 1 provenance, those species and groups that are landed and processed in Canada, contained clams, crab (queen/snow), herring, hake, salmon (no species identified), scallops and shrimp (See *Table 8*). Considering the other tiers of provenance did not have a significant impact on the number of species that appeared to be available (at least 10 servings/Canadian/year), with the exception of lobster (3.6 servings in Provenance tier 1 to 12.3 servings in Provenance tier 3, i.e., accounting for US imports), skipjack tuna (0 servings in Provenance tier 1 to 10 in Provenance tier 3, i.e., imported canned tuna likely) and the volume of shrimp (11.8 serving in Provenance tier 1 to 29 servings in Provenance tier 3, again, due to imported varieties) available. See *Table 7* for domestic production data and *Table 8* for total domestic production, trade and provenance results.

It should be noted that the volumes of many species available per Canadian appear to be negative values or zero. This speaks to the lack of credible and cross-referenced available data around landings, imports, exports, and whether species are considered to be imported as a fish/seafood product or a processed food product, which may complicate and introduce inaccuracy in the data. For example, the Pacific halibut production volume was not available and the trade data indicates that exports exceed imports, therefore the volume available per Canadian is negative.

Species groupings are common in DFO reported statistics such as clams, flatfishes, and other fish categories. It can be expected that some species lacking production data are in fact reported in one of the aggregated categories, however the species-specific breakdown is not

available. Where species specific data is not available the next highest resolution category has been used, if possible.

Table 7 Domestic production (tonnes) for 2017, by species and species groups reported by DFO. Source: DFO freshwater and seafishery landings, aquaculture production statistics and DFO personal communication. denotes that the species is not listed to a species level.*

Fish	Freshwater landings (tonnes)	Seafishery landings (tonnes)	Aquaculture production (tonnes)	Total Domestic Production (tonnes)
Abalone*				
Alewife	1,403	1,676		3,079
Anchovy*				
Arctic Char		83		83
Atlantic Cod		23,319		23,319
Burbot	7			7
Capelin		21,892		21,892
Carp	802			802
Catfish	220	0		220
Clams / quahaug		47,014	1,624	48,638
Cockles				0
Cod*				
Crab Dungeness*				
Crab, Other		9,749		9,749
Crab, Queen		92,458		92,458
Crayfish*				
Cusk		148		148
Cuttlefish*				
Dogfish		153		153
Eel	47	185		232
Flatfishes		22,834		22,834
Flounders*				
Frogs*				
Geoducks*				
Greenland turbot		27,271		27,271
Haddock		19,015		19,015
Hake		97,281		97,281
Halibut *				
Halibut (Atlantic)		8,314		8,314
Halibut (Pacific)*				

Herring		125,294		125,294
Lake trout	262		14,656	14,918
Lingcod*				
Lobster		97,452		97,452
Lobster, Rock*				
Lumpfish roe				0
Mackerel		9,479		9,479
Monkfish*				
Mussel		0	24,448	24,448
Ocean Catfish*				
Ocean perch*				
Octopus				
Other freshwater fish	285			285
Other groundfish		4,163		4,163
Other pelagic and other fish		64	1,674	1,738
Other shellfish		58	127	185
Oyster		1,561	13,800	15,361
Patagonian toothfish*				
Perch	4,228			4,228
Pickerel				
Pike	1,862			1,862
Plaice*				
Pollock		6,735		6,735
Redfish spp.		29,343		29,343
Rock bass	8			8
Sablefish*				
Salmon		12,893	120,553	133,446
Salmon (Atlantic)				0
Salmon, Chinook*				
Salmon, Chum*				
Salmon, Coho*				
Salmon, Pink*				
Salmon, Sockeye*				
Sardine*				
Sauger	133			133
Scallop		55,943	75	56,018
Sea bass*				
Sea cucumber		9,922		9,922

Sea urchin		5,391		5,391
Shad	17			17
Shark		98		98
Shrimp		99,649		99,649
Silversides		178		178
Skate		868		868
Smelt	3,465	70		3,535
Snails*				
Sole*				
Squid		365		365
Sturgeon	122			122
Sucker (Mullet)	2,011			2,011
Sunfish	58			58
Swordfish		1,188		1,188
Tilapia*				
Tomcod	1			1
Trout*				
Tullibee	390			390
Tuna		2,721		2,721
Tuna, Albacore*				
Tuna, Bigeye*				
Tuna, Bluefin*				
Tuna, Bonito*				
Tuna, Skipjack/Bonito*				
Tuna, Yellowfin*				
Whelks				0
White bass	1,178			1,178
Whitefish	5,268			5,268
Yellow Pickerel	7,396			7,396

*Table 8 Imports, exports, re-imports and provenance results. Trade Data from Source: Statistics Canada International Trade Division 2018. Re-import data obtained through personal communication with a DFO employee at @dfo-mpo.gc.ca email address. * denotes an item not listed to the species level in DFO aquaculture production or landings data.*

Species	Total Domestic Production (tonnes)	Exports (kg)	Imports (kg)	Re-Imports (kg)	Prov 1	Prov 2	Prov 3
Abalone*		48,506	261,262		-0.01	-0.01	0.06
Alewife	3,079				0.92	0.92	0.92
Anchovy*		82,818	870,836		-0.02	-0.02	0.24
Arctic Char	83				0.02	0.02	0.02
Atlantic Cod	23,319	6,761,471	2,039,182	1,571	4.97	4.97	5.59
Burbot	7				0.00	0.00	0.00
Capelin	21,892	17,298,384			1.38	1.38	1.38
Carp	802	186,155	947,886		0.18	0.18	0.47
Catfish	220		10,657,535		0.07	0.07	3.27
Clams / quahaug	48,638	10,491,849	3,451,753	16,451	11.46	11.46	12.50
Cockles	0				0.00	0.00	0.00
Cod*		813,324	13,047,721	11,464	-0.24	-0.24	3.68
Crab Dungeness*		161,156	113,706		-0.05	-0.05	-0.01
Crab, Other	9,749	19,243,984	13,681,564	120,858	-2.85	-2.82	1.29
Crab, Queen	92,458	37,731,668	205,764		16.43	16.43	16.50
Crayfish*			1,422	302,404	0.00	0.09	0.09
Cusk	148	104,097			0.01	0.01	0.01
Cuttlefish*			736,301		0.00	0.00	0.22
Dogfish	153	55,264	7,896		0.03	0.03	0.03
Eel	232	445,779	932,682		-0.06	-0.06	0.22
Flatfishes	22,834	31,860			6.85	6.85	6.85
Flounders*		2,861,245			-0.86	-0.86	-0.86
Frogs*			306,044		0.00	0.00	0.09
Geoducks*		1,954,045			-0.59	-0.59	-0.59
Greenland turbot	27,271	8,212,059	98,550	17,010	5.72	5.73	5.76
Haddock	19,015	2,745,857	7,331,593	2,680	4.89	4.89	7.09
Hake	97,281	63,866,438	765,642	24,000	10.03	10.04	10.27
Halibut *		4,011,288	168,181	17,760	-1.20	-1.20	-1.15
Halibut (Atlantic)	8,314	1,427,757	925,871	645	2.07	2.07	2.35
Halibut (Pacific)*		8,616,854	1,779,727	3,540	-2.59	-2.59	-2.05
Herring	125,294	35,066,099	7,998,984	1,581	27.10	27.10	29.50
Lake trout	14,918	78,625	303,244		4.46	4.46	4.55

Lingcod*		59,815	26,736		-0.02	-0.02	-0.01
Lobster	97,452	85,508,127	28,690,823	448,145	3.59	3.72	12.34
Lobster, Rock*		60,275	353,201		-0.02	-0.02	0.09
Lumpfish roe	0				0.00	0.00	0.00
Mackerel	9,479	1,667,942	5,234,919		2.35	2.35	3.92
Mammals		63,462	98,780	63	-0.02	-0.02	0.01
Marine plants	0				0.00	0.00	0.00
Miscellaneous products	3,816	1,587,050	84,027,608	110,373	0.67	0.70	25.94
Monkfish*			104,840		0.00	0.00	0.03
Mussel	24,448	13,884,833	1,628,478	7	3.17	3.17	3.66
Ocean Catfish*		70			0.00	0.00	0.00
Ocean perch*		3,435,293			-1.03	-1.03	-1.03
Octopus		11,837	2,152,674		0.00	0.00	0.64
Other freshwater fish	285	3,495,939	1,802,955	39,094	-0.96	-0.95	-0.41
Other groundfish	4,163	911,622	11,428,738	4,237	0.98	0.98	4.41
Other pelagic and other fish	1,738	67,460	1,346,345	18,000	0.50	0.51	0.91
Other shellfish	185	6,752,154	8,378,572	15,937	-1.97	-1.97	0.55
Oyster	15,361	3,236,938	2,862,509	3,027	3.64	3.64	4.50
Patagonian toothfish*			372,597		0.00	0.00	0.11
Perch	4,228	564,763	248,094	4,083	1.10	1.10	1.18
Pickerel		955,205			-0.29	-0.29	-0.29
Pike	1,862	486,156			0.41	0.41	0.41
Plaice*		431,253	14,473		-0.13	-0.13	-0.13
Pollock	6,735	2,388,948	17,385,730		1.31	1.31	6.53
Redfish spp.	29,343				8.81	8.81	8.81
Rock bass	8				0.00	0.00	0.00
Sablefish*		1,755,452			-0.53	-0.53	-0.53
Salmon	133,446	5,370,577	23,184,217	269,310	38.46	38.54	45.50
Salmon (Atlantic)	0	87,608,559	10,414,731	28,980	-26.31	-26.30	-23.17
Salmon, Chinook*		463,008	564,653		-0.14	-0.14	0.03
Salmon, Chum*		2,315,186	258,702	6,560	-0.70	-0.69	-0.62
Salmon, Coho*		3,061,436	1,022,915	4,517	-0.92	-0.92	-0.61
Salmon, Pink*		590,799	2,070,376	6,386	-0.18	-0.18	0.45
Salmon, Sockeye*		1,096,043	6,116,917	1,841	-0.33	-0.33	1.51
Sardine*		2,822,387	4,175,959	1,588	-0.85	-0.85	0.41

Sauger	133				0.04	0.04	0.04
Scallop	56,018	5,853,101	4,256,979	31,304	15.06	15.07	16.35
Sea bass*		3,950	953,062		0.00	0.00	0.29
Sea cucumber	9,922				2.98	2.98	2.98
Sea urchin	5,391	1,956,912	84,462	26	1.03	1.03	1.06
Seaweed/Marine Plants*			0		0.00	0.00	0.00
Shad	17				0.01	0.01	0.01
Shark	98		307,814		0.03	0.03	0.12
Shrimp	99,649	60,399,616	57,107,813	48,626	11.79	11.80	28.95
Silversides	178				0.05	0.05	0.05
Skate	868	405,249	265,449	73	0.14	0.14	0.22
Smelt	3,535	2,781,007			0.23	0.23	0.23
Snails*		390,530	295,709		-0.12	-0.12	-0.03
Sole*		3,757,570	3,986,034	1,737	-1.13	-1.13	0.07
Squid	365	83,679	10,875,717		0.08	0.08	3.35
Sturgeon	122	3,340			0.04	0.04	0.04
Sucker (Mullet)	2,011				0.60	0.60	0.60
Sunfish	58				0.02	0.02	0.02
Swordfish	1,188	595,490	210,903	1,020	0.18	0.18	0.24
Tilapia*		2,849	7,027,381		0.00	0.00	2.11
Tomcod	1				0.00	0.00	0.00
Trout*		383,066	4,912,822	1,663	-0.12	-0.11	1.36
Tullibee	390				0.12	0.12	0.12
Tuna	2,721	575,461	300,150		0.64	0.64	0.73
Tuna, Albacore*		883,130	4,657,500	41,153	-0.27	-0.25	1.15
Tuna, Bigeye*		201,792	976,277		-0.06	-0.06	0.23
Tuna, Bluefin*		341,792	323,533		-0.10	-0.10	-0.01
Tuna, Bonito*			3,105		0.00	0.00	0.00
Tuna, Skipjack/Bonito*		87,873	33,645,515		-0.03	-0.03	10.08
Tuna, Yellowfin*		9,567	645,434		0.00	0.00	0.19
Whelks	0				0.00	0.00	0.00
White bass	1,178				0.35	0.35	0.35
Whitefish	5,268	4,123,500			0.34	0.34	0.34
Yellow Pickerel	7,396				2.22	2.22	2.22

Affordability

Affordability data are summarized in *Table 9*. The median fish and seafood price was determined to be $8.99/lb. Items at or below the median price were considered “affordable”. Twenty-eight (28) species were determined to fall at or below the median price.

Table 9 Affordability data by species. Median price determined to be $8.99/lb.

Fish prices Sept 2019	Price per lb ($ CAD)	Form
Abalone		
Alewife		
Anchovy	20.79	Fresh
Arctic Char	19.99	Fresh, Fillets
	8.99	Fresh, Whole
Atlantic Cod	10.99	Frozen, Fillets
Burbot		
Capelin		
Carp		
Catfish	9.08	Frozen, Fillets
	8.98	Fresh, whole
	3.54	Frozen, Fillets
Clams / Quahaug	6.99	Fresh
Cockles		
Cod	10.99	Fresh, Fillets
	11.48	
	3.49	Fresh, Whole
	5.49	Frozen, Fillets
Crab Dungeness	11.98	Live
Crab, Other	32.05	King crab, leg, frozen
Crab, Queen	14.98	Snow crab
Crayfish		
Cusk		
Cuttlefish		
Dogfish		
Eel		
Flounders	5.79	Fresh, Whole
Frogs		
Geoducks		
Greenland Turbot	7.98	Whole fresh
Haddock	8.99	Fresh, Fillets
	8.99	Frozen, Fillets

	3.99	Fresh, Whole
Hake	5.99	Fresh, Fillets
Halibut (Atlantic)	24.99	Fresh, Steaks
Halibut (Pacific)	19.98	Fresh Halibut, Steaks
Halibut		
Herring	5.38	Frozen, whole
Lake trout	13.99	Fresh, Fillets
	7.99	Fresh, Whole
Lingcod		
Lobster	12.99	Fresh
Lobster, Rock		
Lumpfish roe		
Mackerel	10.99	Fresh, Whole
	7.18	Frozen, whole
Monkfish	3.99	Fresh, Whole
Mussel	1.99	PEI cultured
Ocean Catfish		
Ocean perch	5.99	Fresh, Fillets
	2.99	Fresh, whole
Octopus	7.99	Frozen, baby octopus, whole
Oyster	2.99/2.00/1.50 each	Fresh
Patagonian toothfish		
Perch		
Pickerel		
Pike		
Plaice		
Pollock	5.49	Fresh, Fillets
	1.59	Fresh, Whole
	5.31	Frozen, Fillets
Redfish spp.		
Rock bass		
Sablefish		
Salmon		
Salmon (Atlantic)	13.99	Fresh, Fillets
	15.66	
	8.99	Fresh, Whole
Salmon, Chinook	8.48	Frozen, Pacific Salmon, Fillets
Salmon, Chum		
Salmon, Coho	11.98	Frozen, Fillets

Salmon, Pink	10.21	Frozen, Fillets
	6.99	Canned
Salmon, Sockeye	13.98	Frozen, Fillets
	10.62	Canned
Sardine	8.96	Canned
Sauger		
Scallop	24.99	Fresh
	23.99	Frozen
Sea bass	9.00	Fresh, Whole
Sea cucumber		
Sea urchin		
Shad		
Shark		
Shrimp	7.26	Frozen
	14.16	Frozen
Silversides		
Skate		
Smelt	4.99	Frozen
Snails		
Sole	8.49	Fresh, Fillets
	12.18	Frozen, Fillets
Squid	9.35	Frozen
	7.99	Frozen, squid tubes
Sturgeon		
Sucker (Mullet)	4.98	Frozen, whole
Sunfish		
Swordfish	19.99	Fresh, Steak
Tilapia	8.99	Fresh, Fillets
	6.99	Fresh, Whole
	5.49	Frozen, Fillets
Tomcod		
Trout	13.99	Fresh, Fillets
	12.99	Fresh, Whole
	10.98	Frozen, Fillets
Tullibee		
Tuna	14.99	Frozen, Steaks
Tuna, Albacore	13.2	Canned
Tuna, Bigeye		
Tuna, Bluefin		

Tuna, Bonito		
Tuna, Skipjack/Bonito	3.74	Canned
Tuna, Yellowfin	15.99	Fresh, Steaks
	9.76	Canned
Whelks		
White bass	3.99	Fresh, Fillets
Whitefish		
Yellow Pickerel		

For several species (Arctic char, flounder, lake trout, monkfish) the pricing information implies that the species is affordable. However, it is worth noting that these prices are per pound, for what is usually the entire fish. If a fish costs several pounds it may no longer be affordable, if the fish must be purchased whole.

The form of a food item has a significant impact on the pricing of that product. As seen in *Table 9*, some species are both affordable and not affordable (i.e. shrimp) based on the specific product (fresh/frozen/canned, species) available for pricing. In this analysis those species with an affordable option have been considered to satisfy this criterion, as the consumer is able to compare and contrast product prices in order to purchase the most cost effective alternative.

It should be noted that affordability was the section with the least consistent and available data. Price were obtained from online and a confidential retailer in Nova Scotia. Access to comparable prices across Canada or for species and forms that may be more or less available across the country were not considered. Additionally, food prices are highly variable based on seasonality, promotions, processing, availability and many other considerations. Prices may therefore be highly variable at different times. This is an important consideration as the species purchased, form, and cost may vary significantly.

The assessment of affordability was also complicated by Canadian food labelling regulations that provide accepted “common names” for fish and seafood. In many cases these common names (i.e. rockfish, shrimp, light tuna) are not specific enough to correlate to a scientific

species name. This leaves some vagueness in assessing the affordability of species as it can be difficult to discern which species is in the food product, for example "Tuna steaks" was a product name provided by the confidential food retailer. According to CFIA's *Fish List* over a dozen species of tuna can be labelled generically as "tuna". Thereby it is difficult to discern whether the listed price applies to all species that may be labelled as "tuna" or whether the price will vary depending on the different species.

Alignment of the Areas of Interest

Overall, the only species (or rather group of species) explored that appears to meet the criteria for all four areas of interest is clams, if they are farmed in Canada. The absence of a DFO assessment has been overlooked in this example, as the farming of shellfish is generally considered to be a sustainable activity if regulations are followed and DFO does not provide sustainability assessments for farming operations.

The remainder of the species assessed fail to meet the criteria for all, or even most of the areas of interest. *See Table 10 for full results table.* Hake, herring and shrimp all satisfied the human health, provenance and affordability criteria, but were not considered environmentally sustainable. While many species satisfied one or two areas of interest, the consequences of failing to meet the other areas makes the species either impractical to recommend or ignores the important consideration of whether it supports human and environmental health concurrently.

Table 10 Overall results. Green indicates that the criteria for the respective area of interest.

Fish	Identified in Health Recommendations?	Environmental Assessment Overall	Affordable?	Prov 1	Prov 2	Prov 3
Abalone		Y		-0.01	-0.01	0.06
Alewife		N		0.92	0.92	0.92
Anchovy	Y	N	N	-0.02	-0.02	0.24
Arctic Char	Y	N	Y (whole)	0.02	0.02	0.02
Atlantic Cod		N		4.97	4.97	5.59
Burbot		N		0.00	0.00	0.00

Capelin	Y	N		1.38	1.38	1.38
Carp		N		0.18	0.18	0.47
Catfish		N	Y	0.07	0.07	3.27
Clams / quahaug	Y	N, Y (farmed)	Y	11.46	11.46	12.50
Cockles		N		0.00	0.00	0.00
Cod		N	Y (whole)	-0.24	-0.24	3.68
Crab Dungeness*	Y	N	N	-0.05	-0.05	-0.01
Crab, Other	Y	N	N	-2.85	-2.82	1.29
Crab, Queen	Y	N	N	16.43	16.43	16.50
Crayfish		N		0.00	0.09	0.09
Cusk		N		0.01	0.01	0.01
Cuttlefish		N		0.00	0.00	0.22
Dogfish		N		0.03	0.03	0.03
Eel		N		-0.06	-0.06	0.22
Flounders	Y	N	Y (whole)	-0.86	-0.86	-0.86
Geoducks	Y (clams)	Y		-0.59	-0.59	-0.59
Greenland turbot		N	Y (whole)	5.72	5.73	5.76
Haddock	Y	N	Y	4.89	4.89	7.09
Hake	Y	N	Y	10.03	10.04	10.27
Halibut		N	N	-1.20	-1.20	-1.15
Halibut (Atlantic)		N	N	2.07	2.07	2.35
Halibut (Pacific)		Y	N	-2.59	-2.59	-2.05
Herring	Y	N	Y (whole)	27.10	27.10	29.50
Lake trout	Y	N	Y (whole)	4.46	4.46	4.55
Lingcod		N		-0.02	-0.02	-0.01
Lobster	Y	N	N	3.59	3.72	12.34
Lobster, Rock*	Y	N		-0.02	-0.02	0.09
Lumpfish roe		N		0.00	0.00	0.00
Mackerel	Y	N	Y (whole)	2.35	2.35	3.92
Monkfish		N	Y (whole)	0.00	0.00	0.03
Mussel	Y	N	Y	3.17	3.17	3.66
Ocean Catfish		N		0.00	0.00	0.00
Ocean perch		N	Y	-1.03	-1.03	-1.03
Octopus		N	Y	0.00	0.00	0.64

Oyster	Y	N	N	3.64	3.64	4.50
Patagonian toothfish		N		0.00	0.00	0.11
Perch		N		1.10	1.10	1.18
Pickerel		N		-0.29	-0.29	-0.29
Pike		N		0.41	0.41	0.41
Plaice		N		-0.13	-0.13	-0.13
Pollock	Y	N	Y	1.31	1.31	6.53
Redfish spp.		N		8.81	8.81	8.81
Rock bass		N		0.00	0.00	0.00
Sablefish		Y		-0.53	-0.53	-0.53
Salmon	Y	N		38.46	38.54	45.50
Salmon (Atlantic)	Y	N	Y (whole)	-26.31	-26.30	-23.17
Salmon, Chinook	Y	N	Y	-0.14	-0.14	0.03
Salmon, Chum	Y	N		-0.70	-0.69	-0.62
Salmon, Coho	Y	N	N	-0.92	-0.92	-0.61
Salmon, Pink	Y	N	Y (canned)	-0.18	-0.18	0.45
Salmon, Sockeye	Y	N	N	-0.33	-0.33	1.51
Sardine	Y	N	Y (canned)	-0.85	-0.85	0.41
Sauger		N		0.04	0.04	0.04
Scallop	Y	N	N	**15.06**	**15.07**	**16.35**
Sea bass	L	N	N	0.00	0.00	0.29
Sea cucumber		N		2.98	2.98	2.98
Sea urchin		N		1.03	1.03	1.06
Shad		N		0.01	0.01	0.01
Shark	L	N		0.03	0.03	0.12
Shrimp	Y	N	Y	11.79	11.80	28.95
Silversides		N		0.05	0.05	0.05
Skate		N		0.14	0.14	0.22
Smelt	Y	N	Y	0.23	0.23	0.23
Snails		N		-0.12	-0.12	-0.03
Sole	Y	N	Y	-1.13	-1.13	0.07
Squid		N	Y	0.08	0.08	3.35
Sturgeon		N		0.04	0.04	0.04

Sucker (Mullet)	Y	N	Y	0.60	0.60	0.60
Sunfish		N		0.02	0.02	0.02
Swordfish	L	N	N	0.18	0.18	0.24
Tilapia		N	Y	0.00	0.00	2.11
Tomcod		N		0.00	0.00	0.00
Trout	Y	N	N	-0.12	-0.11	1.36
Tullibee		N		0.12	0.12	0.12
Tuna	L	N	N	0.64	0.64	0.73
Tuna, Albacore		N	N	-0.27	-0.25	1.15
Tuna, Bigeye	L	N		-0.06	-0.06	0.23
Tuna, Bluefin		N		-0.10	-0.10	-0.01
Tuna, Bonito		N		0.00	0.00	0.00
Tuna, Skipjack/Bonito		N	Y (canned)	-0.03	-0.03	10.08
Tuna, Yellowfin		N	N	0.00	0.00	0.19
Whelks		N		0.00	0.00	0.00
White bass		N	Y	0.35	0.35	0.35
Whitefish	Y	N		0.34	0.34	0.34
Yellow Pickerel		N		2.22	2.22	2.22

Interestingly, some of the species that satisfied the provenance criteria and are available in Canada, may not actually be accessible when we consider the affordability assessment. Lobster, scallops, salmon, and crab all satisfy provenance criteria, but did not meet the affordability criteria. Therefore, while it may be available, it is not necessarily accessible for those who are seeking less expensive seafood options.

These results suggest that there is little alignment between the areas of interest explored in this research, and consequently, little alignment between human and environmental health. However, the paucity of data (demonstrated by the abundance of blank sections in Table 10, as well as each data table throughout the research) suggests that there are likely missed opportunities for aligning human and environmental health.

Chapter 4 Discussion

With only farmed clams satisfying all four areas of interest, hake, herring and shrimp satisfying three of the four areas of interest (notably not environmental sustainability) and the remainder of species and species groups meeting two or fewer criteria, the results show little alignment between the areas of interest. However, there are numerous areas where a paucity of data has prevented a complete analysis. The following chapter will present a discussion of some challenges that emerged throughout this research such as the dissociation of fish on our plates from those in the sea, data issues that complicated this research and other sustainable seafood work, the connection to sustainable food systems and finally, the downfalls of species failing to meet all criteria explored in this study.

Dissociating Fillets from Fish

Figure 5 Throughout the production cycle of fish and seafood it seems to be regulated first as a natural resource, then as a commodity and finally as a food item with little understanding that it is one and the same.

There is a disconnect between the discussion of fish as a natural resource, a tradeable and valuable commodity, and as a food product capable of nourishment and contributing to health (See *Figure 5)*. If we even consider the regulatory landscape for fish and seafood in Canada there is a mismatch of overlapping roles and responsibilities that spans many government departments from DFO, to Parks Canada, CFIA, and Agriculture and Agri-food Canada at the federal level, as well as provincial and territorial government ministries as well (for example

economic development and trade portfolios). Throughout the production process for fish and seafood it is treated as a natural resource first, to be managed and harvested for maximum yield and/or maximum economic gain. Then it becomes a commodity with specific marketing, value added services and industry promotion that takes place. Finally, once it arrives on the dinner plate fish is treated as food. Unlike other food commodities, fish and seafood represent a public resource, meaning that they should be managed for the benefit of the public. The disconnect between fish in the water and fish as food is concerning for the health and sustainability of our fisheries and our population.

The confusion and dissociation worsen when we shift to considering fish as food. CFIA provides a *Fish List* of acceptable common names for fish and seafood species. However, the required labeling for fish and seafood in most cases is not species specific. For example, there are over 100 species that can be labelled as rockfish, and handfuls of species that can be generically labelled as shrimp or as tuna. This prevents consumers, food service businesses, and retailers from making informed purchasing decisions where a variety of species with different sustainability rankings may be labelled with the same terms. Canada also does not require labelling of the fishing region, gear, or stock, but rather just the country of last major transformation (i.e. processing). Canada's food labelling and Shellfish Sanitation Programs have slightly more specific regulations for shellfish species including that the state and facility of production be regularly inspected and approved by Canadian standards (Safe Food for Canadians Regulations, 2019) and that the date and location of harvest be labelled on shellfish in case of contamination (CFIA, 2019). Other countries, such as those within the European Union (EU) require species level identification on fish and seafood products, in addition to details such as the gear used and location of harvest (European Commission, 2014). This implies that the connection between the fishery and the plate is possible, with the appropriate regulations.

In 2019, Canada released its first national *Food Policy for Canada.* Developed by Agriculture and Agri-food Canada, the policy is the first national example of integrating human and

environmental heath with considerations for sustainable food production, drawing the connection between fish in the ocean and on our plates. Interestingly, the policy provides one of the first examples of the explicit inclusion of fish and seafood in food policy in Canada, where it is often neglected or treated similarly to livestock production despite the clear differences in production methods and environmental impact. At present, the policy has identified Action Areas (help Canadian communities access healthy food, make Canadian food the top choice at home and abroad, support food security in Northern and Indigenous communities, reduce food waste) and Priority Outcomes (vibrant communities, increased connections within food systems, improved food-related health outcomes, strong Indigenous food systems, sustainable food practices, and inclusive economic growth) (Agriculture and Agri-food Canada, 2019). However, specific targets have yet to be established. Thus, it is difficult to assess to what extent the considerations for sustainable food production will permeate the policy and whether this will translate to a deeper understanding of the connection between the environment around us and what is on our plates. Ideally, the policy could be an opportunity for government and non-government bodies to reframe how we address food system issues to consider the interconnected and interdependent nature of our food systems, environment and social ecological systems.

Information Challenges

Data access and availability provided a challenge in each of the four areas of interest in this study. Data gaps were found in species level reporting of production and trade, sound justification and clarity in health guidelines, completeness and timeliness of sustainability assessments, national food pricing information, foreign and domestic trade data.

The disconnect between fish in the sea and on our plates, discussed earlier in this chapter, is seen in the information that is required by government agencies and international trade regulations, voluntarily disclosed by producers, processors and retailers at the trade and retail levels. In line with the precautionary approach, species level information should be used for fisheries management to ensure sustainable use of the resource and therefore should be

available for landings of those species. However, throughout this research a DFO employee email correspondence received from an @dfo-mpo.gc.ca email address, dated September 23, 2019, cited that they were not able to provide the species level information given the work required to collect it and concerns for protecting proprietary information of producers. Additionally, they clarified that groupings of species publicly available are “provided to users for convenience, and cannot be construed as a species, per se”. This raises concerns as the species level information should be used for management, and thereby should be accessible and not require excessive work to dig up. Landings and trade data both consist of aggregated categories of species such as “Flatfishes”, “Other Shellfish”, “Fish, Not Elsewhere Specified” or “Other”. This raises concerns about whether we know the status of these fish stocks and whether they are being sustainably exploited, as well as why this information is not available. Put candidly, why are the economic interests of industry members and expediency of management reporting put ahead of the needs and rights of Canadian citizens with respect to management of their public resource?

Health guidelines lack a strong justification for why each species is recommended for human consumption, with the exception of the species discussed in regard to high mercury content. Personal communication through e-mail correspondence with a Health Canada employee at an @canada.ca email address, received on October 2, 2019, indicated that the species listed are not an exhaustive list and are intended to provide some examples of species that are generally low in mercury and other contaminants and contain “higher levels of omega-3 fatty acids”. However, this is not made clear in health guidance documents, leaving the reader to determine for themselves whether the species listed are the most beneficial, a random selection of options or even a list in order of priority. This limits the consumers’ ability to make informed health and purchasing decisions as they may not clearly understand that species not listed in health guidance may be equally, or even more beneficial for health. Additionally, it represents a lost opportunity to promote local, available, and affordable options if they are not explicitly named.

The assessment of seafood species sustainability is complicated by incomplete sustainability assessments. DFO's Sustainability Survey for Fisheries only assesses a portion of the managed fisheries, based on criteria related to the cultural, economic and environmental significance of the stock (DFO, 2019). There are a number of active fisheries in Canada that are not included in the survey. Of those included in the 2017 survey, 59% (105 of 179 assessed stocks) lacked limit reference points, and 40% (73 of 179 assessed stocks) were assessed as "uncertain" due to a lack of relevant information (DFO, 2017). This illustrates a significant data gap in sustainable fisheries management. If we are not aware of the stock status, limit reference points or other information that impacts the stock health, we cannot be sure whether it can be sustainably exploited. Likewise, Ocean Wise does not have assessments for every species explored in this study. This does not mean that species lacking an assessment are not recommended, but rather that they have not been assessed. Without positive assessments from DFO and Ocean Wise species have been considered to be unsustainable, in line with a precautionary approach.

It is likely that some of the unassessed stocks and species discussed could be considered sustainably exploited, if the relevant up-to-date data were available to make that determination. Additionally, in some cases sustainability assessments can shift from positive to negative when new fisheries status information comes to light, for example Atlantic mackerel spawning stock biomass is estimated to be at 5% of the 1980's level, prompting concern about stock health (DFO, 2019c). However, Ocean Wise's assessment of Canada's Atlantic mackerel purse seine fishery preceded this information and therefore does not reflect the current status of the fishery (Lidgard, 2011). In order for an up-to-date understanding of the sustainability of food choices the data used to determine these criteria must also reflect the most recent information available. Practically, the demand on third party assessment bodies to maintain up to date assessments of fisheries is a large undertaking, and it is likely that some lag time will be inherent in the process given the data sources required and the volume of fisheries assessed.

Data around national variations in fish and seafood pricing, and thereby affordability, are not readily accessible. Neither the Consumer Price Index (*Figure 2*) or monthly retail pricing data

base (*Figure 3*) provided by Statistics Canada provide adequate information to support this analysis. Calculating the affordability is also complicated by the multiple methods that could be used, such as cost by weight, by nutrient density and by caloric density. Each of these methods presents its own respective challenges, such as varying nutrient profiles based on processing and form, processed verses raw weight, as well as pricing and availability variations across the country. While each of these methods would have challenges there are applications in which having the relevant information and being able to perform the respective analyses could contribute greatly to informing health and health equity recommendations and policy. A national database of food prices for a variety of fish and seafood (as well as other food items) would be beneficial in informing this section of the research.

Information around the landings of specific species and domestic movement of these products is not available and therefore despite recognition that Canada is a large country, interprovincial accessibility and provenance on a regional, provincial or local level cannot be assessed. In each of these areas greater data availability would enhance the potential to improve the alignment of the areas of interest to support affordable access to locally produced fish and seafood for healthy population and healthy food system.

Finally, the available trade data from Statistics Canada lacks completeness as there are categories that do not have a species associated with it. For example, “Fillets, of tilapias, catfish, carp, eels, Nile perch, snakeheads, dr[ied]/sa[lted]/brine, n[ot] smoked” is a specific trade code that is aggregated into an “Other freshwater fish” category for reporting. This prohibits a species level analysis based on trade codes. Additionally, there are different chapters of trade codes and as such some fish products may be imported under codes for related to the origin as an animal product, while others may be imported under codes related to processed food products which often lack any species identification at all. When we look at the provenance data as a whole, there are some clear issues due to the lack of complete species level data sets. For example, there are no reported landings volumes for sablefish. However, there is just over 1755 tonnes exported which indicates that there should be at least this volume recorded in the

landings data. It is possible that the sablefish landings are captured in one of the aggregated categories, however that is difficult to determine.

This lack of information raises concerns from a social, ecological and economic perspective. From a social perspective, the lack of awareness of whether fish and seafood are affordable speaks to an ignorance of whether those with varying degrees of food security can meet their health needs, as recommended by Health Canada. Additionally, the limited fish and seafood labelling requirements in Canada speak to a lack of information for consumers to make informed purchasing decisions and impact their food system, thereby eroding food sovereignty. From an ecological perspective, missing landings, species labelling, and trade information is contrary to the precautionary approach for fisheries management and undermines the sustainable management of these resources. Finally, from an economic perspective, there are likely missed opportunities for supporting Canadian production, maintaining the economic benefits of supporting local, smaller scale food systems, and seizing opportunities to exploit the economic benefits of Canada's fisheries if we are not aware of what species, and volumes are available, or what the opportunities for local markets are.

Sustainable Food Systems

More holistically, however, these concerns make it very difficult to implement sustainable food systems in Canada because they inhibit a complete and informed analysis of how best to align human health and environmental health.

Sustainable food systems have been proposed as a tool to produce the volume and quality of food needed to meet human health needs in a growing world. A key attribute of sustainable food systems is that they can continue to meet human needs for generations to come- to be sustained in order to sustain us. From a practical perspective, managing a sustainable food system would require knowledge of the resources within that system, the current activities of harvesting and production, the impacts of those activities and the capacity of the system to be sustained in those circumstances. Given the information challenges discussed above, we have some data gaps to address in order to support sustainable fisheries and food systems. How can

we ensure that future generations of Canadians will be able to meet their human health needs if we do not support the alignment of human and environmental health to build sustainable food systems that meet human needs now and in years to come? Furthermore, how can we hope to move beyond national food systems to support sustainable global food systems?

Policy and management decisions should be based on sound and accurate data. Without that information, decisions, even those made by best judgement, can have unanticipated negative implications. Thus, the alignment of human health and environmental health is difficult to assess in the face of data voids. However, this may present an opportunity to concentrate effort on ensuring that data are available and are considered in fish and seafood policy decisions.

The Risks of Missed Alignment of the Areas of Interest

If we return to *Figure 1,* and consider the overlapping and interconnected spheres of human health, environmental health, affordability and provenance of Canada's fish and seafood supply, this research has found these spheres to be rather siloed, with some overlap depending on the species under consideration, but only farmed clams falling within the ideal centre area, satisfying all areas of interest. This speaks to a failure of our food system, human health recommendations and fisheries management to align to support sustainable food systems that are able to produce the quality and quantity of food to meet human health needs. Species or species groups that satisfy only one or two criteria may address some aspect of healthy communities, a healthy society and sustainable food system, however, what is the cost of failing to meet the unsatisfied criteria? Perhaps all criteria except for sustainability are met, leaving the species to be unsustainably harvested to the detriment of the marine environment. If human health recommendations remain unmet the volume of fish and seafood consumed may be greater in order to meet EPA and DHA requirements, thereby increasing the burden on the fishery. If affordability remains unmet human health will suffer, as would the feasibility of local and domestic procurement. Finally, if provenance remains unmet then we must contend with the potential sustainability implications of a globalized seafood supply chain with less capacity to impact management and missed opportunities to reap the socioeconomic benefits of supporting local production.

The absence of fish and seafood species that satisfied the criteria for all four areas of interest, begs the question of whether the scope of this research is perhaps too broad, attempting to encompass and align too many variables. However, each of the areas of interest explored in this project are interconnected, each with its respective importance in considering the overarching research objective at the heart of this work. For example, if a species satisfies the criteria for all areas of interest except for affordability, would it matter that it is recommended for human health, is sustainable, and produced in Canada if it is not accessible from an economic perspective? This would lead to the health benefits of sustainable and local fish and seafood consumption to accrue only to the wealthy, thereby supporting an inequitable distribution of the health benefits of fish and seafood to those who already less likely to experience financial barriers to food security and consequently, less likely to suffer from the health implications of being food insecure. All four areas of interest must be satisfied in order to support health Canadian communities, to access affordable fish and seafood that has been sustainably produced and benefits social and economic wellbeing in their communities.

Chapter 5 Recommendations and Conclusion

To better take advantage of aligning human and environmental health in Canada, four main recommendations are summarized here: better labelling regulations, improved resolution of species' data, attention to emerging health implications and intentionally considering the sustainability of species listed in health recommendations.

Canada's Fish and Seafood Labelling Regulations

The analysis and evaluation of data in this project was complicated by the lack of transparency and labelling regulations in Canada's fish and seafood supply. The environmental sustainability of fish and seafood is dependent upon numerous factors, including the stock status and environmental impact of the fishing gear used. This information is not required for food labelling or seafood traceability in Canada, and therefore is not always accessible. This means that policy, regulations and those along the seafood value chain may lack motivation to source more sustainable options, unless there is sufficient market demand or other motivations to consider the sustainable sourcing of products.

There is opportunity for policy and regulations to require the labelling and traceability of fish and seafood to support sustainable sourcing, similar to the European Union regulations. However, current food labelling requirements in Canada require only the country of origin (read: last major transformation) for a fish or seafood product, with the exception of shellfish which must state where they were grown (CFIA, 2019). CFIA maintains the *Fish List* which specifies the English and French common names that may be used to label fish and seafood in Canada. However, these are not always species specific. For example, Alewife is correctly identified as a single species. However, "shrimp" may be used to label nearly a dozen different species, with varying production methods and sustainability rankings according to both DFO and Ocean Wise. There is opportunity for policy and regulation to require the fishing location, harvest method, and scientific species name either through food labelling, trade or food safety regulations, however there must be sufficient will and collaboration between government agencies to effectively implement this increased data requirement. If this information were

required on food labels it would support all actors along the supply chain to make informed, sustainable seafood sourcing decisions.

Improving Access to Species Specific Data

While it is possible, and even likely, that DFO has species level information on landings and trade of fish and seafood in Canada, this should be more readily accessible and transparently used in fisheries management. Personal communication throughout this research indicated that breaking down aggregated species categories would be too labour intensive; however, the argument can be made that effective and precautionary fisheries management would require that these data be known and considered in fisheries management decision making. The aggregation of species into groups creates sustainability concerns as species within each group may have very different health, stock status and rates of exploitation. In order to avoid this information obstacle species specific information should be available and used wherever possible. Where differentiating species is not possible a thorough analysis of the potential implications of grouping species should be considered. We can turn to the European Union as a starting example of what is possible with regards to species level information, as publicly available data for fisheries landings by member state includes options to report specific species, such as manila clam and solid surf clam with the scientific species name attached to the volume reported, as well as to report species groups such as Donax clams and hard shell clams (Eurostat, 2019). While there are still aggregate species groups reported, the resources are available to publicly report to the species level. Comparatively, clams are reported as a species group in Canada. Perhaps the EU could serve as an example to strive towards in building the options and potential for voluntary or regulated species level data reporting and availability.

Emerging Health Concerns

While Canada's health recommendations focus on avoiding mercury toxicity, there are other environmental contaminants that are of growing concern. Microplastics have been identified in marine animals and the marine environment, including in animals that are destined for human consumption. These plastics can attract and accumulate other pollutants such as persistent

organic pollutants (POPs), polychlorinated biphenyls (PCBs), polycyclic aromatic hydrocarbons (PAHs), and organochlorine pesticides (Smith, Love, Rochman & Neff, 2018). There is a growing body of literature on microplastics and the potential interactions with human health (Lu et al., 2019; Smith, Love, Rochman & Neff, 2018). Chemical contamination, such as flame retardants, has also been raised as a concern due to the similar characteristics that contribute to chemical accumulation and vulnerability to high fishing pressure such as larger, longer lived species (Noziglia, Abbott, Polidoro & Gerber, 2018). And most recently to the fish and seafood landscape is the issue of genetically modified organisms, specifically farmed salmon. Whether or not GMO salmon poses any health concerns or confers health benefits should be transparently communicated to consumers. This is an example where the alignment of human health and affordability may be a new opportunity, should GMO salmon be more affordable, not a health risk, and actually support democratization of an n-3 fatty acid source and the associated health benefits. Emerging health concerns should be explored thoroughly as more information arises and if necessary, be incorporated into health guidelines.

Aligning Human Health and Environmental Health

While the results of this study did not provide a clear subset of species that satisfy all, or even most, areas of interest, there is clearly potential and indeed opportunity for the alignment of human health and environmental health in recommendations, if we consider solely the human health and environmental health assessments. Through providing an arbitrary listing of species in health guidelines that tend to have high omega-3 fatty acid content and low levels of contaminants, Health Canada may be unintentionally shifting Canadians perceptions of what species are desirable to consume. By ensuring that those species listed on public guidelines have favourable sustainability assessments Health Canada has the opportunity to support human and environmental health.

There are further potential missed opportunities for aligning human health, environmental health, affordability and provenance of Canada's seafood supply as a result of the globalized nature and lack of transparency in the seafood supply chain. For example, Canada exports

1,755 tonnes of sablefish to foreign markets. As a fish that is high in n-3 fatty acids, sablefish could contribute to meeting human health needs in Canada. However, it seems that very little remains in the domestic market. Scallops are recommended in health guidelines, are available in provenance tier 1, and may or may not be sustainably harvested. If affordability were not a concern, scallops could satisfy the three remaining areas of interest, if the harvest method, location and species were labelled on the product. Additionally, a lack of traceability in the seafood supply chain may prevent consumers from procuring products, such as scallops, from closer geographic locations, such as across the Canada-U.S. border, rather than from the other side of the country. Shrimp is recommended in health guidelines, may be affordable, is available in provenance tier 1 and may or may not be sustainable based on both DFO and Ocean Wise's assessments. These are just a couple of examples where there are potential missed opportunities for alignment of human health, environmental health, provenance and affordability. With greater transparency and attention to the seafood supply chain the areas of interest may have opportunity to align more closely.

The varied results across the areas of interest suggest that it may be far-fetched to seek species that satisfy multiple areas of interest. It may be necessary to prioritize which areas of interest are most pressing, or personally relevant and base purchasing decisions upon the species that meet those key areas with the remaining areas of interest being considered as nice, but not necessary. For example, a consumer may value supporting their neighbour who fishes, over ensuring that the fishery providing their food is assessed as sustainable by Ocean Wise. Another consumer may not have the privilege to value provenance over affordability. Perhaps each consumer must base their purchasing decisions on their own values and priorities.

Conclusions

In conclusion there is little alignment between human health and environmental health recommendations for fish and seafood consumption, as policy currently stands and as information currently allows for analysis. It appears that, despite data gaps, there is potential for alignment between these areas. With a thorough analysis of each species recommended in

health guidelines against sustainability assessments it is possible to support health recommendations that are more conscious and supportive of fisheries sustainability and environmental health.

The areas of interest provide insight into the variety of challenges and opportunities to build and support local, sustainable food systems that support the health of Canadians and the environment. However, data availability prohibits a thorough analysis of how all species perform against these criteria, leaving consumers to determine which criteria are more poignant in their lives. Through addressing data gaps, a more thorough understanding of how human health, environmental health, provenance and affordability can align to support local, sustainable food systems and healthy populations can be explored further.

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