Assessment of the Necessity, Feasibility, and Potential Strategies for the Creation, Implementation, and Dissemination of Mercury-related Fish Consumption Guidelines in British Columbia

By

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B.A., The New School, 2001

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Abstract

Consumption of mercury in fish in the human diet can cause developmental damage in fetuses and young children, cardiac infarction and infertility in adult men, and neurological damage in people in general. British Columbia does not have fish consumption advisories for sport-caught fish and province-wide testing of fish-mercury levels has not been conducted. Yet preliminary tests show that certain sport-caught fish have mercury concentrations above Health Canada guideline for normal consumption by the general population. Government officials are aware of the potential health damage from mercury in sport-fish from BC, and preliminary research into the necessity of policy to protect fish consumers is being conducted. But, the research required to ground the policy making process has not been done.

There is a need for an assessment of the necessity, feasibility, and strategies for creating and disseminating freshwater fish consumption advisories in British Columbia. The objective of this project was to provide sound scientific research as part of the basis of policy development. I aimed to do this by evaluating what can be learned from a range of fish consumption policies in Canada and elsewhere to guide effective policy creation in BC, if it is deemed necessary. In addition, I assessed whether or not fish consumption advisories would be necessary to protect public health among a sport-fishing population on Elk Lake, Vancouver Island, by evaluating fish consumption, the state of mercury

knowledge among these fishers (current awareness), how mercury information reaches them (information flow), and how they use this information to make decisions about their diet (personal diet management).

I analyzed provincial strategies for the creation, implementation, and dissemination of fish consumption advisories and provided recommendations for BC. I advise that BC conduct one large-scale, province wide fish-mercury survey to ascertain if mercury levels are high enough to cause health concerns. If levels are above 0.5 ppm, guidelines should be instituted and advisories communicated using the Health Canada Tolerable Daily Intake levels. Stakeholder participation is required throughout the process to increase advisory and policy efficacy. I provide recommendations for contents and format of advisories.

I designed and conducted a survey to obtain demographic information, fish consumption behavior, sources of health information, and levels of concern and knowledge regarding mercury, as well as to assess the fishers' level of desire to know more about the benefits and risks of eating fish. Results showed that 40% of respondents constituted a "sensitive population" or could potentially feed fish to a sensitive family member. Half (49%) of those surveyed were concerned about mercury in fish and had a basic or advanced understanding of the issues. The majority of fishers (67%) wanted to know more about the risks and benefits of eating fish and would read a guide about mercury in local fish if it were available (79%). Almost everyone (93%) said they would follow fish consumption guidelines if they were available, while 36% said they would stop eating fish with any mercury in them at all. Fishers trusted "scientists" more than "the media" or "the government" to provide them with correct information and to have their best interests in mind.

Based on this research, fishers could be consuming damaging amounts of mercury if fishers and fish-mercury data in all of BC are similar to those collected for Elk Lake and Vancouver Island. Risk is higher for those individuals who consume fish regularly. I offer recommendations for next-steps and risk assessment. This project endeavors to further the formation of science-based policy. In addition to the fish-mercury data of the Ministry of the Environment, this research aims to provide the means and the methods for creating and disseminating fish consumption guidelines.

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Chapter 1: Introduction

Methylmercury is a neurotoxin that causes developmental delays in babies and young children, as well as neurological and cardiac damage in adults (NRC 2000). Incidentally, people ingest methylmercury mainly through the consumption of fish. Yet fish provide protein, calories, and omeg-3 fatty acids, which are beneficial for neurological development and cardiac health (Hunter *et al.* 1988; Olsen and Secher 2002). Different species, sizes, and populations of fish have different methylmercury concentrations. Methylmercury is only harmful when eaten in sufficient quantities, but the debate over how much is harmful, for who, and what harm methylmercury does, remains open within the scientific and political arenas. Some researchers feel that current reference doses are too restrictive and will keep people from eating a healthy amount of fish (Schoen 2004; Arnold *et al.* 2005). While others feel that reference doses are too lenient and could allow people to consume harmful amounts of methylmercury (Hightower and Moore 2003; Hightower 2004; Oken *et al.* 2005).

Fish consumers still need to know how much of which type of fish are safe to eat, so most governments have a system of regulating commercial fish and advising people on consumption of sport-caught fish. In Canada, the consumption of commercial fish is regulated federally by the Canadian Food Inspection Agency (CFIA). Fish are not sold unless their muscle, the portion humans generally eat, contains less than 0.5 μg of mercury per g of fish (ppm). Certain older, larger species such as tuna, shark, mackerel, and tilefish generally contain more than 0.5 ppm mercury, but are considered delicacies eaten infrequently enough to be safe. Sport-caught fish regulation is the responsibility of the provinces. Most provinces have freshwater fish consumption guidelines to inform fishers of lakes, fish species, sizes, and amounts that are safe to eat, as well as advisories to communicate this information. Yet British Columbia (BC) does not presently have fish consumption guidelines. This is based partially on the unwritten assumption that BC has lower fish-mercury concentrations than do other provinces, as well as the fact that BC does not have a protocol in place for testing fish and communicating information to residents.

The provincial government of British Columbia is looking into the necessity of developing fish consumption guidelines for sport fish consumers in the province. There are many factors to consider and test in order to ascertain whether fish consumption guidelines are necessary, and how to create and communicate them if they are required. This research looks at two aspects of developing and communicating mercury-related fish consumption guidelines for freshwater sport fish: policy formation, and the communication of guidelines to fish consumers through advisories.

1.1 Thesis Structure Summary

1.1.1 Introduction: Summary

The introduction of this thesis provides the background information necessary to appreciate the research presented in Chapters 2 and 3. Basic information on mercury and its biological process are provided and its prevalence in British Columbian fish discussed. The issues surrounding fish consumption guidelines are discussed and assessed, providing recommendations for the format and presentation of advisories in British Columbia, should they be found necessary. Objectives are stated.

1.1.2 Chapter 2: Summary

Chapter 2 is an exploration of the policies and protocols used to create and disseminate fish consumption guidelines and advisories in Canada and elsewhere, with the aim of providing recommendations for British Columbia. The present lack of fish testing and guidelines in BC is explained, and knowledge gaps are illuminated. Basic information on what mercury does to people and the health benefits of eating fish are presented. Then, the scientific uncertainty surrounding the points at which mercury harms people and the translation of those points into to Tolerable Daily Intake (TDI) amounts used in policy formation are investigated. The origins and complexities of the TDI's of the World Health Organization, Canada, and the United States are discussed and recommendations are made for their application in BC. Next, the provincial strategies for creation, implementation, and dissemination of advisories are provided and analyzed for their strengths, weaknesses, and applicability to potential protocols in BC. Protocols in

the United Stated are provided for comparison. The discussion lays out recommendations for the creation of science-based policy for fish consumption advisories in BC.

1.1.3 Chapter 3: Summary

Chapter 3 contains the methods, results, and discussion of the survey of sport-fishers on Elk Lake. The Methods section discusses the rationale and processes used to create the Elk Lake study design. Justifications for the structure of the study and the population selection are provided. Potential survey methods are explored and chosen options are justified. Drawbacks of these methods are discussed. Results for fisher demographics, fishing behavior, and fish consumption are presented, as are fishers' levels of health risk, concern regarding mercury, and knowledge of the issues. Methods of receiving information that are preferred and used are described. The Discussion section synthesizes these data to paint a portrait of one fishing population in BC and analyzes how fish consumption guidelines would be useful to them. Pathways of information transfer are recommended.

1.1.4 Chapter 4: Summary

The Summary of this thesis reviews the major findings, study limitations, and future directions from this research. Conclusions and results from all three chapters are combined to provide clear recommendations for the necessary steps for assessing if fish consumption advisories are necessary, calculating guidelines, creating advisories, and disseminating information within British Columbia

1.2 An introduction to mercury

1.2.1 What is mercury?

Mercury (Hg), in its pure state, is an elemental metal and the shiny silver fluid metal we are all familiar with. It is naturally occurring and is released into the environment through volcanoes, the weathering of rocks, natural mercury deposits, and volatilization from the ocean. The fumes of elemental mercury are harmful to humans, but interestingly enough it is not very harmful to eat mercury as the gut is an effective

lining that does not allow for the transfer of mercury into the blood. Mercury becomes most harmful for human ingestion when it is methylated into methylmercury, which will be discussed further on.

Humanity has had a long and tragic history with mercury. Both King Charles II and Isaac Newton were thought to have died trying to make gold using mercury (Johnson and Wolbarsht 1979). People all over the world still use mercury in the process of gold mining, as mercury and gold form a relatively insoluble bond. Mercury was used to treat constipation in the 19th Century (Mayell 2001); in severe cases, two pounds were ingested. Mercury was thought to cure syphilis (Sartin and Perry 1995) and archeologists used mercury traces to find the army camps of Lewis and Clark (Schwarz 1998) . Mercury was used to remove fur from pelts for felt hats (hence the origin of the term "mad hatter"). Organic methylmercury (MeHg) was used as a fungicide for grains up until the 1960's when it was found to be toxic and subsequently became very cheap (Clarkson and Strain 2003). In 1970's, a massive shipment of wheat was sent to Iraq with the fungicide on it, resulting in the deaths of 10,000 people and severe brain damage in 100,000 more (Bakir *et al.* 1973). Organic mercury was and is still used as a preservative in vaccines. There have been links with these vaccines and autism, but the connections are still being debated (Lee *et al.* 2003). Mercury is in the coal that is burned in coal-fired power plants all over the world, as well as the in the homes of many, many Asians (Bradsher 2006). Mercury is still mined for chemical purposes; most of it goes to the chlor-alkali industry where liquid mercury is used to produce chemicals like chlorine and odium hydroxide. Companies are phasing out the use of mercury to produce plastics, drugs, perfume, and other chemicals, but it is still used. In Japan, from the 1930's to the 1950's, a chemical company dumped its wastewater into the bay of Minamata (Clarkson and Strain 2003). This resulted in "dancing cat" disease as it was first called in the early 50's. Soon thousands were sick, dying, and giving birth to tragically deformed and neurologically damaged children (Harada 1995). Mercury is used in skin-lightening soap in Africa (Harada *et al.* 2001) and teething powder for infants (Counter and Buchanan 2004). Amalgam fillings are 50% mercury. Ten fillings will raise your urinary mercury level by 1 μg Hg/L (Kingman *et al.* 1998). This can be further increased by the chewing

of gum. Scientists suggest those with many mercury fillings should avoid "excessive chewing" (Sallsten *et al.* 2002).

1.2.2 Mercury in ecosystems

1.2.2.1 Pathways of mercury into aquatic environments

Mercury can become vaporized or aerosolized through incineration, then transported atmospherically around the earth. Natural processes such as volcanic activity account for only 30% of the 5,500 metric tons of mercury released into the atmosphere each year (UNEP 2002). Anthropogenic industrial activities such as coal-fired power plants, waste incineration, and chlor-alkali production release the majority (70%) of mercury to the environment. This is increasing by anywhere from 0.6% to 8% each year (Mason 1994; Fitzgerald 1995; Glass and Sorensen 1999).

Once airborne, mercury becomes vapor or attaches to airborne particles. It follows wind paths and can return to the terrestrial and aquatic ecosystems via rain, fog, and dry deposition (Figure 1.1). Because of atmospheric transportation, mercury contamination has been found in pristine arctic lakes far from industrial activity (Blais 2005).

1.2.2.2 The process of bioaccumulation

Most mercury in aquatic environments is in an organic compound called methylmercury (MeHg). Methylation occurs when elemental mercury enters aquatic ecosystems from rain, erosion, or runoff. In the anaerobic (low oxygen) environments common to lake bottoms, sulfur-reducing bacteria methylate mercury through respiratory metabolic processes. However, this process is only partially understood (Benoit *et al.* 2003). Methylmercury binds tightly with proteins and can be more easily assimilated by phytoplankton and zooplankton to travel up foodwebs (Figure 1.2). Because it is the decomposition of organic material that causes anaerobic environments, it is common for fish in newly flooded reservoirs to have elevated levels of mercury (Hall *et al.* 2005). Yet, there is evidence that these elevated levels will often normalize after a period of about 20 to 30 years (Hall *et al.* 2005).

Methylmercury will bioaccumulate when organisms consume it at a greater rate than they can depurate it. The majority of total mercury (>90%) in fish is usually

methylmercury, so "mercury" and "methylmercury" are often used interchangeably in the literature (Scheuhammer *et al.* 1998). Unlike other pollutants, such as PCBs, mercury is stored in fish muscle, and removal of fat will not make fish safer for consumption.

Three important factors that affect mercury bioaccumulation in aquatic organisms are: the amount of methylmercury in the environment, the length the food chain, and how much the organism has eaten. Food chain length and complexity are essential for estimating mercury content because mercury concentrations will increase at successively higher trophic levels of a foodweb (Cabana *et al.* 1994), a process called biomagnification. If a lake has bass (*Micropterus dolomieu*) that eat perch (*Perca flavescens*) that eat minnows (*Cyprinidae*) that eat *Daphnia* spp. that eat algae, the bass will have more mercury than if their diet consisted of minnows alone. It follows that pisciverous fish generally have more mercury than planktivorous fish: because methylmercury is retained by organisms the more of it that is eaten the higher the mercury concentration. Further, because larger and older fish have generally eaten more than others, they usually have higher mercury concentrations than smaller younger fish (UNEP 2002; Weech *et al.* 2004). However, this is not always the case, as fast growth rates can biodilute mercury in the muscle of fish as well (Stafford and Haines 2001). Stocking large, long-lived, pisciverous fish can create high mercury concentrations for sport fishers if they are not fished out fast enough. Bottom feeding has not been shown to be a factor affecting mercury concentrations in freshwater fish due to the low trophic level of invertebrates that benthic fish often consume, as well as the colder temperatures of benthic environments (Tremblay 1999; Kidd *et al.* 2003).

Lakes possess measurable characteristics affecting mercury methylation and bioaccumulation rates. Identifying these factors can aid in detecting which lakes could have high fish-mercury concentrations (Downs *et al.* 1998; Mason *et al.* 2000). Higher water temperatures increase fish metabolic rates, which increase consumption of mercury. Warmer waters also increase mercury methylation rates (Fagerstr and Jernelov 1972; Bodaly *et al.* 1993) and decreases mercury demethylation (Schindler *et al.* 1995). Dissolved oxygen in water will decrease at higher temperatures and increase anaerobic environments, which, in addition to higher methylation rates, will increase the amount of mercury released to the water column from the sediments (Henry *et al.* 1995). Acidic

water (low pH), which can be the result of watershed logging (Garcia and Carignan 2000), leads to an increase in methylation rates, a higher rate of release of methylmercury from sediments (Wiener *et al.* 1990; Mason *et al.* 2000), and the absorption of mercury to humic substances (Lindqvist *et al.* 1991). Highly acidic lakes often have low productivity, and fish often have lower growth rates, resulting in greater bioaccumulation per organism. Increased Dissolved Organic Carbon (DOC) in a lake increases fish-mercury concentrations by decomposing and increasing anaerobic environments, darkening the water and decreasing mercury photo-degradation (Sellers *et al.* 1996), and providing the humic matter for methylmercury to bind to (Watras *et al.* 1998). Yet high DOC can also increase lake productivity, which can increase plankton densities, which will lower fish-mercury concentrations by biodiluting available mercury (Chen *et al.* 2005). Aquatic systems can have high DOC as a result of runoff, watershed logging, and reservoir creation or water level raising. Lakes with a high percentage of wetland often have high DOC and low pH. Smaller lakes seem to have higher fish-mercury concentrations (Bodaly *et al.* 1993; Greenfield *et al.* 2001) because of their higher temperatures and influx of organic material as a percentage of lake volume (Greenfield *et al.* 2001). Forestry practices such as logging have been shown to free methylmercury and mercury from soils, making it available to runoff into lakes (Porvari *et al.* 2003) and significantly increase fish-mercury concentrations (Garcia and Carignan 2005). Proximity to a coal fired power plant, waste incineration site, chlor-alkali plant, or pulp mill can all increase mercury concentrations in fish (Horvat *et al.* 2003).

1.3 Mercury in British Columbia

The lake characteristics described above have made for potentially high fish-mercury concentrations in most of the central and eastern Canadian provinces, prompting the institution of regular lake testing and consumption advisories for sport-caught fish. However, for a variety of founded and unfounded reasons, health officials in British Columbia have not yet concluded that fish consumption advisories are necessary. British Columbia has far less industry than do provinces like Quebec and Ontario, making for fewer coal fired power plants, waste incineration, mining activities, and thus less local mercury deposition. Prevailing Easterly wind currents take atmospheric mercury

eastward, so that the bulk of the atmospheric mercury from North America falls on eastern provinces (USEPA 1997). However, this does not mean that fish in BC are always safe for frequent consumption.

Testing of known contamination sites such as near-mine lakes and reservoirs have resulted in fish consumption advisories for three lakes in BC (MoE 2001); some lakes contain fish twice the Health Canada guidelines. While province-wide tests have yet to be done, recent research at the University of Victoria uncovered certain lakes with fish over the Health Canada guideline of 0.5 ppm (Deagle and Mazunder unpublished data, Figure 1.3). These data prompted the Ministry of the Environment to conduct pilot testing of southern lakes to assess if thorough province-wide fish-mercury testing and guidelines are necessary. Preliminary results show that five out of the eight Vancouver Island lakes tested had fish (> 1 kg) over the Health Canada guideline (Epps *et al.* unpublished data, Figure 1.4). If sensitive populations like pregnant women and children are eating certain species of these fish more than once per week, health damage could occur. Sport fish consumers could be suffering health damage if fish out of these lakes are being regularly eaten, or if other untested lakes have similar mercury concentrations. This will be discussed more throughout Chapter 3.

1.3.1 The potential for increase

In addition, the amount of mercury in fish could be on the rise in BC, as in the rest of the world, as climate change warms waters; which could increase algal abundance, which could increase anaerobic environments due to decomposition (Schindler *et al.* 1995). The result would be more mercury methylation and thus more methylmercury in the foodweb (Booth and Zeller 2005). On the contrary, increased algal abundance could decrease mercury biomagnification due to biodilution (Chen and Folt 2005). Watershed disturbances might increase mercury in BC fish as well. Logging has been shown to increase mercury and methylmercury levels in lakes (Garcia and Carignan 1999) and in fish (Garcia and Carignan 2000). Logging and development disturb sediments, uprooting mercury in the soile, which is transported to lakes (Porvari *et al.* 2003) through increased runoff. This process will also carry organic material into lakes creating larger anaerobic environments for methylation (McMurtry *et al.* 1989). The introduction of non-native

species might also increase fish-mercury concentrations by altering foodwebs and introducing longer-lived fish.

1.3.2 Species of concern

British Columbia is well known for its abundant fisheries, that contain many species presently having or developing mercury concentrations harmful to health. In BC, native char (*Salvelinus malma*) are large, long-lived piscavores that could contain high mercury concentrations. They are also commonly fished by sport fishers and subsistence fishers alike. Pike (*Esox lucius*), largemouth and smallmouth bass (*Micropterus salmoides* and *Micropterus dolomieui*), lake whitefish (*Coregonus clupeaformis*), burbot (*Lota lota*), and walleye (*Stizostedion vitreum*) are all pisciverous species with the potential for elevated mercury levels. Smallmouth bass have been found with elevated concentrations of mercury due to their high trophic level, even though they are not as long lived as certain salmonids (e.g., lake trout) and eat low-mercury invertebrates as well as fish. Although sought by sport fishers, smallmouth bass are an introduced species and efforts are made to limit their distribution. Certain yellow perch (*Perca flavescens*) populations in lakes on Vancouver Island and surrounding islands have shown elevated mercury concentrations. This is unexpected given their small size, short life span, and low trophic level. But because they are introduced, catch limits are high, if present at all. Stocked fish, like rainbow trout (*Oncorhynchus mykiss*), in well-fished lakes are not usually of concern because their diets at fish farms do not seem to contain high levels of mercury. They also seem to be fished before they can accumulate any mercury from the lake they are stocked in. Rainbow trout and lake trout (*Salvelinus namaycush*) in unstocked lakes may accumulate elevated concentrations of mercury. Sterile triploid brook trout (*Salvelinus fontinalis*) and rainbow trout will soon be stocked in BC lakes that lack spawning habitat (Down 2005). Because adults do not spawn or stress about spawning in environments not conducive to it, they live for several years longer than non-altered trout and may accumulate higher concentrations of mercury. This may not constitute a problem because triploid fish might be fished out of the lakes before they have had a chance to accumulate harmful levels of mercury. However, this will depend on fishing pressure and fish size when stocked (Down 2005). While overall fish-mercury

concentrations in BC are lower than in easterly provinces, the risk is still present but remains to be fully evaluated.

1.4 The science behind effective fish consumption advisories

1.4.1 What are fish consumption advisories?

Fish consumption advisories are the primary means of reducing human exposure to mercury (Anderson *et al.* 2004). Governments prefer relying on fish consumption advisories rather than reducing contamination because health problems are decreased while high-priced clean up costs are avoided (Jakus *et al.* 1998). In the case of mercury, clean up might not be possible without large-scale shifts in watershed management and power generation. Some advisories can be as simple as a list of recommended meal frequencies for specific fish species in specific lakes, whereas others can include educational information on the benefits of eating fish, the way mercury harms the body, and even the basics of bioaccumulation, as well as specific consumption amounts for various weights, ages, and sensitivity groups of fish consumers. It is the mandate of most risk assessors and communicators to provide people with information on the risks and benefits of fish consumption so that they can make their own informed decisions (Wheatley and Paradis 1996; Egeland and Middaugh 1997). Risk management is defined as "the process of identifying, evaluating, selecting, and implementing actions to reduce risk to human health and to ecosystems. The goal of risk management is scientifically sound, cost effective, integrated actions that reduce or prevent risks while taking into account social, cultural, ethical, political, and legal considerations;" it assumes that, if given enough information, the public will act to minimize risk (P/CCRARM 1997).

1.4.2 Do people follow fish consumption advisories?

1.4.2.1 People follow advisories

Some surveys have found positive results to fish consumption advisories. In a phone survey Jakus *et al.* (1997) found that American anglers said they would fish in a reservoir with no advisory over a reservoir with one. Burger (1991) found that fishers in

Puerto Rico said they would follow an advisory if they were aware of it. Velicer and Knuth (1994) also found that certain New York groups using Lake Ontario indicated that they would limit consumption of contaminated fish and Fiore *et al.* (1989) reported that 50% of Wisconsin anglers surveyed indicated they did limit fish consumption due to an advisory distributed with fishing licenses. Oken *et al.* (2003) found that women decreased all fish consumption (including low mercury fish) after a national mercury advisory was released in the USA, indicating that their behavior was affected by advisories, whether it was beneficial or not. Fitzgerald *et al.* (2004) found that 90% of pregnant Mohawk women had heard of advisories and 40% reduced their fish consumption as a result. Other researchers have also suggested that women might be more inclined to modify consumption while pregnant (Soumerai *et al.* 1992; Oken *et al.* 2003). However, outside of these last studies, most researchers report that fishers indicate an intention to limit fish consumption of contaminated fish after an education session or during a survey, but do not test if fishers actually act on this intention (Burger and Gochfeld 1991; Velicer and Knuth 1994; Jakus *et al.* 1998; Burger *et al.* 2003).

1.4.2.2 People do not follow advisories

Fish consumption advisories are voluntary and allow people to make their own informed decision about risk exposure. This can be at odds with reducing public health risk as people may not obey the advisories even if they have been successfully communicated and understood (Connelly and Knuth 1998). For the advisory to be effective it must also result in people avoiding contaminated fish, while maintaining the same overall consumption levels by opting for low-mercury fish. People are complex and do not always perceive risk in the same ways. Policy makers, specialists, and even different groups of fishers all see the risks and benefits of eating contaminated fish differently (Burger *et al.* 1999b; Burger *et al.* 2001b). There is little research that tests how fish consumption advisories effect sport fisher consumption directly, and there is ample evidence showing that anglers who know about advisories continue catching and eating contaminated fish (Reinert *et al.* 1991; 1993; Velicer and Knuth 1994; Fleming *et al.* 1995; May and Burger 1996; MacDonald *et al.* 1997; Burger *et al.* 1998; Pflugh *et al.* 1999; Burger 2000a; Campbell *et al.* 2002) The creation and dissemination of fish

consumption advisories can be insufficient or ineffective for inducing risk-reducing behavior. This could be the result of scientific uncertainty, inadequate comprehension of the target audience, poor communication, varying risk perceptions, and simple human bahavior.

1.4.2.3 The role of knowledge

The majority of fishers in the studies listed above who knew of advisories, knew of their existence but did not have accurate information. There are few studies analyzing the contaminated fish consumption of anglers who had accurate and complete information about mercury. In a study of anglers in a contaminated estuary, Burger *et al.* (2004) found a negative correlation between knowledge of advisories and the amount of fish and crabs consumed. People who ate no fish or crabs had the highest level of knowledge, which implies an effective advisory. But the majority of the people who ate the most fish knew of the advisories. Human behavior is extremely complex, and there is no single failsafe method of inducing change in fish consumption, even when laws and fines are in place (Burger 2004). In a survey of risk communication experts, respondents said evaluating risk communication was among their top three priorities (Chess *et al.* 1995a; Chess *et al.* 1995b).

1.4.2.4 Risk perception: Optimism, confidence, and trust

An important factor in compliance with an advisory is risk perception. If fishers do not see contaminated fish as dangerous they will ignore the advisory (Belton *et al.* 1986). But fishers will also sometimes ignore advisories even if they do recognize that the fish is dangerous and do perceive a risk (Belton *et al.* 1986). This may be partially caused by optimism, a trait that has been found to increase longevity (Weinstein 1989), but may also have other deleterious effects. People generally think they are more likely to experience positive things and less likely to be affected by risk than their peers (Weinstein 1989). This optimism is highest in the face of risks when people have little personal experience or knowledge (Weinstein 1989), but the public seems to rely on trusted sources for making judgments about risks and benefits only when personal knowledge is lacking (Siegrist and Cvetkovich 2000). This may be a Catch-22 where fishers will only listen to authorities for fish consumption advice in situations where they

are least likely to follow this advice (i.e. they have little personal knowledge of the situation).

Fishing is an arena in which most fishers feel confident in their knowledge (Belton *et al.* 1986), often turning to each other for information over "expert" sources (Belton *et al.* 1986; Pflugh *et al.* 1999; Jack *et al.* 2003). Social trust in both institutions and people as "experts" is important in reducing the complexity of risk decisions (Siegrist and Cvetkovich 2000). People have trust in others holding similar salient values (Siegrist and Cvetkovich 2000) and there can be a distrust of the government present (Slovic 1993; Burger 2004). Because the harm of mercury damage is not readily apparent (Burger 2000a), fishers will often reject advisories, believing that if the fish were contaminated, they would be able to tell (Belton *et al.* 1986; Burger *et al.* 1993; Fleming *et al.* 1995; Pflugh *et al.* 1999), and that the fish they catch themselves are safer than fish from a store (Burger 1998a). This confidence can make fishers underestimate risks, even when they are high, and reject advisories. The stronger a person's views are, the more resistant they are to change even when new evidence is presented (Slovic 1987). Due to of these issues with fishers and advisories, I measured the knowledge level of fishers, their confidence in their knowledge, and their concern levels to help assess whether they would reject advisories if presented with them.

1.4.2.5 The role of personal choice and potential benefits in risk assessment

People also choose optimism in the face of hazard when risks can be controlled by personal action, such as a dietary shift (Weinstein 1989). This is because people accept risks that they themselves have chosen (Slovic 1987), and eating fish is one of those risks. The Slovic Paradigm states that people view risks that they can't control as more severe than ones that are familiar and that they can control (Burger *et al.* 1997). In addition, when an individual has personal knowledge of a hazard, they feel that they do not need to rely on authorities (Siegrist and Cvetkovich 2000). Changing high risk behavior in people when they perceive that risk as familiar (such as eating fish) is very difficult (Slovic 1987; Weinstein 1989).

Fishing is an important social and cultural activity that many people engage in for recreation and relaxation as much or more than to catch fish to eat (Toth and Brown

1997; Burger 2002a). Licensed fishers in BC said they fished to be in nature, to relax, to get away, for the challenge, to encourage family togetherness and companionship more than to catch fish to eat (Jack *et al.* 2003). Many fishers feel that the risks of eating contaminated fish pale in comparison to the inexpensive caloric source and health benefits of self caught fish (Toth and Brown 1997). There are so many benefits to fishing and fish consumption that people choose to ignore the risks (Burger *et al.* 1998; Burger 2000a). People's perception of risk generally diminishes when they perceive the benefits of an activity as being high and risks low (Slovic 1987). A study of lake Ontario fishers revealed that when health risks were high, most respondents would eat less fish regardless of the benefit level, but when risks were low, most of the change in fish consumption was related to benefit level (Knuth *et al.* 2003). Fishers who perceive low risk are also more confident than those who experience moderate or high risk, which suggests that risk communicators should focus on fishers with elevated risk perceptions; these individuals would be more likely to change behaviors (Knuth *et al.* 2003) and advisories would be more effective.

In my research I measured the perceived benefits that fishers on Elk Lake associated with fishing, as well as their perception of risk. This will help indicate how likely it is that fish consumption advisories will go unheeded. A perception of high benefits and low risk may reduce fishers' compliance with fish consumption advisories.

1.4.3 **Creating and communicating effective fish consumption advisories**

1.4.3.1 The way the advisories are formed impacts their effectiveness

The formation of the advisories is critical for gaining validity among fishers. Fishers in the United States have shown a distrust of government advisories and the government in general (Burger 2004), which may or may not be the case in Canada, and this can cause them to dismiss advisories (Siegrist and Cvetkovich 2000). Including fishers in the advisory formation process by soliciting feedback and incorporating concerns can legitimize advisories and increase compliance (Burger 2000a; Burger *et al.* 2003). In a survey of risk communicators, it was found that involving communities in agency decision-making was their top priority (Chess *et al.* 1995a; Chess *et al.* 1995b).

Differences in the ways that the fishing public and the advisory agencies see risks and benefits suggest that target audiences be consulted and their recommendations considered (Velicer and Knuth 1994). Integrated management and open communication among all stakeholders is key. Burger *et al.* (2003) conclude that it is not so much about reaching target audiences, as it is about communicating with them. This highlights the importance of consulting with local fisherman such as those on Elk Lake during these beginning stages of advisory formation in BC. By doing so we will be able to get a general idea of their concerns, desires, sources of trust and communication for incorporation into advisories if they are deemed necessary.

1.4.3.2 The importance of the demographic of the target audience

It is imperative that communications take into consideration the diversity of the target audience (Connelly and Knuth 1998) and various ethnic, income, geographic, gender, and educational groups have messages tailored to them (Belton *et al.* 1986; Velicer and Knuth 1994; Burger *et al.* 1999a; Pflugh *et al.* 1999; Chess 2001; Burger 2002a; Burger *et al.* 2003; Knuth *et al.* 2003; Chess *et al.* 2005). Segmenting audiences regarding information needs and communication formats may help clarify which approaches to take with each audience (Connelly and Knuth 1998). Approaches like this have been proven more effective in communicating risk and inducing behavioural change (Tilden *et al.* 1997; Connelly and Knuth 1998; Burger *et al.* 2003; Fitzgerald *et al.* 2004; Ashizawa *et al.* 2005; Chess *et al.* 2005). Due to economic and resource constraints, it often makes sense to assess which groups are most at risk and create messages targeting them (Velicer and Knuth 1994; Fleming *et al.* 1995; Tilden *et al.* 1997). Often low income groups, low education groups, and various ethnic minorities will have lower awareness of advisories than others (Fleming *et al.* 1995) and will sometimes eat more fish (Fleming *et al.* 1995). In the aforementioned survey of risk communicators, communicating with communities of different races, ethnic backgrounds, and incomes was their second priority for further research (Chess *et al.* 1995a; Chess *et al.* 1995b).

Due to the statistical limitations in my research of a sample size of 99 fishers, it is not likely that distinct groups who require distinct communication techniques will be apparent with the Elk Lake data. This lack of specification is one of the limits of this

research. If advisories are found necessary, then further research should be done on a wider scale to discern which groups require information and the best ways of reaching them.

1.4.3.3 The importance of the presentation style of the communication

The way in which advisories are presented is also vital. Government communications can be bland, generic, and too complex for easy interpretation (Chess *et al.* 2005). Grunig *et al.* (2002) found that the higher status communicators are, the harder it is for them to effectively communicate to the public. Velicer *et al.* (1994) discovered that risk communicators and target audiences have different ideas regarding what and how risk information should be presented. They recommend that audience preferences should be taken into consideration. Burger *et al.* (2003) also make this recommendation. In a study of various types of risk communication, Connelly (1998) found that for most audiences a cajoling rather than commanding tone better reached participants, and that a combination of both qualitative and quantitative information and both diagrams and text is most effective (Burger *et al.* 2003).

Knuth *et al.* (2003) found that risk perception is so sensitive to wording that it can change when the word "risk" comes before the word "benefit" in a brochure, and vice versa (Knuth *et al.* 2003). Others have reported that respondents were more moved by risk-risk comparisons (the risks of junk food versus the risk of fish) than by risk benefit comparisons and fishers indicated that this would increase their confidence in health decisions by putting them into perspective (Reinert *et al.* 1991). Some advisories are written so as to not alarm the public and this might allow them to misinterpret the message (Burger 2000a).

If advisories are created for British Columbia, communicators must insure that they are written in a language fishers can understand and presented in a format that is interesting, enticing, and comprehensive. Advisories should emphasize the benefits of fish consumption without downplaying potential harm, as well as present fishers with comparative risks to the fish they are eating.

1.4.3.4 Choosing effective channels to communicate to the target audience

Often, risk communicators will make a pamphlet, distribute it with fish licenses, send out some press releases, assume the public has heard it, and hope for the best (Burger *et al.* 1993). But not all people are licensed or read pamphlets (Pflugh *et al.* 1999; Burger 2000a; Beehler *et al.* 2002; Burger *et al.* 2003; Chess *et al.* 2005), and press releases often do not end up as news articles (Chess *et al.* 2005). One study of licensed anglers on the Great Lakes found that only 37% of people who bought fishing licenses actually fished in a given year (Connelly *et al.* 1999). In a government survey, only 40% of BC anglers indicated that they use the regulations as a source of information for fishing in BC (Jack *et al.* 2003).

Conventional communications methods such as licenses and media usually result in about half of anglers having some knowledge of the advisory, and far less having correct knowledge (Belton *et al.* 1986; Tilden *et al.* 1997; Burger *et al.* 1998; Jakus *et al.* 1998; Burger and Waishwell 2001; Imm *et al.* 2005). However, sometimes conventional methods can be effective: in a study in which 50% of anglers comprehended advisories correctly and followed the advice, advisories were communicated through fishing licenses, media press releases, posters at bait and tackle shops, and signs at fish cleaning stations (Fiore *et al.* 1989). When fishers were presented with an educational pamphlet and questioned directly after, most people were able to recall information correctly (Burger and Waishwell 2001). A study on aspirin use showed that changes in health related behaviors do occur when advisories contain a simple message regarding a potentially serious condition and are well publicized through media coverage that reaches both health care providers and the public (Soumerai *et al.* 1992). However, aspirin use does not have the same nutritional, cultural, and recreational associations that fishing does. Classroom workshops worked better than a brochure to inform women of childbearing age and induce a desire to change diet (Burger *et al.* 2003), but methods like this are costly, require many trained professionals, much time, and reach only a small number of people at a time. However they have the advantage of reaching people who might not read a brochure (Pflugh *et al.* 1999). Extensive campaigns among aboriginals of the Amazon have also been shown to lower fish consumers' blood mercury levels without lowering fish consumption (Mergler 2001), but efforts like this would not be

relevant to recreational sport fishers in BC, given the effort necessary and comparative risk.

One way to figure out how to reach people is to ask them and take their recommendations into consideration (Burger *et al.* 2003). However, research from past studies shows that different populations learn information from different sources (Burger *et al.* 2001b; Bjornberg *et al.* 2005b). The communication of advisories is an area in which a clear description of the target audience(s) is necessary. If advisories are found necessary, a broader survey should be undertaken. In lieu of further research, a combination of channels incorporating traditional (media) and untraditional (doctors) might be most effective.

1.4.3.5 The target groups of fish consumption advisories

Much media attention is focused on the risk of mercury to mothers and infants. Although infants and young children are most sensitive to the health effects of mercury, adults can suffer health damage from mercury in low doses as well (Stern 2005a). Because of this, the traditional focus on women of childbearing age might need to be expanded. Men generally make up a greater percentage of sport fishers, eat larger portions of sport fish more frequently than do women (Krebssmith and Smiciklaswright 1985; Fleming *et al.* 1995; Burger *et al.* 1998; Burger 2000b; Imm *et al.* 2005), and should not be ruled out when communicating caution. In the United States, a national fish consumption advisory exists for sensitive populations alone, and no consumption information is provided to adult males. In addition, when targeting women of childbearing age specifically, studies have found low consumption levels of sport caught fish (Stern *et al.* 2001; Knobeloch *et al.* 2005), and have had difficulty gathering reliable fish consumption data among women who eat fish sporadically (Stern *et al.* 2001). However, among women who eat fish regularly, fish consumption data has proven reliable (Bjornberg *et al.* 2005b). This is not to say that mercury is not a threat to women and children, or that they should not be informed. In fact, some studies suggest that pregnant women are more likely than other groups to modify eating behavior in the face of risks (Soumerai *et al.* 1992; Oken *et al.* 2003), and represent an extremely responsive audience for advisories. However, the extent to which the warnings target women and

children might be giving some adult men the impression that mercury is not an issue about which they need to be concerned.

1.4.4 The potential damage of advisories

For some groups of people, eating within the fish consumption guidelines would mean a total ban on local fish consumption (Boischio and Henshel 2000; Arnold *et al.* 2005). Lower income people might not have an affordable, healthy alternative to contaminated fish (Arnold *et al.* 2005; Dorea *et al.* 2005). Many First Nations people living traditional lifestyles rely on the health, social, cultural, and economic benefits of eating fish (Egeland and Middaugh 1997). In Alaska, Egeland (1997) found that consumption of commercial food was more harmful to indigenous people than the consumption of contaminated fish. In Canada, Wheatly (1995) stated that fish advisories and a decrease in fish consumption would disrupt social practices that are a critical part of indigenous culture. Similar findings were described by Shkilnyk (1984), who showed how dangerously high fish-mercury concentrations led to advisories encouraging the cessation of consumption among the Ojibwa people in Canada. This led to massive socio-cultural and socio-economic disruption. Fish consumption advisories should be issued when there are healthy alternatives for people (Wheatley and Paradis 1996) so that overall health is not lowered. Other, lower-mercury fish, or smaller fish of the same species are an ideal alternative.

Fish advisories may also have the unintended consequence of reducing fish consumption overall, even when certain fish are not contaminated (Oken *et al.* 2003). In Alaska, aboriginals became suspicious of salmon after a fish advisory and moved towards more unhealthy foods, even though the salmon were low in mercury (Arnold *et al.* 2005). A broad study conducted by Harvard researchers (Cohen *et al.* 2005) analyzed health benefits and harm from contaminated fish and concluded that advisories might do more harm than good to pregnant women. Ideally, advisories would induce women to substitute high mercury fish with the same amount of low mercury fish. However, if women decrease consumption of fish altogether (Oken *et al.* 2003), countervailing risks substantially reduce net benefits. This finding is backed up by the problematic Seychelles Island studies, where the children of mothers who ate more mercury scored higher on one

performance test because their mothers had also eaten more fish (Davidson *et al.* 1998; Clarkson and Strain 2003). When people follow fish consumption advisories, it can improve public health, however unintended decreases in overall fish consumption can create health loss. Risk managers need to assess and consider how populations will respond to advisories, how those responses will influence nutrient intake and contaminant exposure, and how these changes will affect aggregate public health.

If advisories are instituted for BC, they should carefully emphasize the benefits of fish consumption and be thoroughly tested prior to provincial distribution to insure fish consumers do not overreact. Ways to potentially mitigate overreaction to fish consumption advisories include letting anglers know that they can still fish and still eat the fish they catch, depending on species size and contamination levels (Reinert *et al.* 1991; Burger *et al.* 2001a). This would allow people to follow advisories while still gaining the health benefits from eating fish. Recommendations of healthy food substitutes might also prevent a health decline from eating less fish. Minimizing necessary behavioral modification by telling fishers ways to cook and clean fish in order to lower risk allows them to continue enjoying fishing while lowering health damage (Reinert *et al.* 1991; Burger *et al.* 2001a). Communicators can also encourage catch and release in very contaminated waters where fishing has been shown to be a recreational and cultural activity. Besides preventing an overreaction to fish consumption advisories, these techniques may also reduce the chance that the advisories are rejected by anglers (Reinert *et al.* 1991; Burger *et al.* 2001a). They would also keep fisheries and tourist industries from financial loss.

1.4.5 Conclusions

Human behavior is complex and people will not always act in their informed best interests. Even when fish consumption advisories are necessary to protect health and anglers are aware of them, advice may be ignored. In order to communicate effectively with fish consumers, research must be done to assess the nature of the group or groups that need to be targeted, be they from a province, an economic class, a gender, or ethnic group. This will enable the communication of advisories that are from a trusted source, transmitted through channels that will reach anglers, use language that is appropriate for

the audience targeted, and incorporate the group's concerns and needs. This can also increase fish consumers' confidence in the advisories when they are distributed. Advisories should emphasize the benefits of fish consumption without minimizing potential harms of mercury, and provide risk-risk comparisons for fishers to gauge their actions. Recommendations for other species of fish, amounts of meals, or even catch and release should be included so that fishers can continue eating fish and enjoying the activity of fishing while reducing potential harm from mercury. Steps should be taken to insure that fishers are not reducing consumption of all fish, or even all sport fish by conducting a pre-dissemination pilot study or a post-dissemination survey.

The complexity and importance of designing effective strategies for forming and disseminating fish consumption advisories necessitates an understanding of the target audience. This research paints a portrait of one fishing community in BC that can be used to supply policy makers and risk communicators with a general idea of the levels of knowledge and concern of fishers for potential incorporation into advisories or the bases for further research, as well as pathways and methods of communication that would be most effective at reaching this population.

1.5 Current protocols for fish consumption advisories

1.5.1 Advisories in other regions

The implementation of sport-fish consumption advisories is a major undertaking. Governments complete the steps outlined above with varying degrees of thoroughness depending on the extent of their mercury contamination, resources available, and perception of risk. Organizations such as the World Health Organization (WHO) are concerned with limiting health damage from mercury but also quite focused on the importance of fish, be they contaminated or not, in the diets of groups without access to healthy replacement foods. Because of this focus on sustenance fishing, the WHO uses what many researchers consider to be a high amount for the tolerable daily intake of mercury (Rice *et al.* 2003; Rice 2004). In the United States, where most freshwater fish are under mercury advisory, the Environmental Protection Agency (USEPA) utilizes the most strict mercury guidelines of any country, sometimes prohibiting consumption with

laws. Fish testing, reassessment of reference doses, and research into target audience comprehension and compliance are all conducted regularly (USEPA 2004a). Yet some researchers still consider the tolerable daily intake amount used by the USEPA to be dangerously high, especially for sensitive populations (Stern 1993; Rice *et al.* 2003; Stern and Smith 2003; Hightower 2004; Rice 2004; Oken *et al.* 2005; Trasande *et al.* 2005), while other consider EPA intake amounts unnecessarily low (Schoen 2004; Arnold *et al.* 2005).

In Canada, the provinces are ethically responsible for sport fish consumption advisories. Provinces with advisories use the Health Canada guidelines for normal fish consumption to recommend tolerable daily intakes of mercury. Health Canada uses the same tolerable daily intake amounts as the WHO for both general and sensitive populations (Health Canada 2004). These amounts are twice the levels the USEPA considers safe. Most provinces have policies to test fish, assess risk, and create and disseminate advisories. The Great Lakes provinces have extensive testing and advisories: Ontario issues a 23 page publication every two years as a guide to eating sport fish (Ontario MoE 2005). Other jurisdictions, such as Nunavut, have no program for testing fish and no fish consumption advisories issued. The extent to which each province issues fish consumption guidelines depends on the recorded levels of mercury in fish, the potential for harmful consumption rates among residents, the level of concern and public outcry, and the perception of risk by government officials.

1.5.2 British Columbia at present

Presently British Columbia has no formal process or policy in place for the testing of sport fish, the creation of fish consumption advisories, or their distribution. This is mainly because it is unknown if province-wide guidelines are necessary. Three lakes in BC have fish under consumption advisory, and consumption information on those fish is publicized via the Freshwater Fishing Regulations Synopsis. However, most fishers do not read the Regulations and would more likely look for information on the internet, through media sources, from health care providers, or each other (Jack *et al.* 2003). The Ministry of the Environment (MoE) has only recently recorded mercury concentration in

sport fish above the Health Canada guideline for regular consumption in certain lakes with no advisories (Fig 1.4).

More research is required to establish if sport fish consumers are being harmed by mercury in BC's freshwater fish. The levels of sport fish consumption and types of fish consumed must be determined for sport fishers in general and sensitive populations. If they are eating enough fish to cause damage, hair samples should be taken to see if the damage actually exists. If a health threat is present, policy needs to be produced so that advisories are created and communicated. Such policy is already in use in most of Canada and assessment of these policies could provide BC with best practices to implement. The importance of stakeholder participation throughout the advisory creation process suggests that fishers should be consulted to determine what they know, what they need to know, and how they would like to receive information from risk communicators (Chess *et al.* 1995a; Chess *et al.* 1995b). Government officials are aware of the potential health damage from mercury in BC fish, and preliminary research into the necessity of policy to protect fish consumers is being conducted. But the research required to ground the policy making process has not been done.

1.6 Objectives of this study

In British Columbia, there is a need for an assessment of the necessity, feasibility, and strategies for creating and disseminating freshwater fish consumption advisories. The objective of this project was to provide sound scientific research as part of the basis for policy development. I aimed to do this by evaluating what can be learned from a range of fish consumption policies in Canada and internationally to guide effective policy creation in BC, if it is deemed necessary. In addition, I assessed the necessity of fish consumption advisories to protect public health among a sport-fishing population on Elk Lake, Vancouver Island, by evaluating fish consumption, the state of mercury knowledge among these fishers (current awareness), how mercury information reaches them (information flow), and how they use that information to make decisions about their diet (personal diet management).

Figures: Chapter 1

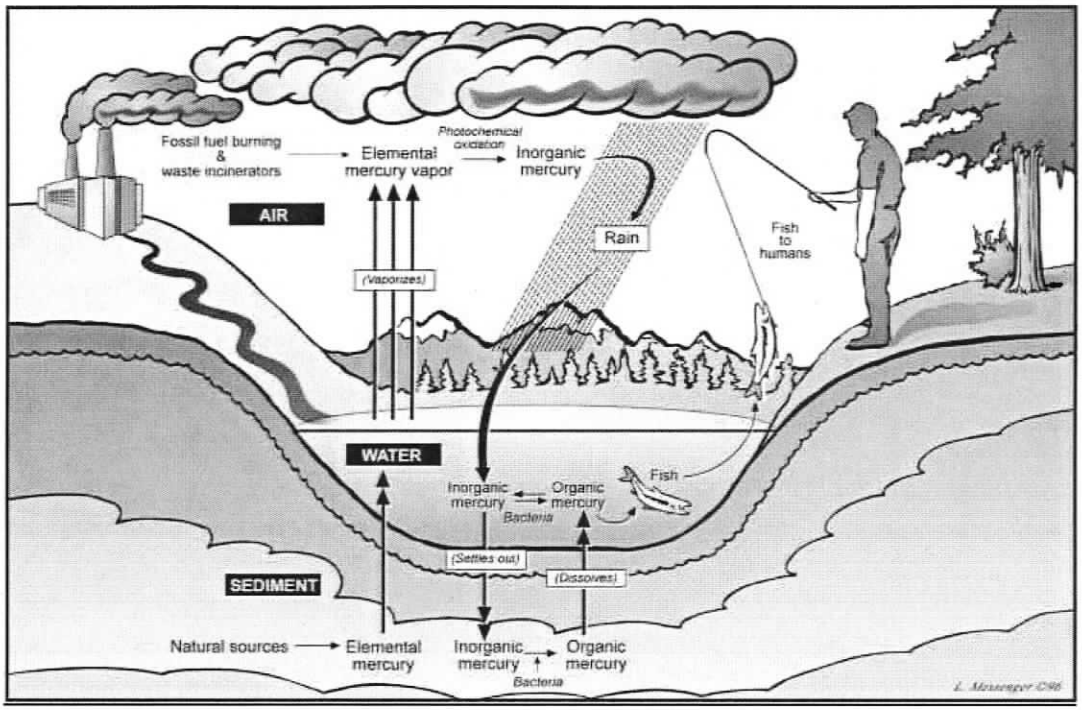

Figure 1.1. Pictorial representation of mercury cycling in the environment. (Source: Brachman *et al.* 2002)

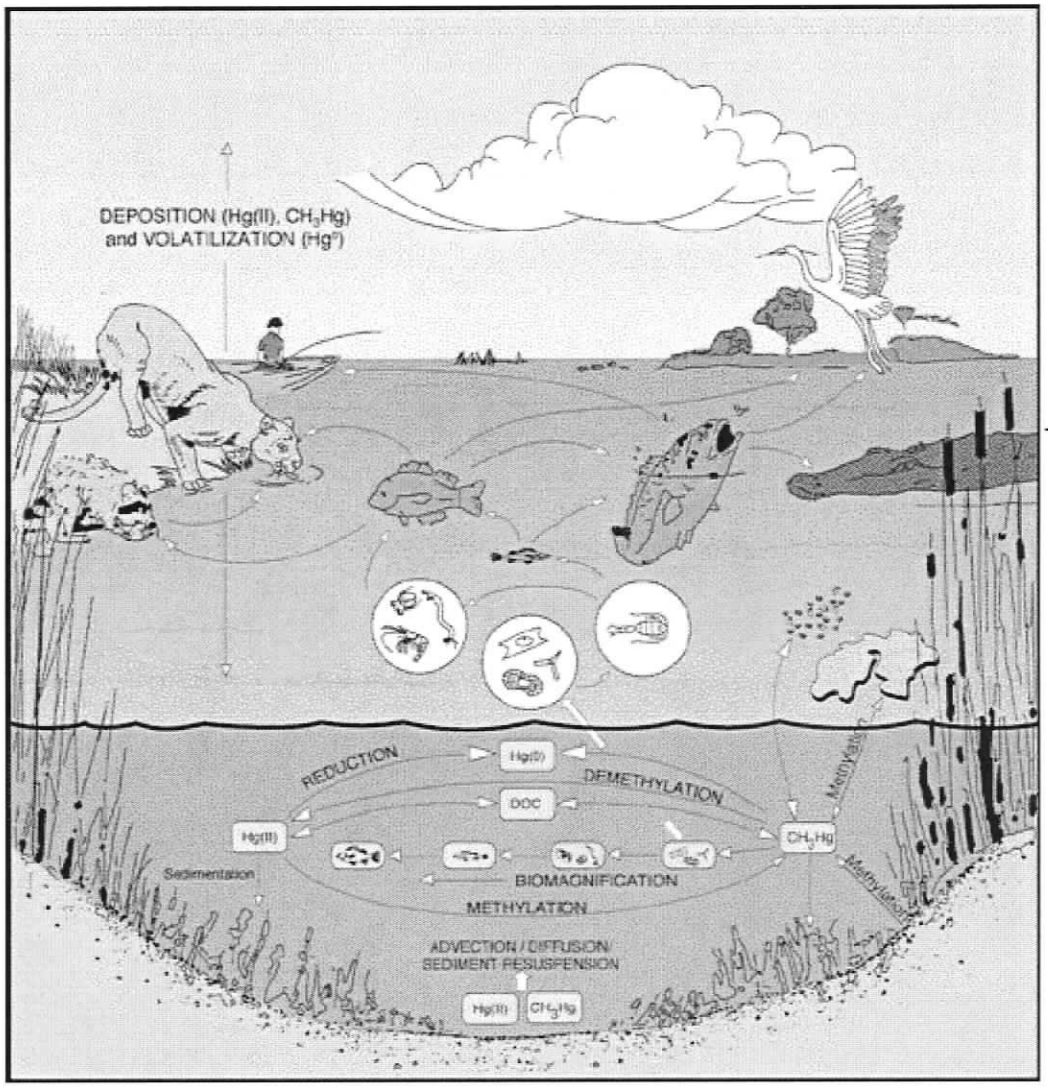

Figure 1.2. Pictorial representation of processes leading to bioaccumulation of methylmercury in the foodweb. (Source: USGS 2000).

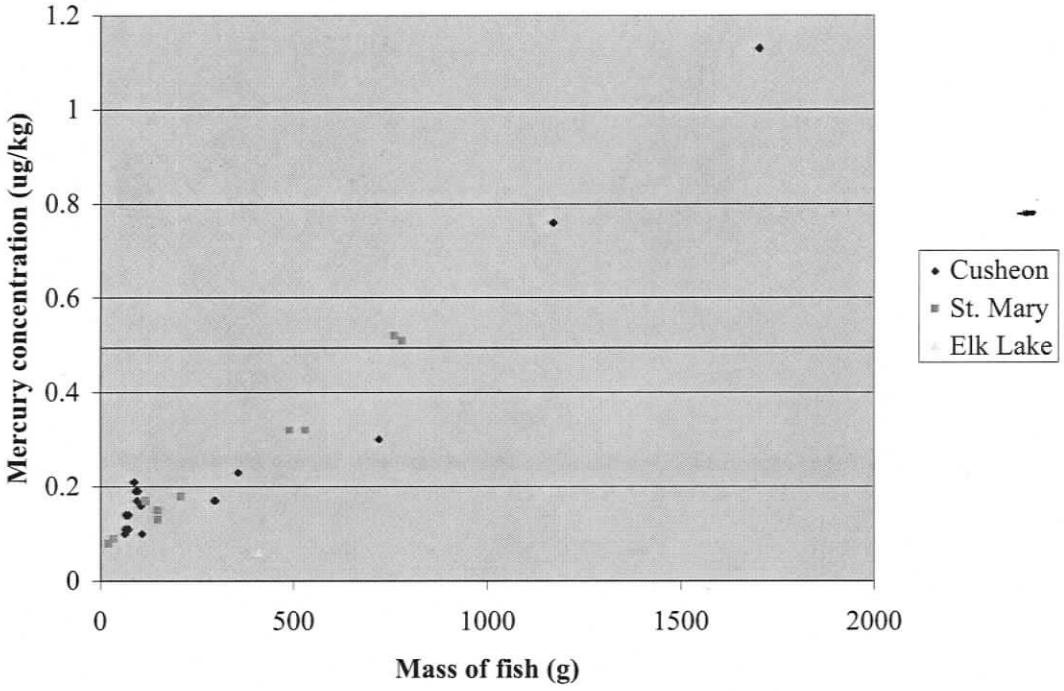

Figure 1.3. Mercury concentration in small mouth bass found in lakes on Vancouver Island (Deagle unpublished data).

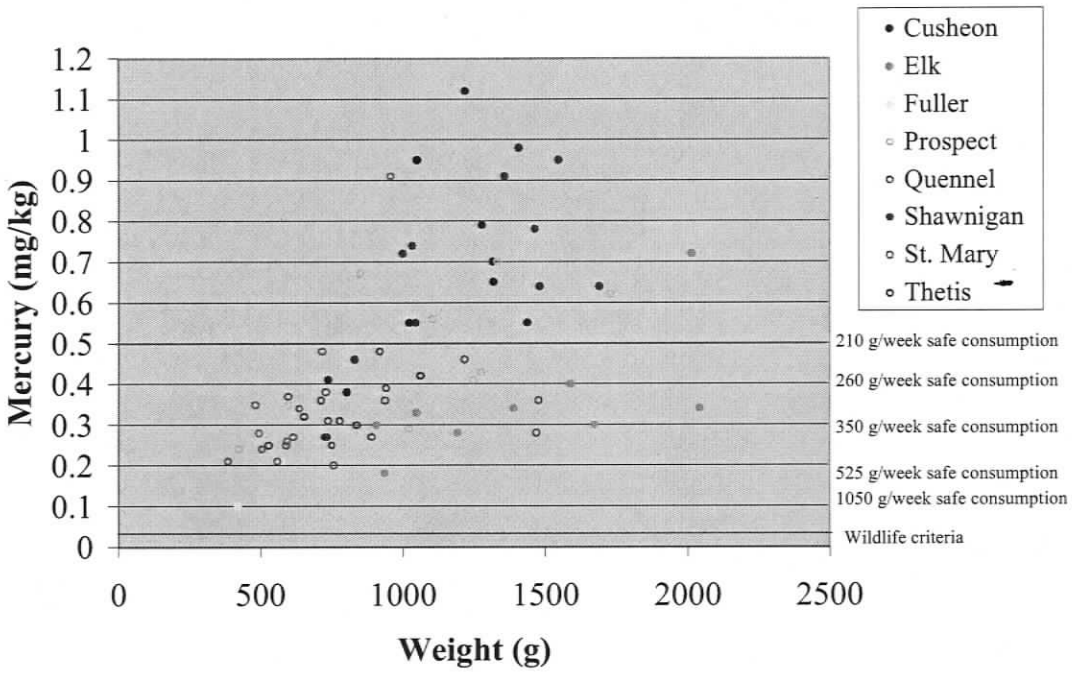

Figure 1.4. Mercury concentration in small mouth bass found in lakes on Vancouver Island (Epps and Rieberger unpublished data).

Chapter 2: Recommendations for British Columbia: An evaluation of Canadian fish consumption advisory creation protocols and communication policy

2.1 Abstract

Governments can protect their citizens from the harmful effects of mercury by issuing fish consumption advisories and recommending guidelines for safe lakes, fish species, and meal amounts to fish consumers. This information is critical for populations most sensitive to the potential damages of mercury: women of childbearing age, pregnant women, nursing mothers, and young children. Because fish are so beneficial, especially for sensitive populations, guidelines must encourage the maximum amount of fish consumption while protecting people from mercury levels known to cause harm. Consumption guidelines are developed by policy making bodies and based on scientific research. Yet there is scientific uncertainty surrounding how much mercury people can consume safely and policy makers must make complex decisions. Various provinces, countries, and international organizations use different Tolerable Daily Intake amounts for mercury, issue separate guidelines based on diverse methods of testing, and communicate advisories in numerous ways. In Canada the responsibility for fish-mercury testing and the creation and dissemination of fish consumption advisories is relegated to the provincial authorities. Strategies and protocols vary widely among provinces in relation to their respective fishing pressures and levels of mercury contamination. Presently, British Columbia does not have fish consumption guidelines for sport caught fish. This paper evaluates what can be drawn from a range of fish consumption policies to guide effective policy creation, implementation, and dissemination in British Columbia.

2.2 Introduction

Canada has many lakes and abundant fish making freshwater fishing an important resource for both commercial and communal provisions. In 2000, 3.6 million Canadians spent $6.7 billion on recreational fishing (DFO 2005) and in 2001 the average Canadian

ate 9.57 kg of both fresh water and marine commercial fish products (Stats. Can. 2004). Fishing supplies a staple protein source for many sustenance fishers and provides recreational and sport fishers with reasons to be outside, be together, or be alone (Toth and Brown 1997; Burger 2002a; Burger *et al.* 2005). Fish contain omega 3 fatty acids essential to neurological development and constitute a low fat, high protein diet (Hunter *et al.* 1988). However, industrial activity, wind patterns, reservoir development, limnology, and geology mean that certain fish species from certain water bodies have mercury concentrations detrimental to human health when eaten in large enough quantities.

2.2.1 Fish consumption guidelines

When a government establishes that sport fish from within its borders have high enough mercury levels to cause health damage to fish consumers, fish consumption guidelines are created and advisories issued to inform anglers and their families of the benefits and risks of eating sport caught fish (Anderson *et al.* 2004). Guidelines can inform consumers of safe fish species, meal sizes, and meal frequencies to maximize the benefits of fish consumption and reduce health damage caused by mercury. Sport fish can be a cheap and healthy source of protein and Omega-3 fatty acids, which are especially important for fetal development (Hunter *et al.* 1988; Olsen and Secher 2002). Difficulties in the creation of guidelines arise from scientific uncertainty about the exact amount of mercury that different groups of people can safely consume (Stern 1997; Rice 2004; Stern 2005b, a), as well as how to create and communicate guidelines that people will follow.

For guidelines to be effective, they must be communicated through channels and in a form that fishers trust, find interesting, comprehensible, and can easily find (Connelly and Knuth 1998). These steps are critical because fish consumers often ignore guidelines (Belton *et al.* 1986; Velicer and Knuth 1994; Pflugh *et al.* 1999). Advisories are most effective when they target specific groups (Velicer and Knuth 1994; Connelly and Knuth 1998) and are created, from beginning to end, with the participation of all stakeholders: policy makers, fisheries managers, researchers, fishers, and fish consumers (Chess *et al.* 1995a; Chess *et al.* 1995b). Advisories must inform fishers of the benefits of

eating fish along side the risks, as studies have shown a decrease in beneficial low-mercury fish species when people are warned to decrease high-mercury fish (Oken *et al.* 2003).

In order to create sport-fish consumption guidelines, local fish must be tested and appropriate intake amounts created for specific groups of people. It is well known that mercury is harmful when consumed but the exact amounts that can be ingested without harm for both frequent and infrequent consumers remain unknown (Rice 2004; Stern 2005b, a). This scientific ambiguity makes for difficult policy creation (Meffe and Viederman 1995), especially among sustenance fishers, aboriginal communities (Wheatley and Paradis 1995; Egeland and Middaugh 1997), and women of childbearing age (Cohen *et al.* 2005).

The combination of scientific research and public policy can create more effective fish consumption advisories and keep people from eating unhealthy amounts of mercury (Ashizawa *et al.* 2005). But the processes involved with combining scientific research and policy are often complex. Policy makers may be hesitant to institute fish consumption advisories if fisheries are financially profitable to their region (Burger *et al.* 2001a). Or, alternately, policy makers can be inclined to institute guidelines, as they are far less expensive than environmental remediation (Jakus *et al.* 1998), which, in the case of mercury in fish, may not be possible. One study of elected officials in the United States, found them more concerned with issues surrounding fisheries than fishers themselves (Burger *et al.* 1999b); this was possibly a result of effective lobbying by due to vocal fisheries groups. The circumstances in which policies are written can be time-pressed and confusing, with no one person in charge (Meffe and Viederman 1995). Policy is often created at the behest of public outcry (Burger *et al.* 1999b), and there is not time in such circumstances for scientific research to be analyzed and incorporated, much less conducted (Meffe and Viederman 1995). Researchers interested in the creation of science-based policy must produce research that is issue driven, comprehensible, and available for policy makers before conditions arise that policy must be written immediately (Rohlf 1991). It the aim of this project to provide policy makers in BC with some of the information they would need to produce science-based fish consumption advisories, as necessary.

2.2.2 Fish consumption guidelines in British Columbia

British Columbia has no formal process for the testing of sport-caught fish, the creation of fish consumption advisories, or their distribution. Three lakes in BC -- two reservoirs and one mining site -- have fish under mercury advisory (MoE 2001), yet province-wide fish-mercury testing has not been conducted to see if sport fish consumers should limit intake of certain species from certain lakes. In addition, it is unknown if people are eating enough sport-fish to cause health damage. Both Washington state and Alberta (the areas surrounding BC) have more extensive fish testing and advisories than does BC. Presently, the BC Ministry of the Environment (MoE) is conducting preliminary tests to see if province-wide testing for mercury concentrations are necessary to protect BC's sensitive human populations and those whose diets consist mostly of fish. Preliminary results indicate that certain large, old, high trophic level fish have been found with mercury concentrations in excess of the Health Canada guidelines (Figures 1.3 and 1.4). However, it has yet to be determined if this warrants fish consumption guidelines and advisories. In order for this to be established, province-wide fish-mercury testing must be conducted, sport-fish consumption levels must be determined, Tolerable Daily Intake (TDI) levels of mercury must be decided upon, and health damage potential must be quantified. For advisories to be issued, the most effective methods of communication with fish consumers should be assessed and tested. Sound mercury-related policy should be based on scientific research. Academic researchers and the MoE are taking the preliminary steps to guide scientifically based policy formation, but more research is necessary to fill knowledge gaps.

2.2.2.1 Mercury in British Columbia

It is generally assumed that fish in BC do not have very high mercury concentrations as compared with other Canadian provinces. This is based on of BC's lower level of most contaminating industries and convenient upwind location from most of North America's mercury deposition. However, it is difficult to know with certainty given the lack of testing that has been done on BC's freshwater fish.

British Columbia lies upwind of most industrial emissions along the Prevailing Easterlies of North America. The east coasts of Canada and the United States have elevated mercury concentrations in their fish from the increased mercury deposition in the region (USEPA 1997). Even areas on the east coast that have low regional mercury emissions can have elevated mercury concentration in fish from these wind patterns carrying and depositing mercury (Power *et al.* 2002). British Columbia also has fewer industries that are known to produce mercury emissions. There is only one base metal smelting facility and one solid waste incineration facility, both of which are monitored and subject to the Canada Wide Standards of mercury emissions. There are no existing biomedical waste, hazardous waste, or sewage sludge incineration facilities (Environment Canada 2000). The Northwest and Central Canadian region has the lowest atmospheric mercury deposition of any Canadian region other than the Arctic (Pilgrim 1998). However, BC is actively promoting coal burning power plant development in the province (MoEMPR 2002). Logging has also been shown to increase fish-mercury concentrations in impacted watersheds (Garcia and Carignan 1999, 2000, 2005). Given the volume of logging within BC, this could contribute to rising fish-mercury concentrations.

2.2.2.2 Fish-mercury testing in British Columbia

Fish testing in 2000 resulted in three BC lakes being placed under fish consumption advisory for mercury (MoE 2001) in lake trout (*Salvelinus namaycush*) and bull trout (*Salvelinus confluentus*). Each lake had factors known to contribute to high fish-mercury concentrations: Jack of Clubs Lake and Pinchi Lake were both historic sites of mercury mining and Williston Reservoir has elevated mercury levels as a result of flooding to complete the reservoir. Pinchi Lake contained lake trout that had mean mercury concentrations almost two times the Health Canada guideline of 0.5 ppm. Williston Reservoir had bull trout with mean mercury concentrations just over the Health Canada guidelines, but there is evidence that these fish might be returning to safe levels (Hills 2005), as newly flooded organic carbon promotes methylmercury production at far higher rates than organic carbon that is a few years old (St Louis *et al.* 2004; Hall *et al.*

2005). Comparable data for Jack of Clubs Lake fish are not available. Carpenter Reservoir also had bull trout that exceeded the Health Canada guidelines. Other species have also shown reason for concern: northern pike (*Esox lucius*) in Pinchi, Tezzeron, Stuart, Great Beaver, and Fraser lakes were shown to have mercury concentrations above the Health Canada guideline (0.5 ppm) (Weech *et al.* 2004). Other lakes in the province contain fish with mercury concentrations lower than the Health Canada guideline, but could still be harmful to human health if eaten in frequent, large amounts, especially by children and pregnant women.

Recent testing by the MoE has found fish-mercury concentrations double the Health Canada guidelines in certain lakes (MoE unpublished data, see Figure 1.4). If anglers are consuming these fish regularly, or sensitive populations are consuming them at all, this could pose a health risk. Mercury concentrations above Health Canada guidelines have also been found in smallmouth bass and yellow perch in St. Mary Lake and Cushon Lake on Saltspring Island (Deagle and Mazumder unpublished data, see Figure 1.3), as well as in small mouth bass in Prospect Lake, Elk Lake, Shawnigan Lake. Province-wide testing of fish will need to be conducted to determine if BC should consider issuing consumption guidelines. To date only selected lakes and species have been tested. Even though BC's relative mercury concentrations may be low, there is still the possibility that individual freshwater fish contain enough mercury to cause a risk to human health. Certain local species could be of concern. Individuals or populations of large, long-lived fish, high on the food chain, such as bull trout (*Salvelinus confluentus*), lake trout (*Salvelinus namaycush*), pike (*Esox lucius*), and others may contain high levels of mercury. In order to conduct a proper risk assessment, fish consumption data on small mouth bass (*Micropterus dolomieui*)) must be combined with consumption data to determine if health damage could be present.

2.2.2.3 Knowledge gaps for guideline formation in British Columbia

The Ministry of the Environment is aware of the issues surrounding mercury in sport fish and is working to assess the necessity of sport-fish consumption advisories. In order to do this, fish-mercury levels must be quantified, a Tolerable Daily Intake amount

must be decided upon, and guidelines for consumption must be calculated. Once it is determined how much fish different groups of people must consume in order to create cause health damage, a risk assessment must be conducted to figure out if people are eating enough of high mercury species for this to occur. If this is found to be the case, the best methods and paths of communicating with fish consumers must be ascertained by interviewing, learning from, and testing the responses gained from fish consumers. Along with the MoE's testing of fish-mercury in selected lakes, this study aims to provide preliminary research in order to determine and instate advisories grounded on scientific research if intervention is needed to protect public health. These steps require policy formation and research protocols that other provinces and countries have already established. My project illuminates what can be learned by assessing existing policy protocols to provide recommendations for British Columbia.

2.2.3 Mercury in people

It is important to create fish consumption advisories for high-mercury fish because mercury, more specifically methylmercury, is damaging to people. Unfortunately, the exact amount of mercury that different populations of people can ingest without health damage remains in the realm of scientific uncertainty. The gastrointestinal tract absorbs almost all (~95%) of the methylmercury in fish and transports it to most organs, especially the heart, liver, kidneys and brain (NRC 2000). Methylmercury is a neurotoxin that, when consumed in large enough quantities, concentrates in the central nervous system to cause brain damage and organ failure. Methylmercury is lipophillic and can cross into the placentas of pregnant women. The ratio of MeHg concentrations in maternal blood to umbilical cord blood is thought to be widely variable; if one were to estimate an average, it seems to be 1:1.7 (Stern and Smith 2003). Because the blood-brain barrier is not fully developed until after the first year of life, methylmercury is particularly harmful to fetuses and babies (Rodier 1995). The children of women who had high blood mercury concentrations while pregnant have been shown to suffer permanent brain damage, IQ loss, depressed growth, hearing loss, and behavioral problems (Grandjean *et al.* 1997). Moreover, methylmercury will accumulate in the breast milk of nursing mothers and continue to pass to the baby after birth

(Grandjean *et al.* 1995; Bjornberg *et al.* 2005a). Children are also at risk of mercury damage because many guidelines are calculated using a per kg body weight dose based on a 70k adult. Hence children's exposure can be two to three times higher (Zahir *et al.* 2005).

Humans can eliminate methylmercury from their bodies after ingestion through urine, feces, and breast milk. The half-life of mercury in the human body is about 1.5 – 2 months (NRC 2000). When a person consumes mercury at a higher rate than the body can excrete it, bioaccumulation occurs. In addition, neurological damage can occur from a single high mercury fish meal (>2.0 ppm) in high risk populations like pregnant women, babies, and young children (Ginsberg and Toal 2000). The consumption of high mercury fish has also been linked to cardiac infarction (Salonen *et al.* 1995a; Salonen *et al.* 1995b) and decreased sperm count (Dickman *et al.* 1998; Dickman *et al.* 1999) in adult men at hair mercury concentration of 2 ppm and 4 ppm respectively. In another study, men who had had a heart attack had 15% higher mercury concentrations that those who did not (Guallar *et al.* 2002). It has also been hypothesized that senior citizens might experience greater damage than younger adults due to their slower metabolic rates (West *et al.* 1997). Mercury from blood capillaries penetrates into hair follicles and can be used to reflect mercury exposure. A large study in the United States using this technique estimated that 1 in 12 women of childbearing age has mercury levels high enough to cause health damage (Trasande *et al.* 2005).

2.2.4 The benefits of fish consumption

Although mercury is damaging, fish consumption is extremely beneficial for humans, especially pregnant women, and people should not be warned away from eating fish. All people can benefit from eating two 227 g servings of fish each month (15 g/day) (Table 2.1) (Gochfeld and Burger 2005), as fish provide an excellent source of protein, will lower cholesterol, and are cardio protective (Chan and Egeland 2004). Fish is beneficial to the hearts of men, but mercury can reduce those protective benefits (Rissanen *et al.* 2000). Fish are also often people's only source of the omega 3 fatty acids (Holub 1989) developing brains require (Hunter *et al.* 1988). Oken *et al* (2005) found that infants scored 4 points higher on a visual recognition test for every additional weekly

serving of fish eaten by the mother while the child was in utero. However, at hair mercury levels of 1.55 ppm, scores dropped by 7.4 points. Infant scores were highest among women who ate more than two servings of fish per week but had hair mercury levels ≤1.2 ppm. Another study found that between 8 and 15 g of fish per day reduced low birth weight and between 5 and 38 g/day reduced pre-term birth by as much as three times (Olsen and Secher 2002). Helland *et al.* (2003) found that one dose of cod liver oil while pregnant and one dose while lactating increased child IQ at age 4. Because some studies have found that pregnant women may reduce consumption of low-mercury fish when advisories are issued for fish with high mercury (Oken *et al.* 2003), and pregnant women are hypothesized to be very responsive to dietary shifts in order to protect offspring (Soumerai *et al.* 1992; Oken *et al.* 2003), fish consumption advisories must encourage fish consumption while limiting intake of mercury.

2.2.5 Scientific uncertainty surrounding Tolerable Daily Intake amounts

In order for guidelines to be issued, risk assessors must discern the amount of mercury people can ingest without health damage, determine how much mercury is in local fish, and perform simple calculations to set an amount of fish different groups of people can consume per time period. However, there is much debate over the exact amount of mercury that can be ingested without adverse effects to sensitive and general populations, and the many of the correlations necessary to convert mercury intake to health damage remain unknown (Rice 2004; Stern 2005b).

2.2.5.1 The creation of Tolerable Daily Intake amounts

After Minamata disease was discovered in Japan in the 1950's and in North America and around the world in the 1970's, the World Health Organization (WHO), Canada, and the United States issued Tolerable Daily Intake amounts (TDI's) for mercury and based fish advisories on these. The TDI is the amount that can be eaten every day during a 70-year life time with no adverse effects. The TDI's were calculated by looking at mercury poisoning in Iraq, measuring mercury concentrations and intakes in the mothers of infants with measurable health damage (a very difficult condition to

quantify), and locating the point at which no observable effects were found (Rice *et al.* 2003; USEPA 2004b). It was thought that the children born to women with hair-mercury levels below 20 ppm were safe. The WHO used this data to create a Tolerable Weekly Intake amount of 3.3 μg of mercury per kg of body weight (μg/kg bw), or 0.47 μg/kg bw/day (WHO 2003). This amount was adopted by Health Canada in 1972 (Health Canada 2004).

At this same time the United States Environmental Protection Agency (USEPA) concluded that a maternal hair mercury concentration of 11 ppm was sufficient to protect a fetus (USEPA 2000). A TDI of 0.1 μg/kg bw/day for even the most sensitive populations was calculated by estimating conversions from hair, to maternal blood, to fetus and applying a 10 fold uncertainty factor. Even at the time, some researchers felt that this was too high and suggested RfD's between 0.03 and 0.07 μg/kg bw/day (Stern 1993, 1997).

2.2.5.2 Updating Tolerable Daily Intake amounts

More recently, three major long-term studies were conducted on populations consuming high amounts of mercury in order to refine the levels at with damage occurs. A study of mother/infant pairs in the Faroe Islands found developmental damage in children born to mothers with hair mercury concentrations averaging 4.3 ppm (Table 2.2) (Grandjean *et al.* 1997; Grandjean *et al.* 1998; Grandjean *et al.* 2003). A second study in the Seychelles Islands did not find developmental damage among population with mean maternal hair concentrations of 6.8 ppm (Davidson *et al.* 1998; Myers *et al.* 2000). The Seychelles Island study actually found developmental benefits associated with higher levels of maternal mercury levels, most likely associated with the benefits of eating fish (Clarkson and Strain 2003). A third study among a population in New Zealand found neurological damage among children with mothers whose hair mercury concentrations averaged 8.3 ppm during birth (Crump *et al.* 1998).

2.2.5.2.1 Derivation of the World Health Organization's TDI

The WHO convened a panel to consider this new evidence. The panel ignored the New Zealand study because of data problems and focused the Seychelles and Faroe Islands (WHO 2003). Benchmark dose levels were averaged from these two studies to conclude with a maternal hair mercury concentration of 14 ppm, below which most people would be safe. This led to a steady-state daily ingestion of methylmercury of 1.5 μg/kg bw/week which would result in safe ingestion for even the most sensitive populations. An uncertainty factor of 6.4 was applied to account for unknowns in mercury correlations to conclude in a safe consumption rate of 1.6 μg/kg bw/week, which would result in maternal blood mercury concentrations estimated to be without appreciable adverse effects in children in utero (Table 2.3). Thus, 0.23 μg/kg bw/day became the Reference Dose (RfD) for safe consumption. They noted that health damage was found in adults with lower hair-mercury concentrations than would be obtained by adhering to the RfD, but decided to only consider data concerning in utero mercury exposure and child cognition to develop the RfD (WHO 2003).

2.2.5.2.2 Derivation of the Health Canada TDI

Health Canada reviewed these new data as well in 1998. The conclusion was that the TDI of 0.47 μg/kg bw/day was acceptable for the general population but that pregnant women, women of childbearing age, and young children eat no more than 0.2 μg/kg bw/day (Health Canada 2004). This dose is slightly lower than the WHO TDI of 0.23 and double the USEPA's TDI of 0.1 μg/kg bw/day. The Health Canada dose corresponds to a maternal blood concentration of 20 ppb, which is more than three times the USEPA dose of 5.8 ppb. Health Canada is aware of this discrepancy and is in the process of reviewing a potentially lower dose (USEPA 2005a). When a person's diet is based primarily on fish, variable guidelines are recommended (Table 2.4)(Nagpal 2001).

2.2.5.2.3 Health Canada guidelines for commercial fish

For commercial fish, Health Canada used data from a study in Iraq in the 1970's to set a federal mercury concentration limit of 0.5 μg Hg/g fish tissue wet weight (w/w) for domestically produced and imported commercial fish that are thought to be consumed

with regularity by the average person (CFIA 2002). Unlimited consumption of fish under 0.5ppm is encouraged for even the most sensitive populations. This commercial dose of restriction is lower than that in the United States of 1.0 ppm (Smith and Sahyoun 2005). Certain fish have mercury concentrations between 0.5 and 1.5 ppm but can still be sold because they are considered delicacies and not consumed regularly. These fish include such as shark (*Selachimorpha*), swordfish (*Xiphias gladius*), and mackerel (*Scombridae*). Women of childbearing age, young children and nursing mothers are advised to restrict consumption of these high mercury fish to once per month, whereas sensitive populations in the United States are advised not to eat these high mercury fish ever (USEPA 2004a).

Fish consumption guidelines are based on an average weight of 70kg and an average meal size of 227g for all fish consumers. This can cause guidelines to be over or under protective if consumers differ in weight or meal amount (Marien and Stern 2005). Variable guidelines for different weight groups would make advisories more effective at protecting health.

2.2.5.2.4 Derivation of the US Environmental Protection Agency's Reference Dose

The US National Research Council (NRC) calculated a Reference Dose (RFD) by considering all three major studies on maternal blood mercury and fetal development (NRC 2000; Rice *et al.* 2003; Rice 2004; Trasande *et al.* 2005). It was concluded that the Faroe Island Study was the most robust and it was used to create a Reference Dose (RfD) (Rice *et al.* 2003). The RfD is the amount that can be eaten every day by the most sensitive populations during a 70-year life time with no adverse effects, and corresponds to the TDI.

The NRC, using the Faroe data, found a blood-mercury concentration of 58μg/L to be the lower limit of the 95% confidence interval for the concentration at which there is a doubling of the number of children scoring in the clinically subnormal range on a particular test. The choice of "doubling" seems completely arbitrary; it could have been "increased by 50%," in which case the threshold would have been lower. What is important to note is that this is not a concentration below which no observable effects were found. They then divided this by a ten-fold uncertainty factor to arrive at a benchmark blood mercury concentration of 5.8 μg Hg / L blood. This corresponds to 1

ppm in hair and is the basis of the RfD (Rice *et al.* 2003; Trasande *et al.* 2005). From here a TDI of 0.1 μg/kg bw/d was calculated to protect sensitive populations. This is the lowest TDI in the world, and the exact same as the amount before the reanalysis.

2.2.5.2.5 Problems with Tolerable Daily Intake amounts

Many industry advocacy groups feel that the USEPA's ten-fold uncertainty factor is unnecessary and keeps people away from eating a healthy amount of fish (CCF 2006). However, while the NRC took 5.8μg/L to be a buffered and safe dosage of mercury, the Faroe study actually *began* seeing developmental affects at 5.8μg/L or 1 ppm in hair. In addition, the NRC assumed a maternal to umbilical cord blood mercury concentration ratio of 1:1. In fact, research suggest a wide variety of maternal to cord blood ratios, and that, if an average was to be found, it was closer to 1: 1.7 (Stern and Smith 2003). If this is taken into account, the safe benchmark dose of mercury is 3.41 μg/L and the RfD sinks to 0.06 μg/kg bw/day with *no* uncertainty factored in (Rice *et al.* 2003; Trasande *et al.* 2005). Others suggest that the RfD should be reduced further, to 0.05 μg/kg bw/day (Stern 2005b). If members of sensitive populations in Canada follow the Health Canada TDI of 0.2 μg/kg bw/day, they will exceed 1 ppm hair mercury concentrations.

It is important to note that all of the TDIs were developed based on maternal and fetal mercury levels, and no government body has taken adult mercury damage into account. This is important because increased rates of cardiac infarction were observed in men with hair mercury concentration of 2 ppm (Salonen *et al.* 1995a; Salonen *et al.* 1995b), and decreased sperm count was found among Japanese men with hair mercury concentration 4 ppm (Dickman *et al.* 1998; Dickman *et al.* 1999). If men and non-menstruating women in Canada follow the Health Canada TDI of 0.47 μg/kg bw/day for the general population, they will exceed 2 ppm.

2.2.5.2.6 Practical application of TDI's to commercial and sport-fish In BC

A TDI of 0.1 μg/kg bw/day is sufficient to keep hair mercury levels in men and non-menstruating women from surpassing 2 ppm. The most restrictive and precautionary TDI of 0.06 μg/kg bw/day would protect sensitive populations from breaching 1 ppm. If these were applied in Canada, both the commercial and sport-fish consumption guidelines

would look very different. Fish with mercury-concentrations of 0.5 ppm, the level at which unlimited consumption is recommended, could only be eaten 2 times per month by the general population and 1 time per month by sensitive populations (Table 2.5). High-mercury fish like shark, tuna, and mackerel could only be eaten in a small portion once a month and every other month by general and sensitive populations respectively. Revised guidelines for commercial fish commonly found in Victoria BC are presented in Table 2.6.

Sport fish in British Columbia would also have to come under advisory. Small mouth bass (*Micropterus dolomieui*), recently tested by the MoE, average 0.3 ppm, and could only be eaten 3 times per month by the general population and 2 times per month by sensitive populations, sometimes even less depending on the lake (Table 2.7). Stocked rainbow trout, thought to be safe for limitless consumption, would have to be reduced to 8 and 5 times per month for general and sensitive populations respectively. If sport fishers were eating more than 2 to 3 meals of small mouth bass per month, health damage could be taking place.

Yet certain sport-fish in British Columbia would also have to come under advisory if guidelines were created using Health Canada TDI's (Table 2.8). Small mouth bass, and even rainbow trout would be limited for consumption by both general and sensitive populations for certain lakes. Small mouth bass levels are high enough to warrant a province-wide advisory to limit consumption of large fish of the species.

2.2.5.2.7 Tolerable Daily Intake amounts summary

The fish amounts recommended by following the most restrictive and precautionary of Tolerable Daily Intake amounts leaves fish consumers eating far less fish that previously allowed by Health Canada guidelines. If these guideline were implemented, the drastic change could scare fish consumers into reducing consumption of even low mercury fish (Oken *et al.* 2003), which would bring overall heath damage (Cohen *et al.* 2005). These precautionary TDI's should not be implemented unless actual health damage could be verified by testing the hair-mercury concentrations of consumers of commercial and sport fish. Studies that have both asked fish consumers how much fish they eat and measured hair mercury concentrations have found that hair-mercury is often

lower than predicted by calculations using questionnaires and mercury concentration of fish consumed (Stern *et al.* 2001; Loranger *et al.* 2002; Canuel *et al.* 2006). This could be due to poor estimation of meal frequency and amounts by fishers; ethnic difference in metabolization of mercury; disparity between fish-mercury concentrations used and those in the fish eaten; or the use of averages for metabolization rates when age, gender, and weight will alter these rates significantly. Yet because fish consumption surveys are not always an accurate way to gauge mercury exposure, the combination of fish-mercury data and fish consumption information may not be enough to require such precautionary TDI's. Hair mercury tests should be conducted, and only if fishers surpass 1ppm and 2ppm for sensitive and general populations respectively, should more restrictive commercial and sport-fish consumption guidelines be instated.

2.3 Policy strategies and analysis

Once amounts of mercury that cause health damage have been established, governments must continue the processes of assessing risk, creating guidelines, and communicating them to fish consumers. Different provinces, countries and governing bodies have different strategies for creating and implementing policy to perform these tasks. British Columbia has none, but is currently assessing the necessity and feasibility of policy implementation.

2.3.1 Federal responsibilities

In Canada, the federal government regulates commercial and marine fish, while it is the responsibility of each provincial government to monitor mercury concentrations in freshwater fish and to set and publicize consumption guidelines if they are deemed necessary. An exception is made for First Nations communities, which will be discussed further on. For commercial fish, it is Health Canada's role to set the TDI for mercury and consumption guidelines. Health Canada recommends that people do not exceed 0.47 μg Hg/kg of body weight/day and sensitive populations eat no more than 0.2 μg Hg/kg of body weight/day (Health Canada 2004). The commercial restriction concentration follows from this and fish are not allowed to be sold over 0.5 ppm unless they are considered delicacies and eaten rarely (Health Canada 2004). The Canadian Food

Inspection Agency (CFIA) has the responsibility of testing fish to make sure mercury concentrations fall below 0.5 ppm (CFIA 2002). Sometimes the CFIA will have fish companies test their own fish and report back. Yet for freshwater sport fish, there is no federal body that oversees the provincial governments' processes regarding consumption advisories. Most provinces have used Health Canada's guidelines for their own freshwater fish advisories. Different provinces use different departments for testing, creating, and publicizing fish consumption advisories (Table 2.9).

2.3.2 Provincial strategies for the creation, implementation, and dissemination of fish consumption advisories

2.3.2.1 Great Lakes

Mercury concentrations in Canadian fish vary according to region, with the eastern provinces receiving having higher industry levels and mercury deposition (Pilgrim 1998). Because Ontario and Quebec contain the vast majority of Canada's population and border the Great Lakes, the policy surrounding fish consumption guidelines in these areas is far more comprehensive than the rest of the country. Both provinces require full books to contain their advisories. In Ontario, every single fish is under advisory, guidelines are distributed for more than 1,700 lakes and rivers, and are updated biannually. Quebec is similar and tests 800 lakes, but updates every 5 years. Both provinces have vast networks of government agencies, academic researchers, and private companies that collaborate on fish testing, advisory creation, implementation, communication, and efficacy testing. Quebec is the hub of the Collaborative Mercury Research Network (COMERN), an academically-based interdisciplinary group. Ontario has a chart with meal frequencies for each species of each lake based on fish length and whether or not the consumer is a member of a sensitive population. Quebec's chart is similar but without the column for sensitive populations, notifying them in the instructions to only eat fish from the 8/month meal category. However, for the general population, Quebec allows for the consumption of between 1.0 and 2.0 ppm twice per month and fish over 2.0 ppm once a month. This is higher than the Health Canada

guidelines, which restrict consumption of all fish over1.5 ppm. Neither province has an "unrestricted consumption" category of fish and uses 8 meals per month as the highest number for the general populations. Both provinces include educational material on where mercury comes from, how it gets into fish, the benefits of eating fish, and how it harms people. Ontario publishes the Guide in English and French only but distributes instructions on how to use the guide in 17 different languages. Quebec only publishes their guide and instructions in French, which could be dangerous for the high numbers of tourists eating fish. Ontario's distribution network is vast, encompassing such non-traditional locations as beer stores and Canadian Tire, while Quebec's Guide is not available online and only distributed at government offices. Ontario and Quebec are also the only two provinces to test the efficacy of their advisories: Ontario issues a questionnaire to fish consumers biannually, and Quebec relies on COMERN to survey fishers.

2.3.2.2 Other provinces

The remaining provinces have less extensive testing and guidelines. Most fish in Nova Scotia and New Brunswick have mercury concentrations above 0.5 ppm due to their eastward longitude and proximity to provinces and states with high mercury emissions. Both provinces lack strict protocols for testing fish and creating guidelines. Various government offices collaborate to collect samples and respective Departments of Health issue the advisories. Both provinces publicize guidelines in the middle of Fishing Regulations booklets, and distribute them in locations where fishers purchase licenses. In New Brunswick, sensitive populations are advised to eat no fish from the province; while in Nova Scotia, they can eat three species of fish when they are small. Sensitive populations are given different consumption advice but no other information is provided to emphasize the point or tell them why. No educational information about mercury is given, but phone numbers are included for further inquiry. Prince Edward Island only has one lake with trout under mercury advisory, possibly owing to its size.

The four remaining large provinces, Alberta, British Columbia, Manitoba, and Saskatchewan, also vary among each other. Saskatchewan has a low population and few

natural lakes in populated areas. They have a protocol in place for testing and advisory creations through the Saskatchewan Environmental Resources Management department (SERM), which would entail the creation of advisories for lakes, fish species, and population sensitivities. However guidelines themselves were not found to exist: the Fish Anglers Guide claims they are available but does not say where. On the other hand, Manitoba, "the land of the lakes," has 42 lakes and rivers under advisory, tests fish every few years, and updates guidelines and advisories accordingly. Manitoba publishes a 3-page pamphlet containing educational information regarding mercury bioaccumulation, as well as fish species, meal amounts, and water bodies that are low in mercury in order to encourage fish consumption. Pamphlets are available online and from government offices. Manitoba is also in the process of updating current guidelines (created in the 1990's) to be more restrictive. While guidelines used to allow unlimited consumption under 0.5 ppm, new guidelines will recommend general populations eat 8 meals per month of fish from 0.2 – 0.5 ppm, and 18 per month if they are less than 0.2 ppm. Sensitive populations will be advised to eat only 8 meals per month of fish less than 0.5 ppm and 3 meals of fish between 0.2 and 0.5 ppm. These, when instated, will be the most precautionary guidelines in the country.

Alberta, with far fewer lakes, has 16 water bodies under mercury advisory. In 2002, government officials, municipal representatives, First Nations leaders, and members of many public sectors, conducted a broad study of mercury in lakes, resulting in guidelines and advisories. In 2004, a risk assessment of Alberta Parks was conducted and advisories were updated. Advisories are published in the Sport Fishing Regulations booklet with can be ordered online or picked up with licenses. The advisories include the basics of bioaccumulation and a limitation of fish from certain lakes to 1 meal per week for the general population and a restriction from eating those same fish for sensitive populations. Alberta and Manitoba are the provinces British Columbia bears most resemblance to in contamination levels and population. The provinces of Newfoundland and Labrador are managed along with the territories of Canada, discussed below.

2.3.2.3 Territories and First Nations Communities

While most of Canada's sport fish consumption advisories are created at the provincial level, advisories aimed at First Nations communities and those of the northern territories, are managed by federal authorities and organizations. First Nation communities do not have to purchase fishing licenses and would not be reached with advisories in fishing regulations. The Northwest Territories, Nunavik, Yukon, Nunavut, and Northern Labrador are managed by the federal Northern Contaminants Program (NCP) and the Department of Indian and Northern Affairs (DIAND) that runs the Territorial Contaminants Committee (TCC). All three work together to collect data and conduct risk assessments if necessary. Health Canada is consulted throughout the process and will create guidelines if they are necessary and send them as recommendations back to the other governing bodies. The TCC devises advisories and a communication plan that is culturally sensitive for target communities by consultation with the northern Aboriginal organization within the TCC. Information may be released through press releases but community and fact to face meetings are used more often. The territorial chief medical officers of health, as well as the regional Aboriginal organizers and Health Canada, make sure people receive information.

In addition, DIAND publishes a two page pamphlet containing educational information on mercury in the environment, bioaccumulation, how mercury harms women of childbearing age and their children. The pamphlet informs readers to avoid large, old, predatory fish but does not give fish species, lakes, or sizes. The pamphlet also contains information on the benefits of eating fish and the importance of fishing to the traditional lifestyles and cultures of First Nations. The pamphlet uses pictures of First Nations people and is an excellent example of target audience communication.
When fish consumption guidelines are published, a more restrictive set of TDI's are used for people subsisting on fish (Table 2.4)(Nagpal 2001). These TDI's are far closer to the USEPA RfD and are considered sufficient for both general and sensitive populations.

2.3.3 Strategies and protocols of the United States

The vast majority of water bodies in the United States are under fish consumption advisory. Even though mercury levels are between 0.04 and 1.5 μg/g (USFDA 2006), a

recent study estimated that between 310,000 and 630,000 children are born each year with chord blood levels high enough to cause loss of IQ (Trasande *et al.* 2005). Coal production and incineration are on the rise and mercury trapping technologies might not be implemented (DePalma 2006; Romero 2006), so fish-mercury concentrations might increase over time. Because environmental remediation is not an option in the current political climate, fish consumption advisories are strong, ubiquitous, and growing in number. Only Alaska and Wyoming remain without fish advisories (USEPA 2005b). In a recent media survey of fish species recommended for consumption based on contaminant levels and environmental impact, only 2 out of 24 species were anadromous, the rest were marine, and not one was freshwater (Burros 2006a). It is far cheaper for the government to limit the consumption of fish than to compel or legislate a decrease in mercury emissions (Jakus *et al.* 1998), even though one study found the economic cost of the neurological damage caused from mercury to be USD $8.7 billion in lost productivity (Trasande *et al.* 2005). The topic of mercury in fish in the United States is widely known and discussed by the general population, partly as a result of media attention over the past few years (Anderson *et al.* 2004; Burros 2006b).

In contrast to Canada, the responsibility to test fish-mercury concentrations and issue fish consumption advisories for freshwater fish is federal in the United States. The United Stated Environmental Protection Agency (US EPA) collects data on mercury concentrations in fish nation-wide and issues national and lake-specific fish consumption advisories. In 2004, the EPA and the Federal Department of Agriculture issued fish consumption advisories aimed at pregnant women, women who may become pregnant, nursing mothers, and young children (USEPA 2004a). While this advisory emphasizes the health benefits of a diet that included fish, it also recommends women and children eat no shark, swordfish, king mackerel, or tilefish at all and limit consumption of other species (e.g., one can (170 g) of white albacore tuna per week; two meals (340 g) of shrimp, canned light tuna, salmon, pollock or catfish per week). The advisory recommends women check local advisories when eating sport-caught fish, and, if no advisory is available, eat only one meal (170 g) per week. It advises women to follow the same recommendations when feeding fish and shellfish to young children, but to serve them smaller portions.

Interestingly, the United States does not have an advisory for the general population. The advisory for sensitive populations is the only one publicized and no RfD exists that is more permissive of mercury intake. However, sensitive populations are warned to adhere to the RfD in such a way that suggests other may exceed it, yet nothing is explicitly stated (USEPA 2004a).

Because advisories are so abundant in the United States, research into how consumers perceive advisories and how perceptions relate to fish consumption are many (Burger and Gochfeld 1991; Burger 1998c; Burger *et al.* 1998; Burger *et al.* 1999a; Burger 2000a; Burger and Waishwell 2001; Burger 2004, 2005). Studies on fish consumption after advisories have even been used to create policy and effectively communicate with target groups in the Great Lakes region (Ashizawa *et al.* 2005). While the United States and Canada are quite different politically and culturally, these studies can be used to create effective fish consumption policy here.

2.4 Discussion

2.4.1 Advisory formation

Ontario and Quebec, with the highest fish-mercury concentrations and population density, have the most thorough and extensive fish testing protocols and consumption advisories. All fish in both provinces are under advisory. Provinces such as Saskatchewan have lower mercury levels, lower fishing pressure, and lower population density, and therefore have no advisories and no testing. British Columbia falls between these two groups of regions in the necessity for testing and advisory formation. All provinces with populations comparable to British Columbia (Alberta, Manitoba) have clear knowledge of their fish-mercury levels through regular or widespread testing, and create and distribute fish consumption guidelines.

Generic default values for consumer body weight (70 kg) and fish meal portion size (227 g) are used by all provinces and do not necessarily relate to specific populations or individuals in those populations. Not even the most extensive advisories have meal frequency recommendations for different weights and meal sizes. This insures that guidelines are generally either too restrictive or lenient for consumers. By providing meal

frequency and size recommendations for different body weights, the maximum amount of fish can be eaten by those capable of it and smaller individuals will be adequately protected (Marien and Stern 2005).

All provinces except for Quebec follow Health Canada guidelines for fish consumption even though these guidelines might be updated in the future to be more restrictive (USEPA 2005a). The rationale behind Quebec's decision to allow more mercury than the Health Canada TDI is unclear. Given the level of mercury in Great Lakes fish and the high fishing pressure, it is surprising Quebec and Ontario have not opted for more precautionary TDI's. The territories use of more restrictive TDI's is prudent given the higher fish consumption of First Nations communities for whom fishing is a stable and traditional food source. Manitoba's future adaptation of more restrictive and specific guidelines is the result of Health Canada's updated TDI's in 1998, revealing the pace of the transfer from science into policy.

The age that advisories recommend children limit consumption until changes from province to province, from years 8 to 15, which some advisories simply stating "young children." Nova Scotia, Prince Edward Island, and New Brunswick all define young children as being less than 8 years old. Neurological damage has been thought to occur at greater risk to children 14 and under; 15 is the age that should be used and it should be stated clearly.

The processes by which provinces get from fish-mercury data to risk assessment remain unclear and could be ascertained with further research. For instance, Prince Edward Island institutes mercury advisories when only one fish from a lake has been shown to breach 0.5ppm, while other provinces may rely on mean mercury levels for the species before creating guidelines. Provinces like Ontario and Manitoba use fish-mercury averages along with a power series regression model and the Health Canada TDI to create meal frequency recommendations based on predicted body burden levels rather than simply placing fish species with concentrations lower than 0.5 ppm in the "unlimited consumption" category.

2.4.2 Stakeholder participation

Ontario, Alberta, and Quebec are the only provinces that incorporate stakeholder participation into the testing and advisory formation process. Stakeholder participation throughout advisory creation and dissemination can make advisories more comprehensible, trustworthy, and more likely to be followed (Velicer and Knuth 1994; Chess *et al.* 1995a; Chess *et al.* 1995b). Stakeholder participation can also illuminate target groups so that communications can be tailored to their needs (Connelly and Knuth 1998). Quebec is the home base of COMERN, which conducts research in many provinces among fishers, communicates information to policy makers, and evaluates various methods of communicating information to policy makers. Ontario not only produces guideline instructions in various languages, but also has a separate pamphlet for pregnant women. This is the only province to focus specifically on target groups and also the only province to test advisory efficacy through questionnaires. DIAND and the NCP communicate and incorporate the suggestion of fish consumers, nongovernmental organizations, and First Nations community leaders to ensure that messages are being well received.

2.4.3 Communication methods

Many provinces communicate advisories through sport fishing regulations documents, but this method does not reach unlicensed anglers, non-fishing consumers of sport fish, or people who do not read regulations booklets cover to cover, which is usually the majority (Jack *et al.* 2003). The approach of Ontario and Quebec to have a separate booklet is good in that they can place it in locations that regulations are rarely found, such as beer stores and Canadian Tire. Manitoba's three-page pamphlet is distributed in all government offices rather than just those selling licenses. However, distribution of the pamphlet with licenses would be prudent too. Ontario's method of distributing a pamphlet directly to health officials is the perfect way to reach the sensitive population target audience. The territories' pamphlet is well designed with pictures for easy comprehension and distribution, and their reliance on community outreach is an effective way to get feedback and ensure people comprehend advisories.

Ontario is the only province to use traditional media channels to communicate advisories when they are updated. The territories also use this method even when fish are found to be safe, in order to encourage consumption. Media press releases are cheap and can be effective in reaching fishers who do not normally read regulations. All provinces should use this communication channel to reach fish consumers in addition to those already in use.

Posting advisories online is a cheap and effective way to reach an audience actively looking for advisories and, therefore, more responsive to them. Saskatchewan and Quebec do not have their advisories posted online at all, although Quebec has educational information and instructions on how to use the guide. Prince Edward Island, Nova Scotia, New Brunswick, and Alberta all have advisories online, but in almost impossible locations to find, most more than 40 pages deep into the fishing regulations. Having advisories online and easy to find through Google and government websites is a way to save paper and effectively reach people who are actively looking for information. In addition, the internet is the perfect forum for educating people who want more information, as links to other informative websites take few resources to createe.

While technically required to be so, not all provinces have guidelines available in French. Ontario publishes the Guide in English and French, as well as distributes instructions in 17 languages, being sure to reach all ethnic groups. Quebec only publishes the Guide and instructions on how to use it French, which makes communication to English speaking residents, tourists, and Cree who do not speak French impossible. No guides were found in any First Nations' languages.

2.4.4 Information communicated

Information on the health benefits of eating fish is important because fishers can overreact and stop consumption of low mercury fish when advisories are issued (Oken *et al.* 2003; Arnold *et al.* 2005; Cohen *et al.* 2005). Only half of the provinces, including the territories, include this information: Alberta, Saskatchewan, New Brunswick, Nova Scotia, and the Prince Edward Island do not. Information on the benefits of eating fish, as well as encouragements to do so, are especially important among First Nations communities because fishing can be such an critical part of a traditional lifestyle, without

which, societies, cultures, and human health can suffer (Shkilnyk 1984; Wheatley and Paradis 1995, 1996; Wheatley 1996, 1997; Wheatley and Wheatley 2000). Risk-risk comparisons (those that compare the health risks from eating contaminated fish to those from other harmful activities such as smoking) are important so that consumers can put mercury consumption in perspective (Reinert *et al.* 1991). The territories and Quebec are the only areas to do this. The lack of fish consumption guidelines in the advisories to the territories is unusual, especially when more restrictive TDI's are theoretically in place. This could be a result, in certain areas, of eating within guidelines, and could mean a total ban on local fish consumption. This could lead to a net reduction in public health (Boischio and Henshel 2000; Arnold *et al.* 2005).

2.4.5 Recommendations for British Columbia

Provinces that are similar to British Columbia in population density and fishing pressure have fish testing and fish consumption advisories distributed to the public. Both Alberta and Washington State, the areas around BC, have advisories instated as well. Testing of selected lakes on Vancouver Island has found fish-mercury concentration above 0.5 ppm. If people are eating these fish in large enough quantities, and other lakes have similar levels, health damage could be occurring. In order to protect public health, BC should conduct a risk assessment to decipher if advisories are necessary, and implement them if needed.

2.4.5.1 Mercury testing

Like Alberta and Manitoba, BC should conduct one large scale, province-wide fish-mercury assessment to ascertain mercury concentrations for various species and lakes in this province. After this initial study, only tests of highly contaminated lakes would be necessary in the future. A broad spectrum of lakes from north and south, near urban areas, with high fishing densities or subsistence fishers should be tested. Fish sampling should be conducted by angling large fish of each species rather than through nets and sampling all fish caught. Fishers are more inclined to keep large fish when caught and, given that mercury concentrations in older larger fish are higher (UNEP

2002; Weech *et al.* 2004), these are the concentrations that should be used. If mercury concentrations of a fish species in certain lakes are found to be above 0.5 ppm, advisories should be issued for that lake. If concentrations are generally found to be higher than 0.5 ppm for a certain species, a province wide advisory should be instated. If fish are found that breach 2 ppm, a cessation of consumption of that species should be recommended, as even one meal can cause health damage to a developing fetus (Ginsberg and Toal 2000).

2.4.5.2 Guideline formation

While the exact levels of mercury people can ingest without harm remain to be pinpointed this scientific uncertainty will always be present in research of this sort and policy makers should not see this as a reason for ignoring potential health risks (Meffe and Viederman 1995). The research is clear that the Health Canada TDI is too high to protect sensitive populations from neurological damage and men from heart failure. In an ideal scenario, the most precautionary of TDI's would be implemented and recommended. However, due to the tendency of fish consumers, especially pregnant women, to reduce consumption of even low mercury fish in the face of advisories (Oken *et al.* 2003; Arnold *et al.* 2005), and given the health benefits of eating fish, especially for pregnant women (Cohen *et al.* 2005), the most precautionary TDI's should not be instated unless health damage can be verified as likley. Acting on risk assessments when actual harm is low can cause more health damage than it prevents (Wheatley and Paradis 1996; Wheatley and Wheatley 2000). If mean mercury levels are greater than 0.5 ppm, advisories should be issued according to the Health Canada TDI. But if levels are consistently higher, or found in highly fished lakes or species, hair-mercury testing should be conducted on sport-fish consumers to assess if hair mercury levels of 1 ppm and 2 ppm are present for sensitive and general populations respectively. If these concentrations are not found, the more restrictive TDI should not be recommended, as it would unnecessarily limit beneficial levels of fish and could cause people to limit consumption further than advised.

If high fish-mercury concentrations are found in lakes used as subsistence fisheries by First Nations Communities, DFO should be alerted to work with

communities to instate and communicate advisories. Because First Nations people do not require fishing licenses, communication methods will have to be more diverse. Academic institutions could be utilized to work with these communities.

2.4.5.3 Stakeholder participation

Policy makers should continue to work with academic researchers, requesting data as needed and incorporating research into policy formation. Researchers should continue to create issue based science and format results in ways and through channels so that policy makers have access to them (Meffe and Viederman 1995). Scientists should come down from the ivory tower and work on issue-oriented problems in an interdisciplinary fashion (Rohlf 1991). Communications from researchers to policy makers should be precise and clear, as excessive or complex scientific information can cause policy makers to ignore research (Smith and Trip 339). If conducted in this fashion, research can be incorporated into policy decisions in order to more effectively communication fish consumption advisories (Ashizawa *et al.* 2005).

Communications with fishers to assess their levels of knowledge, fish consumption behavior, and what information they need and want to know in order to make healthy diet decisions should incorporated (Burger 2000a; Burger *et al.* 2003). Often public concerns and an agency's assessment of health risk do not correlate, resulting in some public health concerns being inadequately addressed and others commanding a disproportionate amount of agency resources (Tinker *et al.* 2000). Stakeholder participation will insure that messages are heard and are more likely to be trusted and followed (Belton *et al.* 1986; Chess *et al.* 1995a; Chess *et al.* 1995b). Because of gaps in the ways that the fishing public and the advisory agencies see risks and benefits, target audiences should be consulted and their recommendations considered (Velicer and Knuth 1994). While it is rare in other provinces, preliminary versions of the advisories should be tested and the comments of the fish consumers integrated. This is necessary because some advisories can miss target audiences completely, and only through research can effective policies and communications be instated (Ashizawa *et al.* 2005).

2.4.5.4 Communication Methods

If guidelines are created and advisories issued for BC, they should be communicated to fish consumers through multiple methods. A prominent page in the Sport Fishing Regulations should also be used to alert those 40% of BC fishers who read the Regulations (Jack *et al.* 2003), hoping they would pass this information on to other fishers and provide a more credible source (Belton *et al.* 1986). But this should not be the only method of communication. Surveys of fishers to illuminate target groups and design specific communications would be most effective, but might not be necessary. In lieu of this, a media campaign should be launched, an easily found webpage created, and signs should be posted on highly contaminated lakes. A short pamphlet like the one used by Manitoba or the territories would be easy to distribute and reach a broader audience than inclusion in the regulations alone.

A pamphlet targeting pregnant women specifically to be placed in doctor's offices should only be made if health risks are found to be high. Given that most pregnant women eat more commercial than sport fish (Morrissette *et al.* 2004), a random telephone survey or a survey in a doctor's office would need to be conducted to ascertain sport fish consumption among women of childbearing age in order to warrant this action. Only if pregnant women were shown to eat sport fish should this pamphlet be created. For BC, this might prove unnecessary.

2.4.5.5 Information communicated

Information specifying fish species, fish sizes, lakes, and meal frequencies should be provided for both general and sensitive consumers. Advisories should specify that the age of "young children" is ≤15. Consumption pattern data, species–specific contaminant data, and body weight data need to be used together to make advisories more specific and encourage maximum safe fish consumption while restricting only necessary (Marien and Stern 2005). Advisories for varying body weights are easy to create and follow (Table 2.5).

Government communications can be bland and complex (Chess *et al.* 2005) and surveys should be conducted to assure that fish consumers comprehend advisories. A cajoling rather than a commanding tone should be used (Connelly and Knuth 1998) and diagrams like those used territorial advisory pamphlets should be included to reach fishers with different learning styles or who do not speak English well (Burger *et al.* 2003). Information on the benefits of fish consumption and the basics of mercury in the ecosystem must accompany guidelines in order to keep consumers from cutting back on net fish intake. Risk-risk comparisons should be used to put mercury consumption into perspective (Reinert *et al.* 1991).

Providing fishers with alternatives to eating high mercury fish can keep fishers healthy and fishing. Recommendations could include lower mercury species, smaller sizes of fish, or other foods (Reinert *et al.* 1991; Burger *et al.* 2001a). Communicators can also encourage catch and release in very contaminated waters where fishing has been shown to be a recreational and cultural activity. This would also protect fisheries and tourist industries from financial loss (Burger *et al.* 2001a). Steps should also be taken to insure that fishers are not reducing consumption of all fish, or even all sport fish by conducting a pre-dissemination pilot study or a post-dissemination survey. Advisories should then be updated accordingly.

2.5 Conclusion

The breadth of the Great Lakes provinces' fish testing and advisory communication is not necessary in BC to protect public health, but some level of risk assessment is required to discern whether health damage is occurring. If high fish-mercury concentrations are found, many lessons can be learned from other provinces in order to institute fish consumption guidelines. By working with policy makers, other researchers, and fishers, this project establishes communication among stakeholders that will help to create sound, science-based policy and advisories that improve public health.

Tables: Chapter 2

Table 2.1. Benefits of fish consumption with respect to heart disease and stroke (Source: Gochfeld and Burger 2005).

Fish consumed (g/day)	Reduced health infliction
15	fatal heart disease
14	myocardial infarction in men
32	myocardial infarction in women
14	heart disease in nurses
32	stroke in nurses
7 - 22.5	overall adult cardiovascular benefit

Table 2.2. Estimates of maternal hair mercury concentrations associated with benchmark lower dose confidence limits for fetus neurotoxicity.

Study Site	Maternal Hair Hg	Age	Result
Faroe Islands	4.3 ppm	7	negative effects
Seychelles	6.8 ppm	5	positive effects
New Zealand	6.0 ppm	6	negative effects

Table 2.3. Tolerable Daily Intake (TDI) values used by various international and national agencies.

Agency	TDI for general populations (μg/kg/day)	TDI for sensitive populations (μg/kg/day)	Other specifications
World Health Organization	0.23	0.23	
Health Canada	0.47	0.2	* Pregnant women & children should eat shark/tuna/etc. ≤ 1x/month * Others eat shark/tuna/etc. ≤ 4x/month * Fish completely safe if < 0.5ppm Hg
US EPA	none	0.1	* TDI's only for sensitive populations * Fish >1ppm Hg not to be eaten * Fish > 0.2ppm Hg eaten ≤ 1x/week

Table 2.4. Aquatic life guidelines for fish/shellfish when human diet is based primarily on fish (Source: Nagpal 2001).

Hg concentration (µg total Hg/g w/w)	Safe Quantity for Weekly Consumption (grams w/w)
0.5	210
0.4	260
0.3	350
0.2	525
0.1	1050

Table 2.5. Revised consumption advice for fish at different mercury concentrations based on precautionary Tolerable Daily Intake (TDI) amounts (0.06 μg/kg/day for sensitive populations and 0.1 μg/kg/day for the general population) and compared to current Health Canada recommended meal frequencies. Estimated meal size is 227 g.

		Meals per month safe to eat for people of different body weights and sensitivities							
		Calculated based on precautionary Tolerable Daily Intake amounts						Current Health Canada recommendations	
[Hg] in fish (ug/g)	**Health Canada risk category**	General pop.			Sensitive pop.			General pop.	Sensitive pop.
		50 kg	70 kg	90 kg	50 kg	70 kg	90 kg	70 kg	70 kg
0.50	< 0.5 ppm	1.3	1.9	2.4	0.8	1.1	1.4	unlimited	unlimited
1.00	0.5-1.5 ppm	0.7	0.9	1.2	0.4	0.6	0.7	4	1
1.50	0.5-1.5 ppm	0.4	0.6	0.8	0.3	0.4	0.5	4	1

Table 2.6. Revised mercury concentrations and consumption advice for commercial fish in Victoria based on precautionary Tolerable Daily Intake amounts (0.06 μg/kg/day for sensitive populations and 0.1 μg/kg/day for the general population). Estimated meal size 227 g.

		Meals per month safe to eat for different people					
	[Hg]	General population			Sensitive population		
Kind of fish	in ug/g	50 kg	70 kg	90 kg	50 kg	70 kg	90 kg
Tilapia	0.023 B	28.7	40.2	51.7	17.2	24.1	31.0
Farmed atlantic salmor	0.036 B	18.4	25.7	33.0	11.0	15.4	19.8
Rainbow trout	0.037 B	17.9	25.0	32.1	10.7	15.0	19.3
Trout	0.037 B	17.9	25.0	32.1	10.7	15.0	19.3
Sockeye	0.038 B	17.4	24.3	31.3	10.4	14.6	18.8
Wild sockeye	0.038 B	17.4	24.3	31.3	10.4	14.6	18.8
Farmed salmon	0.04 B	16.5	23.1	29.7	9.9	13.9	17.8
Flounder	0.049 D	13.5	18.9	24.3	8.1	11.3	14.6
Coho salmon	0.05 A	13.2	18.5	23.8	7.9	11.1	14.3
Wild coho	0.05 A	13.2	18.5	23.8	7.9	11.1	14.3
Red spring salmon	0.053 B	12.5	17.5	22.4	7.5	10.5	13.5
Spring salmon	0.053 B	12.5	17.5	22.4	7.5	10.5	13.5
Wild spring salmon	0.053 B	12.5	17.5	22.4	7.5	10.5	13.5
Sole	0.06 A	11.0	15.4	19.8	6.6	9.3	11.9
Canned light tuna	0.085 B	7.8	10.9	14.0	4.7	6.5	8.4
Cod	0.095 D	7.0	9.7	12.5	4.2	5.8	7.5
Skate wing	0.137 D	4.8	6.8	8.7	2.9	4.1	5.2
Perch	0.14 D	4.7	6.6	8.5	2.8	4.0	5.1
Alaska black cod	0.17 D	3.9	5.4	7.0	2.3	3.3	4.2
Grey cod	0.17 B	3.9	5.4	7.0	2.3	3.3	4.2
Red snapper	0.189 D	3.5	4.9	6.3	2.1	2.9	3.8
Snapper	0.189 D	3.5	4.9	6.3	2.1	2.9	3.8
Halibut	0.252 D	2.6	3.7	4.7	1.6	2.2	2.8
Canned albacore tuna	0.26 B	2.5	3.6	4.6	1.5	2.1	2.7
Rockfish	0.29 A	2.3	3.2	4.1	1.4	1.9	2.5
Hawaiian ahi tuna	0.325 B	2.0	2.8	3.7	1.2	1.7	2.2
Dover sole	0.9 C	0.7	1.0	1.3	0.4	0.6	0.8
Sword fish	1.822 B	0.4	0.5	0.7	0.2	0.3	0.4

References:
A: (Marien and Stern 2005)
B: (Dabeka *et al.* 2004)
C: (USFDA 2006)
D: (USEPA 2001)

Table 2.7. Fish consumption guidelines for select British Columbia fish and lakes based on precautionary Tolerable Daily Intake levels (0.06 μg/kg/day for sensitive populations and 0.1 μg/kg/day for the general population) and most recent Ministry of the Environment fish-mercury data. Estimated meal size is 227 g.

Location and species of fish being eaten	[Hg] in fish (ug/g)	Meals per month safe to eat for people of different body weights and pregnancy status					
		General population			Sensative population		
		50 kg	70 kg	90 kg	50 kg	70 kg	90 kg
Cusheon Lake							
Small Mouth Bass	0.637	1.0	1.5	1.9	0.6	0.9	1.1
Rainbow Trout	0.230	2.9	4.0	5.2	1.7	2.4	3.1
Elk Lake							
Small Mouth Bass	0.354	1.9	2.6	3.4	1.1	1.6	2.0
Fuller Lake							
Small Mouth Bass	0.103	6.4	9.0	11.6	3.9	5.4	7.0
Rainbow Trout	0.055	12.1	16.9	21.8	7.3	10.2	13.1
Langford Lake							
Small Mouth Bass	0.104	6.4	8.9	11.4	3.8	5.3	6.9
Yellow Perch	0.080	8.3	11.6	14.9	5.0	6.9	8.9
Rainbow Trout	0.060	11.0	15.4	19.8	6.6	9.3	11.9
Prospect Lake							
Small Mouth Bass	0.474	1.4	1.9	2.5	0.8	1.2	1.5
Quennell Lake							
Small Mouth Bass	0.350	1.9	2.6	3.4	1.1	1.6	2.0
Rainbow trout	0.090	7.3	10.3	13.2	4.4	6.2	7.9
Shawnigan Lake							
Small mouth bass	0.737	0.9	1.3	1.6	0.5	0.8	1.0
Spider Lake							
Small mouth bass	0.130	5.1	7.1	9.1	3.0	4.3	5.5
Rainbow trout	0.050	13.2	18.5	23.8	7.9	11.1	14.3
St. Mary Lake							
Small mouth bass	0.346	1.9	2.7	3.4	1.1	1.6	2.1
Yellow perch	0.070	9.4	13.2	17.0	5.7	7.9	10.2
Rainbow trout	0.100	6.6	9.3	11.9	4.0	5.6	7.1
Thetis Lake							
Small mouth bass	0.318	2.1	2.9	3.7	1.2	1.7	2.2

Table 2.8. Fish consumption guidelines for select British Columbia fish and lakes based on Health Canada Tolerable Daily Intake levels (0.2 μg/kg/day for sensitive populations and 0.47 μg/kg/day for the general population) and most recent Ministry of the Environment fish-mercury data. Estimated meal size is 227 g.

Location and species of fish being eaten	[Hg] in fish (ug/g)	Meals per month safe to eat for people of different body weights and pregnancy status					
		General population			Sensative population		
		50 kg	70 kg	90 kg	50 kg	70 kg	90 kg
Cusheon Lake							
Small Mouth Bass	0.637	4.9	6.8	8.8	2.1	2.9	3.7
Rainbow Trout	0.230	13.5	18.9	24.3	5.7	8.0	10.3
Elk Lake							
Small Mouth Bass	0.354	8.8	12.3	15.8	3.7	5.2	6.7
Fuller Lake							
Small Mouth Bass	0.103	30.3	42.4	54.5	12.9	18.1	23.2
Rainbow Trout	0.055	56.9	79.6	102.4	24.2	33.9	43.6
Langford Lake							
Small Mouth Bass	0.104	29.9	41.8	53.8	12.7	17.8	22.9
Yellow Perch	0.080	38.8	54.4	69.9	16.5	23.1	29.7
Rainbow Trout	0.060	51.8	72.5	93.2	22.0	30.8	39.6
Prospect Lake							
Small Mouth Bass	0.474	6.5	9.2	11.8	2.8	3.9	5.0
Quennell Lake							
Small Mouth Bass	0.350	8.9	12.4	16.0	3.8	5.3	6.8
Rainbow trout	0.090	34.5	48.3	62.1	14.7	20.6	26.4
Shawnigan Lake							
Small mouth bass	0.737	4.2	5.9	7.6	1.8	2.5	3.2
Spider Lake							
Small mouth bass	0.130	23.9	33.4	43.0	10.2	14.2	18.3
Rainbow trout	0.050	62.1	87.0	111.8	26.4	37.0	47.6
St. Mary Lake							
Small mouth bass	0.346	9.0	12.6	16.2	3.8	5.3	6.9
Yellow perch	0.070	44.4	62.1	79.9	18.9	26.4	34.0
Rainbow trout	0.100	31.1	43.5	55.9	13.2	18.5	23.8
Thetis Lake							
Small mouth bass	0.318	9.8	13.7	17.6	4.2	5.8	7.5

Table 2.9. Fish-mercury testing, fish consumption advisory creation, and dissemination protocols in Canadian Provinces. Part 1 of 4.

Province	Hg Fish Advisories	Fish Testing Protocol	Guideline Creation Protocol	Stakeholder Participation
Alberta	16 water bodies are under advisory for mercury.	Contaminating Industries test fish and reports to Alberta Health & Wellness. In 2004, HC's Bureau of Chemical Safety conducted a risk assessment in Alberta Parks.	Alberta Health & Wellness takes recommendations to the Public Health Advisory Comm. who takes them to the Provincial Health Officer who creates guidelines and advisories.	In 2002, the Northern River Basins Study was managed by aboriginal leaders, govt. officials, and municipal representatives along with members of the environmental, health, agricultural, industrial, and public sectors. This resulted in updated advisories for affected lakes.
British Columbia	Unknown. 3 reservoirs and 1 lake have high Hg fish and are under advisory. Some fish from popular angling lakes have Hg over the HC guideline, but mean levels remain below. No Provincial Guidelines exist.	Polluting industries and university researchers test of their own volition. Ministry of Environment currently testing select southern lakes. Fish testing is sporadic and last conducted in 2005.	None	None
Manitoba	42 lakes and rivers are under advisory.	Manitoba Hydro monitors flooded lakes. The Manitoba Dept. of Water Stewardship monitors fish near industrial areas, urban centers, agricultural zones, reservoirs, and recreational angling lakes. Testing from the 1980s to the 1990s ceased when levels declined. Resumed in 2000s and found decline.	Guidelines are updated every few years to reflect new testing and research.	Unknown.
NFL & Labrador	Hg levels >HC guidelines have been found in 8 lakes, all of which are under advisory. 2 lakes, the results of flooding, have very high fish-Hg.	The Federal DFO oversees fish testing. Health Canada collects and analyses samples. DFO may also work with Universities to collect data.Star Lake, with the highest Hg, is tested annually.	The federal DFO oversees guideline creation. They receive data from HC and assess if guidelines are necessary. It is unclear what Hg TDI they are using or what contaminant levels are. Northern Labrador is part of the Northern Contaminants Program (see Nunavut)	DFO works with academic institutions to collect data. In northern Labradoe, he NCP works with various government agencies and community leaders to create and issue advisories.
New Brunswick	Most species of fish in NB are above the HC guideline. Exceptions are Atlantic salmon and brook trout <29cm.	The federal DFO last conducted extensive testing in 1997.	New Brunswick Dept. of Health and Wellness use DFO data to create advisory.	Unknown.
Northwest Territories	3 reservoirs and one lake have high Hg fish. Some fish from popular angling lakes have Hg over the Health Canada guideline, but mean levels remain below. There are warnings and education, but guidelines in the traditional sense do not exist.	The federal DFO monitors fish. Communities often collect fish samples and send them to DFO for analysis. If levels are >HC guidelines, data are sent to HC for risk assessment. Fish testing is sporadic and at the behest of residents.	HC guideline used. HC and GNWT assess if guidelines are necessary. The Center for Indigenous Nutrition and Env. also uses data to assess indigenous exposure. The NWT Env. Contaminant Comm. also assesses risk.	Gov. agencies work closely with residents and First Nations communities. The N.W.T. Env. Contaminants Comm.. includes representatives from GNWT Health, the Center for Indigenous Nutrition & Env., and the Northern Contaminates program.

Table 2.9 cont'd. Fish-mercury testing, fish consumption advisory creation, and dissemination protocols in Canadian Provinces. Part 2 of 4.

Province	Hg Fish Advisories	Fish Testing Protocol	Guideline Creation Protocol	Stakeholder Participation
Nova Scotia	Most species of fish are above the HC guideline. Exceptions are Rainbow trout, white perch, and small brook trout.	Fish testing is conducted by the NS Dept. of Fisheries and Aquaculture. No strict protocol is in place.	No strict protocol is in place. The NS Dept of Health, the Dept of Environment and Labour, and the NS Dept of Fisheries all collaborate on advisories.	Government agencies collaborate on guideline formation. NS is part of the New England Governors and Eastern Canadian Premiers association.
Nunavut	Unknown levels of Hg and no advisories.	None. The federal DFO would collect fish samples if it was found necessary. As part of the NCP, DIAND would collect samples as well.	Nunavut Health & Social Services would be responsible for issuing advisories if it was found necessary. The Nunavut Environmental Contaminant Comm. And Health Canada would also participate in the process.	As part of the Northern Contaminants Program (NCP) federal government agencies, territorial health officers, and aborigional community leaders would work together if necessary.
Ontario	All fish in Ontario are under advisory for many contaminants. Hg levels are high. Fish consumption guidelines most extensive in Canada, with recommendations for each species in more than 1,700 lakes and rivers.	The Ontario Ministry of the Environment and the Ministry of Natural Resources collect samples. 100 old and 50 new locations are tested each time. Ontario Power Generation, various universities, and angler clubs also collect samples. Fish in Great Lakes tested each year, alternating species.	The Ontario MoE issues the guidelines using a power regression model and the HC TDI. Average body weights and meal sizes are assumed.	Government agencies work with universities, angler clubs, international Great Lakes organizations, conservation authorities, and private consultancies. Advisories are tested by issuing a questionnaire to fishers biannually.
Prince Edward Island	1 lake has trout with Hg >0.5ppm and it is under advisory.	Unknown.	Unknown. The PEI Dept. of Health advises the public.	Unknown.
Quebec	Due to the high industry levels and population, Quebec has high fish Hg and extensive guidelines. More than 800 lakes and 40 fish species are reported on.	The ministère des Ressources naturelles et de la Faune (MRNF) decides which lakes to test and collects samples. The ministère du Développement durable de l'Env. et des Parcs (MDDEP) tests samples and discusses analysis with the ministère de la Santé et des Services sociaux (MSSS). Hydro Quebec also tests fish in reservoires, as do university researchers. Selected lakes tested every 5 -10 years.	The MDDEP and the MSSS issue guideline after getting additional data from Hydro Quebec and university researchers. The Collaborative Mercury Research Network (COMERN) conducts extensive research in Quebec. Guidelines are higher than the HC limitations.	Many government agencies work together to produce guidelines, as well as industry representatives. Researchers of COMERN in the social and physical sciences work with fishers to test advisory efficacy.
Sask	Fish Hg levels are unknown and no advisories are issued.	Saskatchewan Env. & Resource Mngmt. (SERM) tests popular fishing lakes, commercially fished lakes, and waters near pollution for Hg. New data are collected annually.	Unknown.	The committee that makes up SERM is comprised of representatives from the provincial Depts of Env. and Resource Management as well as Health.
Yukon	Fish Hg levels are unknown and. According to the Env. Canada website, no advisories are issued.	The Dept. of Indian Affairs and Northern Development collects and analyzes fish samples, as part of the Northern Contaminants Program (NCP). Results are sent to the Yukon Contaminants Comm. (YCC). Testing frequency is unknown.	Fish-Hg data sent to YCC, which decides if assessment is needed. Data may be sent to HC for analysis. Results sent to the Yukon Dept. of Health, which informs the YCC and the Depts. of Health & Social Services (HSS) and Renewable Resources. HSS and the Min. of Health will issue advisory if necessary.	As part of the NCP, federal government agencies, territorial health officers, and aborigional community leaders all work together.

Table 2.9 cont'd. Fish-mercury testing, fish consumption advisory creation, and dissemination protocols in Canadian Provinces. Part 3 of 4.

Province	Information Communicated	Advisory Communication Strategy	Target Group Communication	Potential Weaknesses
Alberta	•Brief basics of bioaccumulation. Fish from 16 water bodies are indicated that fishers should eat no more than 1/ week. Fish size and meal sizes are not mentioned. • Recommends curious anglers contact regional Fish and Wildlife office for more information. Phone number given.	• Advisories are in the sport fishing regulations •They are distributed where fishers purchase licenses. Can be printed or ordered online but are hard to find.	Women of childbearing age and children are advised not to eat certain fish.	Only communicated through Fishing Reg.s. Specific populations are not targeted. Sizes of fish are not mentioned. Benefits of eating fish not provided.
British Columbia	Fish from 2 lakes have high Hg-concentrations. Normal consumption is fine but high consumption may cause health damage. Contact local health unit for more information. No contact information given.	•3 sentences on page 78 of the Freshwater Fishing Regulations Synopsis. •Regs are distributed with fishing licenses at bait & tackle shops.	None.	Hg levels unknown, fish consumption unknown, advisories minimal. Health damage could exist.
Manitoba	Info on Hg, bioaccumulation, and fish species, meal amounts, and water bodies safe for consumption. For non-sensitive anglers: recommends 10 meals/week of fish 0.5-1.0 ppm for short term, or 1 meal/week for long term. For fish 1.0-1.5 ppm recommends 7 meal/week for short term, or 1 small meal/week for long term. Fish >1.5 ppm not to be eaten. Women and children <15 only to eat fish <0.5ppm. Recommendations are more restrictive in future advisories.	•3 page pamphlet •Available online, and from government offices that serve the walk-in public. •Phone number and address provided for further inquiry.	Aside from specific guidelines for sensitive populations, the guide does not target specific groups. Nutrition advice to First Nations comes from HC.	Advisories do not take consumer weight into consideration. Specific audiences are not targeted.
NFL & Labrador	6 lakes have advisories limiting fish to once/week. 2 lakes have specific advisories in oz/week that are safe for women of childbearing age, children 5-11, and children 1-4. No contact information is provided.	• DFO sends releases to the provincial and local media when advisories are created or renewed. May also create signs on lakes and host public information sessions.	Specific amounts are given for women of childbearing age.	Lake testing freq. unclear. Aside from guidelines for sensitive pop., groups are not targeted. Consumer weight not considered.
New Brunswick	Advisories are based on HC guidelines. Women of childbearing age are advised to avoid sport fish except for Atlantic salmon. Small brook trout may be eaten 1/month. Pregnant women should avoid all fish. Children >8, men, and older women, may eat small brook trout 1/week, and other fish 2/month. Phone number and address are provided for further inquiry.	•On page 40 of the Sport Fishing Regulations. •Available online but difficult to find. Reg. booklets distributed at bait & tackle shops, & government offices where anglers purchase licenses.	Women of childbearing age and pregnant women are given different meal frequencies.	Advisories only available in Reg.s and difficult to find. Aside from guidelines for sensitive pop., groups are not targeted. Consumer weight not considered. Meal size not provided.
Northwest Territories	Fact sheets include information on bioaccumulation, where Hg comes from and how it gets into fish, how it hurts people, health benefits of eating fish, risk-risk comparisons of eating fish, advice to eat smaller fish, lower on the food chain. Examples of safe fish are given. Traditional foods are reaffirmed as safe and healthy. No specific fish species or meal amounts are provided as safe. The Env. Canada website advises that sportfish should be eaten 2/month. Phone number and address are provided for further inquiry.	Fact sheets distributed are short, clear, and use pictures and text. Territorial health depts. decide how to communicate with communities. Media alerted, but more often communities host meetings with researchers & NWT ECC members. Indian & Northern Affairs Canada produces factsheets available online.	Indian and Northern Affairs creates factsheets targeting First Nations fishers. They contain pictures of aboriginal women. Info targeting women on why to eat less is provided.	Fish species and meal frequency and sizes are not provided except on the Env. Canada website.

Table 2.9 cont'd. Fish-mercury testing, fish consumption advisory creation, and dissemination protocols in Canadian Provinces. Part 4 of 4.

Province	Information Communicated	Advisory Communication Strategy	Target Group Communication	Potential Weaknesses
Nova Scotia	All rainbow trout and small brook trout and perch are always safe to eat. Brook trout and perch >25cm should be eaten 1/week. Other fish should be eaten 2/month. Children <8, pregnant women and nursing mothers should only eat rainbow trout, perch and small brook trout. Phone number provided for further inquiry.	• The NS Dept of Fisheries & Aquaculture publishes the advisory on page 63 of the sport fishing regulations. •Booklet is available online but difficult to find.	Pregnant women, young children, and nursing mothers are given different consumption advice.	Advisories are hard to find, give limited information, communicated only through fishing reg.s, and are not audience specific.Information on the benefits of fish are not included.
Nunavut	No information is communicated.	If advisories were found necessary, as part of the NCP, the Nunavut Contaminants Comm. would work with press and communities to spread information.	Aborigional advisors part of the Contaminants Comm. and would assure advisories would be comprehensive.	Risk levels are unknown.
Ontario	For each water body, there is a list of fish species and the amounts that can be eaten for each length of fish by the general population as well as women of childbearing age and children <15. Meal amounts for body weights are not given. The Guide has information on where Hg is from, the process of bioaccumulation, and the sources and amounts of the HC TDI levels. Many phone numbers and addresses provided.	•The Guide to Eating Ontario Sportfish is a book published biannually. A 3 page pamphlet describing how to use the Guide is published in 17 languages. • About 350,000 copies of the guide are published and distributed by the MoE to gov. offices, tourist kiosks, fish licenses distributors, beer stores and Canadian Tires. The MoE also issues lake signs, bulletins, and press releases. Guides are also available online.	Guide contains numerous messages for pregnant women and the MoE issues a seperate pamphlet for medical officers of health. Guide is not in Regulations so more acceble to non-fishers. Ethnic groups are targeted with instructions in thier language.	The only potential problem is that the Guide is massive and complex. But while it may intimidate some consumers, it is the most comprehensive advisory in Canada. Meal amounts are based on average body weights but this is stated and assumes smaller people eat less.
Prince Edward Island	Pregnant women and children <8 should avoid trout from one lake.	•Communication strategy is unknown. It is available online but very difficult to find.	Unknown.	Advisories are limited and officials could not be reached for info.
Quebec	Fish with Hg <0.5 ppm can be eaten 8/month. Hg contents and healthy meal frequencies provided for various water bodies and sizes of each fish species. Women of childbearing age, nursing mothers, pregnant women & young children instructed to only eat fish <0.5ppm. Info on Hg in fish, people, and the environment also provided. Phone # and address provided for further inquiry.	Fish consumption guide is in French only and available in paper form from MSSS offices. Instructions on how to use guide and extensive info on Hg & fish are also in French only and available on MDDEP website. COMERN researchers conduct community outreaches and info sessions, as well as test the efficacy of advisories and recommend changes.	A paragraph recommends women of childbearing age, nursing mothers, pregnant women, and young children are to eat less contaminated fish.	The Guide is not available online and distributed only through gov. offices. The Guide and instructions are only available in French while many fish consumers are tourists.
Sask	Consumption advisories for lakes, fish species, and populations sensitivity levels are given.	Guidelines unavailable on EC website.The Fish Anglers Guide mentions that fish are tested and results available but doesn't say where. Methods of distribution are unknown.	Unknown.	Guide is not available online.
Yukon	No information is communicated.	If advisories are issued, the Yukon Contaminants Comm. would communicate them through notices and community meetings, & Fishing Regulations Summary	As part of the NCP, advisories would be created with consideration of aborigional communities.	It does not seem that fish are tested for Hg in the Yukon.

Chapter 3: Knowledge, concern, and communication potential within a sport fishing community on Vancouver Island

3.1 Abstract

British Columbia has no fish consumption guidelines for sport-caught fish. However, the Ministry of the Environment is currently conducting fish-mercury tests of selected lakes on Vancouver Island to see if BC fish could contain enough mercury to cause health damage to regular or sensitive consumers. Preliminary results indicate that there is enough mercury in some fish, small mouth bass especially, to cause damage depending on levels of consumption. The next necessary step for assessing risk, is to quantify angler consumption. If a suitable risk is found, measures need to be taken for the institution and dissemination of fish consumption guidelines alerting fishers to lakes, species, and amounts of fish that are safe to eat, so that they may continue fishing and eating healthy sport-caught fish.

A survey was designed to obtain demographic information, fish consumption behavior, sources of health information, and levels of concern and knowledge regarding mercury, as well as to assess the fishers' level of desire to know more about the benefits and risks of eating fish. The survey was conducted during the spring and summer of 2004 and 99 fishers on Elk Lake were interviewed. The study evaluated the state of mercury knowledge among fishers (current awareness), how mercury information reaches fishers (information flow), and how they use that information to make decisions about their diet (personal diet management).

Results showed that 40% of respondents constituted a "sensitive population" or could potentially feed fish to a sensitive family member. Half (49%) of those surveyed were concerned about mercury in fish. The majority (67%) of people wanted to know more about the risks and benefits of eating fish and would read a guide about mercury in local fish if it were available. Half (49%) of people had a basic or advanced understanding of the issues surrounding mercury in fish. There was a significant correlation between fishers who knew more about mercury and those who were concerned about it. Results indicated that the best way to reach fishers with fish consumption information was a combination of pathways focusing on a website. They

trusted scientists more than the media or the government to provide them with correct information and to have their best interests in mind. Recommendations are made for further testing and the eventual institution and distribution of fish consumption guidelines.

3.2 Introduction

Fish consumption is beneficial to human health but can also cause damage from the mercury contamination that exists in certain populations, species, sizes, ages, and tropic levels of fish. Governments protect fish consumers by providing recommendations for sport, sustenance, and commercial fish. Health Canada adopted a mercury concentration limit of 0.5 mg Hg/kg fish wet weight for domestically produced and imported commercial fish that are thought to be consumed with regularity by the average person. Other fish, such as shark, swordfish, and non-canned tuna, have mercury concentrations that exceed the limit; however, they are thought to be delicacies and not consumed often enough to cause damage.

In Canada, the regulation and advisory creation process for commercial fish is federal, while provinces are responsible for creating consumption advisories for sport fish. Most provinces have protocols in place for testing fish, creating consumption guidelines, and communicating advisories to fish consumers. Yet BC is only now looking into province-wide fish testing to ascertain the extent to which advisories are necessary. Certain fish have already been found with mercury concentrations above the Health Canada concentration for unlimited consumption, so if anglers are consuming fish frequently enough, or constitute sensitive populations, BC fish could be causing health damage. It is unknown what information consumers are using to make diet decisions for self caught fish. This study will provide policy makers with effective pathways and formats to communicate necessary information to sport fishers.

3.3 Study rational and objectives

In order to assess the potential health risk of BC fish for sport fish consumers and implement effective fish consumption guidelines, it is necessary to know the various mercury concentrations of fish species, sizes, and ages from various lakes, reservoirs, and rivers. Then the amount of methylmercury that is safe for general human consumption, and how much is safe for sensitive populations and subsistence fishers needs to be determined. Then one has to ascertain how much fish fishers are eating and feeding to others, and whether or not these amounts constitute a health risk.

All, or most, of these steps are conducted by most Canadian provinces in order to adequately protect their fishers and fish consumers. Presently, the Ministry of the Environment in BC has tested fish-mercury concentrations in selected lakes on BC's islands (Epps and Rieberger unpublished data) (Figure 1.4). Results indicate that, if sport fishers are eating these fish regularly and feeding them to others who fall into sensitive groups, fish consumption guidelines would be necessary to protect the health of these people (Table 2.8).

It has been shown that policy makers and scientists can have elevated conceptions of how dangerous a health issue is and how much action is necessary compared to the fish-consuming public (Burger *et al.* 1999b). With various policy changes in the United States taking place in the last year, much attention has been paid by the press to the issues of mercury in fish (Burros 2006b), so it can be expected that fishers would know about the issue and might also be concerned. However, since BC does not have fish consumption guidelines, it was unknown what information fishers were using to make diet decisions.

In order for fish consumption guidelines to be effective, it is essential to understand how the target audience perceives the issues surrounding mercury in fish (Connelly and Knuth 1998; Burger *et al.* 1999a; Burger 2002a; Knuth *et al.* 2003; Chess *et al.* 2005). Before the provincial government commences creating and disseminating information about mercury in local fish, it is necessary to assess what information fish consumers know, what they want to know, and whether or not that information would be helpful to them. Conventional methods can sometimes be effective in reach fish consumers, but often fishers do not read fishing regulations (Pflugh *et al.* 1999; Burger *et*

al. 2003; Jack *et al.* 2003) and can miss, ignore, or misinterpret media alerts (Belton *et al.* 1986; Tilden *et al.* 1997; Burger *et al.* 1998; Jakus *et al.* 1998; Burger and Waishwell 2001; Imm *et al.* 2005). In order for advisories to work, the best paths and forms of communication must be determined, and then, of course, they need to be implemented. To complete these steps, a survey of sport fishers had to be conducted. This survey also accomplished a desirable goal of involving all stakeholders in the policy process from the beginning, to insure that advisories, if necessary, are comprehensible, trustworthy, and effectively communicated to those who need them (Chess *et al.* 1995a; Chess *et al.* 1995b).

The objectives of the present study were to assess a) fishers' state of knowledge about mercury in fish (current awareness), b) how mercury information is conveyed to fish consumers (information flow), and c) how humans use that information to make decisions about their diet (personal diet management).

3.4 Methods

3.4.1 Summary of methods

3.4.1.1 Study design

A questionnaire was designed to obtain demographic information, fish consumption behavior, sources of health information, and levels of concern and knowledge regarding mercury, as well as to assess the fishers' level of desire to know more about the benefits and risks of eating fish. The survey design was based on the Salant & Dillman Method (Salant and Dillman 1994), as well as the fish consumption and knowledge surveys of Dr. Joanna Burger and others (Burger 1998b; Burger *et al.* 1999c; Pflugh *et al.* 1999). The University of Victoria Human Research Ethics Board approved the questionnaire and sampling procedures.

3.4.1.2 *Sampling procedures*

Ninety-nine sport fishers were interviewed on Elk Lake between May and August, 2004. Interviews took place from dawn till dusk on all days of the week. Subjects were interviewed from shore, on a dock, and from canoes, but were more likely to agree to be

surveyed from the shore or the dock than from a boat. Fishers were asked to respond if they were actively fishing at the time of approach and each fisher was interviewed only once, even if present on subsequent visits. When surveying more than one fisher in a group, attempts were made to keep voice levels low so as not to bias the next respondent. Attempts were made to integrate with the fishing community on the dock and to actively fish with them in order to increase rapport. Fishers seen on subsequent visits would often inquire about the study's progress.

The questionnaire was long, over 200 questions, and took 20 to 40 minutes to complete depending on how much the interviewee felt like talking. Subjects were warned in advance of the time commitment so as not to tire by the end. Interviews were conducted by the lead author alone, or with a partner present when a boat was necessary. Sensitive questions such as income and education were asked at the end of the survey.

After the survey, respondents were asked if there was anything else important about the lake, fishing, or mercury in fish they would like to add, or if they had any questions that could be answered. Fishers who requested more information about the benefits and risks of mercury in fish were provided with it.

For open-ended questions, the primary author read all responses for each question, and then categorized them into themes. For some responses $N \neq 99$ because respondents chose not to answer certain questions. We used non-parametric analysis of variance (Chi-square, Mann Whitney ,Wilcoxon option in SPSS 11), yielding an X^2 statistic to examine difference among groups. We used a significance level of $P < 0.05$.

3.4.2 Selection of study site

3.4.2.1 Commercial fish consumers vs. sport fish consumers

All fish have some mercury in them. Some regions and lakes have fish with mercury concentrations harmful to normal human consumption. Ocean fish can have similarly high concentrations. Fish consumers need to be provided with information advising them of safe species and amounts of both commercial and sport caught fish. In Canada, the CFIA tests commercial fish for elevated mercury concentrations and advises sensitive populations and others away from regular consumption of high-mercury fish. However, this is not always an effective method of protecting people, as some people are

not aware of the advisory warnings, and certain individual fish can have mercury concentrations far higher than the mean of that species. The only known case of Minamata disease in BC recently was the result of commercial fish (Copes *et al.* 2004), and some studies have shown a higher correlation between hair-mercury levels and commercial fish than sport-fish in women who eat both. It may well be true that Canada and BC could improve their communication of the risks of eating high-mercury commercial fish to all people, yet Canada, and thus BC, does have policy in place for testing and alerting fish consumers on these issues. No policy or regular testing exists in BC for sport-caught fish. It was the intention of this study to assess if this lack of sport fish advisories could be harmful, and to do that, sport-fishers and sport fish consumers had to be consulted.

3.4.2.2 Water body selection

Sport fishers in BC fish in lakes, rivers, and the ocean. Ocean fish such as tuna, shark, and mackerel are well known for their high mercury averages and other fish with high mercury are being discovered (Wiwchar 2004; Debruyn 2006). Yet most of these fish inhabit waters far from the coast, in inaccessible locations for the majority of regular sport fishers. In addition, the vast majority of ocean and river angling effort has focused on salmonids (BC Fisheries 2000), which are low mercury fish (USFDA 2006). Even if ocean fish were deemed a significant health threat to BC's anglers, saltwater, tidal, and in-river salmon fishing are regulated by Fisheries and Oceans Canada (DFO 2005) and advisories would be issued on the federal level if they were deemed necessary (BC Fisheries 2000).

Most of the fishing done in BC is done in lakes (Jack *et al.* 2003). About half of the lake-angling effort in BC is in lakes that are stocked (BC Fisheries 2000), but even stocked lakes have been shown to contain non-stocked fish with high mercury concentrations as well (Epps and Rieberger unpublished data) (Figure 1.4). In addition, the logistics of locating fishers on a lake is far easier than finding anglers fishing along the coast. Thus, it was determined that this research would focus on sport fishers who angle in lakes.

3.4.3 Description of the study site: Elk Lake

3.4.3.1 Physical and ecological characteristics of Elk Lake

Elk Lake is a natural lake located at the south east tip of the island (48°31' N, 123°23'W) (Figures 3.1A & 3.1B) and Kainz and Mazumder (2005) confirmed it as mesotrophic and monomictic. It has a maximum depth of 17.9 m and a mean depth of 7.7 m (MoELP 1992). It has a flushing rate of 4.5 years and a dissolved organic carbon (DOC) concentration of 5.6mg/L (Kainz and Mazumder 2005). Davies *et al.* (2004a) confirmed that Elk has a pH of 8.2 and covers 246 ha. Elk was formed 10,000 years ago during the last glaciation. During the summer stratification, the deep water of the hypolimnion loses oxygen below 6 m, reaching anoxia at the bottom (MoELP 1992). Elk Lake has one major creek, O'Donnell, that feeds into it and dries up in the summer. The lake is home to mergansers, Canada geese, buffleheads, kingfishers, bald eagles, and osprey. Its zooplankton are dominated by *Daphnia* spp. and calanoid copepod (Davies *et al.* 2004b). The lake is quite beautiful with yellow pond lilies and cattails (Figure 3.2).

3.4.3.2 Fish and fish-mercury levels of Elk Lake

Elk Lake is stocked with 20,000 rainbow trout annually, most of which are 10" long, catchable, and caught directly (FFSoBC 2005). An analysis of fish gut contents from surrounding lakes found the diets of rainbow trout consisted mostly of *Daphnia* spp.; although there were many benthic, pelagic, and terrestrial invertebrates found as well (Table 3.1). Cutthroat trout can use O'Donnell Creek to spawn because they do so in the winter, but rainbow trout spawn in the spring and their eggs are lost (Rimmer 2005). Triploid trout will soon be stocked in Elk and will not attempt to spawn.

Elk Lake contains native species of three-spine stickleback (*Gasterosteus aculeatus aculeatus*), cutthroat trout (*Oncorhynchus clarki clarki*), and prickly sculpin (*Oligocottus rimensis*). Introduced fish include rainbow trout (*Oncorhynchus mykiss*), smallmouth bass (*Micropterus dolomieu*), yellow perch (*Perca flavescens*), pumpkinseed (*Lepomis gibbosus*), and carp (*Cyprinus carpio*). Fish in Elk Lake are low in contaminants including mercury (Kainz, In press). Only one fish, a smallmouth bass, had mercury concentrations above the Health Canada guideline of 0.5 ppm (Table 3.2). Smallmouth bass reproduce in the lake, while rainbow trout, which have very low

concentrations of mercury, are stocked and caught without time to ingest as much mercury from the environment. The mean mercury concentrations for smallmouth bass in Elk Lake is 0.33 ppm. While this is lower than the Health Canada guideline, if eaten in large enough quantities, frequently, this could pose a health threat.

3.4.3.3 History of human use of Elk Lake

Before Europeans arrived on Vancouver Island, the Coast Salish people inhabited the Saanich Peninsula. The Songhees and the Saanich used the area for hunting, fishing and collecting plants. In the 1850's the Saanich Peninsula, and Elk Lake with it, was purchased from the Coast Salish people for 386 wool blankets. From 1872 to 1916, Elk Lake was the drinking water supply for Greater Victoria. It was still used as a minor drinking water source until 1977. Beaver Lake, which was a separate water body, became connected to Elk when a dam was constructed at the outlet of Beaver Lake. A railway ran adjacent to the lake from 1894 to 1919, but was later replace by the Pat Bay Highway. Elk Lake became a CRD park in 1966 (CRD 2002).

3.4.3.4 Contemporary human use of Elk Lake

The watershed is partially undeveloped and contains wetland, grassland, and forest. A major highway runs adjacent to the lake and houses line about 1/4 of the lakeside. Elk Lake is just 10 km from downtown Victoria and accessible by bus. The lake is part of a protected regional park and is used mostly for recreational purposes. Many people use the lake to swim, water-ski, and boat. Elk Lake is also the training location for the Canadian Olympic Rowing Team.

Elk Lake was selected for this survey because, out of the potential 2,321 angling lakes on Vancouver Island, Elk is the most popular sport fishing lake with 15,448 registered angler fishing days per year (up from 11,053 in 1992), and possibly many more unregistered anglers (Aitzhanova and Rimmer 2003). This both means that Elk Lake is an important part of Vancouver Island sport fishing, and makes it the easiest place to survey the necessary number of fishers make reliable conclusions. Fishers on Elk catch an average of 1.5 fish per day and keep about 38% of their catch (Aitzhanova and Rimmer 2003), which could potentially result in harmful levels of mercury being consumed.

3.4.4 Comparison of Elk Lake, Vancouver Island, and BC Fishers

Fishing has been part of culture in British Columbian for thousands of years. Freshwater anglers currently spend $527 million annually pursuing BC fish (Jack *et al.* 2003). A mail survey of licensed anglers in 2000 prepared for the government reported that about 9% of BC residents purchased fishing licenses in 2000 and spent an average of 16 days fishing (Jack *et al.* 2003). On Vancouver Island there were 34,354 anglers with sport fishing licenses in 2000 and fishers spent over $16 million per year ($478 per angler). The average age of male fishers on the island was 48, and for females it was 43. Four species of fish make up 85% of the fish caught by residents of the island: cutthroat trout (42%), rainbow trout (32%), bass (7%), and freshwater salmon (4%). While fishers on the island kept an average of 47% of their catch in the 1980's, as of 2002, they only kept 20 to 26% of their catch. The average catch per angler per day was 1.86 fish (Jack *et al.* 2003). A mail survey of licensed anglers on Vancouver Island in 2002 found that fishers on Elk Lake caught an average of 1.5 fish /day and kept about 38% of their catch (Aitzhanova and Rimmer 2003).

There is the possibility that fishers on Elk could be unrepresentative of fishers in BC on the whole. A comparison of demographic information and fishing behaviors between Elk Lake, Vancouver Island, and British Columbia (Table 3.3) shows that Elk fishers are of a different demographic than others, but still have similar fishing and fish consuming behaviors. Much of the differentiation can be attributed to the data that the government data were collected by surveying licensed anglers, while Elk Lake data was from surveying fishers on Elk who may not have been licensed. Due to the fact that BC allows fishers under the age of 16 to fish license free, Elk Lake fishers under 16 were extracted from the data for the sake of this comparison.

Vancouver Island has the most male skewed sex ratio in anglers of any region in BC (BC = 79% male, Vancouver Island = 87.1% male). Elk Lake was 79.8% male, almost identical to BC as a whole, but less than Vancouver Island (Jack *et al.* 2003). Vancouver Island has a younger average age than BC as a whole (BC = 46.5 years; Vancouver Island = 43.8 years). The demographic on Elk Lake was 40.6 years, younger than either area, and younger than the average for any region in BC. Vancouver Island has the highest percent of local fishers of any region in BC (BC = 89.2% locals;

Vancouver Island = 97.4% locals). Elk Lake fishers were 95.6% locals. Vancouver Island fishers have on average a slightly higher income than BC as a whole. The income levels on Elk Lake were much lower, with almost twice as many fishers earning less than $20,000 than is in BC as a whole (BC = 15.8%; Elk Lake = 34.4%). Fishers on Elk Lake had on average a much lower education level. 55% of fishers in BC have a degree/diploma from university/college/trades, while only 20% of fishers on Elk Lake had this. Thus, Elk Lake fishers are slightly younger than fishers elsewhere in the region, as well as less educated and earn less income. There is the possibility that those fishers with less income would be less likely to purchase fishing licenses and would not be as highly represented in the Jack and Levey (2003) study, making Elk fishers less disparate from others. The common correlation of income with education might explain the low education on Elk. Elk Lake is also located in a university town, and some fishers were undergraduate students: earning little money and without a university degree. This would make Elk fishers different from the regional fishers, and is something to consider.

Elk Lake fishers are similar to average fishers in BC and on Vancouver Island in keeping about 25% to 38% of the fish they catch (Aitzhanova and Rimmer 2003; Jack *et al.* 2003). Elk Lake was similar to BC as a whole in that the major fish species caught was rainbow trout, but on Vancouver Island cutthroat trout were also a major fish species that did not figure prominently at Elk Lake. Elk Lake was different than the average for Vancouver Island or BC in that a significant percentage of small mouth bass were also caught, which could be important given the potential mercury content in these fish (Figure 3.2). People on Vancouver Island on average spend significantly more days per year fishing than those in all of BC. This study shows that the anglers surveyed on Elk Lake spent far more days fishing than the average for the region or province compared to the 2000 data (Jack *et al.* 2003) (Elk Lake = 35; Vancouver Island = 15.2; BC = 11.6). This is an expected artifact of the survey methods used. The survey for Vancouver Island and BC was mailed to people who bought fishing licenses, and may contain many people who fish once and stop. This Elk Lake survey was done on people that were actually found fishing, and so people who fished more often should have a considerably higher representation. While it is impossible to ascertain form these data if Elk Lake anglers fish more or less than their regional counterparts, it is apparent that the Elk Lake data is more

representative of individuals who fish more often and might eat large amounts of sport-caught fish. If this is the case, information from these fishers and this research would be more relevant to the creation of fish consumption advisories than from a cross section of licensed anglers. Yet even with similar demographics, Elk Lake fishers might not be representative of BC fishers on the whole. The only way to test this would be to extend relevant parts of the survey to fishers province-wide, and this option is not available in the present study.

3.4.5 Survey rationale

3.4.5.1 Survey methods

When surveying fishers, one has the option of organizing a focus group, attending an occasion that would draw many anglers into one location, conducting a phone or mail survey, or doing a site-specific survey of anglers as they fish. Focus groups can provide insights into anglers' more complex emotions and perceptions (Beehler *et al.* 2001), but only reach a limited number of people and provide only qualitative data. To understand what fishers on a lake generally think or do, quantitative data from many people was necessary. Conducting the survey at a large fishing event would have captured many sport fishers from BC and minimized time spent surveying (Burger *et al.* 1997; Burger 1998a, 1999, 2002a) However, it was more relevant to survey those fishers that would fish in lakes regularly, rather than those who might compete in salmon catching competitions.

Mail or phone surveys are truly population based but surveys reach only those with fishing licenses (Beehler *et al.* 2002), unless they are random and ask about fishing, which can be a daunting project requiring thousands of calls (Jakus *et al.* 1998; Imm *et al.* 2005; Knobeloch *et al.* 2005). Even then phone surveys might find only a small percentage of respondents eat sport fish (Knobeloch *et al.* 2005). Mail surveys are also costly, can take a year to complete, and are usually accompanied with response rates well below 60% (Fiore *et al.* 1989; Courval *et al.* 1999; Beehler *et al.* 2002; Trondsen *et al.* 2004). Phone surveys as well usually have response rates around 50 to 60% (Tilden *et al.* 1997; Jakus *et al.* 1998). Larger surveys of anglers conducted while fishing, or "creel surveys," may lack external validity because they depend on a convenient sample, but

they can capture unlicensed anglers as well as those who might not take the time to answer a phone or mail survey. Response rates for creel surveys are typically around 80% (Burger *et al.* 1998; Burger *et al.* 1999b; Burger *et al.* 1999c; Kosatsky *et al.* 1999; Pflugh *et al.* 1999; Campbell *et al.* 2002; Flaherty *et al.* 2003), far higher than phone or mail surveys. Having a high response rate can eliminate response bias and insure that efforts are efficient (Salant and Dillman 1994). A response rate of 65% is considered sufficient for a study of this sort (Dolsen 1991).

3.4.5.2 Sample Size

This survey did not attempt to be random but to ascertain an unbiased sample of those fishing on Elk Lake. Everyone encountered was asked to be surveyed and almost everyone on the lake was asked most days. One hundred and thirty one fishers were approached in total. For the study to be accurate, a margin of error of +/- 5% is necessary. The "Margin of Error" is aptly named, as it is the amount the survey result might be off by. So if a result was obtained of 65% of survey respondents being in favor of testing every lake in BC for fish with elevated concentrations of mercury and a margin of error of 5%, the actual number of respondents who are in favor of the testing could be anywhere from 60% to 70%.

Another important goal of this survey is to have a confidence level of 95%. The confidence that level refers to is in the margin of error. It is saying "I am 95% sure that the margin of error is 5%." Or, more explicitly, "I am 95% sure that the percentage of people surveyed who eat their catch from Elk Lake is between 60% and 70%." So as the confidence level goes up, the margin of error also increases.

So, with a population of 131 people, it is necessary to calculate how many people must be surveyed to achieve a +/-5% margin of error and a 95% confidence level. Salant's sample size calculation was used (Salant and Dillman 1994).

$$n = \frac{P(1-P)}{(e/Z)^2 + \frac{P(1-P)}{N}}$$

Where n = sample size desired
N = population size (100)
e = margin of error (.05)

z = confidence level (1.96 for a 95% confidence level)
p = the likely variability of the population (how differed their answers are likely to be. Since we do not know this, we must assume they will be split evenly between two opinions and thus, a 50/50 split which gives us a p of 0.5)

$$\text{So, } n = \frac{0.5(1-0.5)}{(0.05/1.96)^2 + \frac{0.5(1-0.5)}{100}} \Rightarrow \frac{0.25}{0\ .00065 + (.25/131)} \Rightarrow \frac{0.25}{0.00256} \Rightarrow 98$$

Thus, I had to survey 98 people in order to get a margin of error of +/-5% and a confidence level of 95%. I surveyed 99 fishers, so this sample size is sound.

3.4.5.3 Questionnaire structure

Quantifying dietary intake is an inexact science and will always be estimated with error (Beaton 1994). It is difficult to collect reliable data on the fish consumption of fishers (Belton *et al.* 1986; Blake *et al.* 1989; Burger *et al.* 1993); however, it is absolutely necessary for the assessment of risk and the creation of consumption advisories (Reinert *et al.* 1991). The main areas for error are the amount of food eaten, the frequency with which it was eaten, and over what period of time.

3.4.5.4 Question format

I used a combination of multiple choice, single word, yes/no, and open-ended questions. For open-ended questions, response categories were created for those questions in order to analyze results (Pflugh *et al.* 1999). The survey was long, and took about 30 minutes to administer, depending on how long fishers felt like talking. This is much longer than most surveys but has been shown to work in the past (Burger *et al.* 1999c) and fishers were told of the survey's length before committing to the survey. It has been found that many food intake questions (>30) will cause people to overestimate responses (Krebssmith *et al.* 1995). While others have found that, when several items are summarized into one question, people will underestimate responses (Serdula *et al.* 1992). It has also been reported that foods never eaten are easy to recall (Krall 1988), and that foods eaten more frequently are easier to remember that foods eaten rarely (Nomura

1976; Colditz 1987; Jarvinen *et al.* 1993; Stern *et al.* 2001; Bjornberg *et al.* 2005b) People who eat fish rarely might give more unreliable responses than those who eat fish frequently.

3.4.5.5 Data collection models

There is an element of Heisenberg's uncertainty principle in collecting dietary data: meal frequency or portion size can be measured for any given population, but not both. There are three main types of dietary data collection methods (Maggi *et al.* 1993): direct weighing, which is accurate but requires long term participation on the part of the respondents and is very expensive (Dellinger 2004); diet diaries, which are slightly less accurate, also take time, and tend to distort normal intake patterns (Tran *et al.* 2004); and diet recalls, which are subject to recall bias. In a review of dietary recall methods, Smith (1993) found that people have excellent relative judgments of frequency of consumption when content cues are given to characterize food type and meal size. Some researcher employ conceptual weight estimates (a 6 oz can of tuna, for instance) (Smith 1993; Burger 2002b), while others use models of typical fish volumes and shapes for various species (Block *et al.* 1986; Burger *et al.* 1999c; Shatenstein *et al.* 1999; Burger *et al.* 2001a; Loranger *et al.* 2002; Cole *et al.* 2004). I asked respondents to estimate meal size by weight, prompting them by telling them that a normal can of tuna is 6 oz, which has been show to be a dependable method of obtaining accurate information (Burger *et al.* 1999c; Burger 2002b).

3.4.5.6 Recall timeframe

When estimating fish consumption, researchers will often estimate a time frame so that respondents have a context in which to think (Beehler *et al.* 2002). Some studies ask respondents for total number of fish meals in the past 12 months (Courval *et al.* 1996; Tilden *et al.* 1997; Courval *et al.* 1999; Beehler *et al.* 2002; Burger 2002b; Cole *et al.* 2004; Bjornberg *et al.* 2005b; Knobeloch *et al.* 2005), the average number of meals per month (May and Burger 1996; Burger *et al.* 1999a; Burger *et al.* 1999c; Burger 2000b), the number of meals eaten in the past three weeks (Kosatsky *et al.* 1999), or even the last 24 hours (Acheson *et al.* 1980; Tran *et al.* 2004). Sometimes there is even a combination of timeframes: "How many fish meals have you eaten each week over the past 12

months?" (Knobeloch *et al.* 2005). When testing different food frequency questionnaire methods, Subar (1995) found that respondents preferred to give consumption frequency in "past year" or "typical month" more than "last year," "last month," or "last week" given that the latter two might not reflect seasonal variation and all three were difficult to recall. Whereas Smith's dietary survey review also reported that, when content cues are given, the length of time being recalled does not affect validity (Smith 1993). Twenty–four hour recall is the most accurate of study types, but given the variation of diet from one day to another, this would not represent normal intake (Paustenbach 2000).

For the purpose of this study, I asked fishers to estimate how many times they ate fish and fish species each month, which has been shown to be an effective time frame (Van Staveren 1985; Bloemberg 1989). Had I ask about fish consumption three weeks prior to the survey, data would have represented fishing season (Shatenstein *et al.* 1999). Given that self-caught fish consumption varies according to season (Wheatley and Paradis 1996), I was interested in collecting data spanning the respondent's annual life. However, I felt asking respondents to recall how many meals of each species of fish were consumed over the past year would create unreliable data.

3.4.5.7 Recall bias

Researchers have attempted to reduce and test recall bias in many ways. One way is to repeat the survey on the same participants within a short timeframe (<6 months) (Jarvinen *et al.* 1993). Another way is to use two methods and compare them, which requires a large sample size (Maggi *et al.* 1993). Other researchers ask the same question multiple times, perhaps in different ways to test Convergent Validity (Salant and Dillman 1994). I asked fishers both how many times they ate fish per month and how many times they eat fish each month that they caught, bought from a store, or ate in a restaurant. Some fishers ate fish that friends or family gave them, so some total fish per month answers were higher than the summation of category breakdowns. Data might be unreliable when the summation of the categories is larger than the number given for total meals per month. Twelve fishers in this survey gave amounts for category breakdowns that, when combined, were ≥1 more meal than they indicated they ate per month. Four fishers gave answers that were ≥2, and no fishers gave answers of 3 or higher. The mean

number of fish meals per month for the summed categories was 5.2, while the mean number for total meals per month was 5.7. These frequencies are fairly close and show that recall bias may be low.

However, even with all these precautions, obtaining accurate data is very difficult. Loranger *et al.* (2002), conducted both food a food frequency survey among anglers as well as collecting hair samples. They found that the mercury concentrations predicted by the questionnaire and their model overestimated actually body burdens by an average factor of greater than 6. They conclude that direct hair-mercury measurement remains the more effective means to assess mercury exposure. However the time period fishers were asked to recall was 1 to 4 months prior to the interview, which might have increased error. In addition, by asking fishers to estimate meal size based on size of fish caught, exaggeration might have been a factor. Other studies have also collected fish consumption data and hair mercury samples, resulting in low correlation between predicted hair mercury concentrations and those found (Stern *et al.* 2001), even when recall bias was thought to be low (Canuel *et al.* 2006). This disparity was potentially due to recall error, but various ethic hair types, and metabolic rates from ethnicity, age, gender, and weight may also have influenced results.

A similar study was conducted by Shatenstein *et al.* (1999), in which fishers answered a food frequency questionnaire and had blood samples taken, kept a food diary over the course of a month, and then had another blood sample taken and answered another questionnaire. Food frequency was found to be highly similar for all three phases of the survey and correlated with blood samples. Yet researchers found portion size to be overestimated when compared to actual consumption, even though models had been presented to fishers to estimate weight. In a food recall survey of many types of food, conducted only 24 hours after meals had been eaten, other researchers found underestimation more common than overestimation, but error in the majority of responses (Acheson *et al.* 1980; Blake *et al.* 1989). In a review of dietary survey methods, A.F. Smith (1993) concluded that people were incapable of accurately estimating portion size through recall. Even though portion size is still used to estimate fish intake, an element of error should be assumed, and is something to take into consideration when evaluating food frequency questionnaires.

3.4.5.8 Drawbacks of methods

Given the inability of people to estimate portion size for fish consumption, hair mercury testing would make this study more robust and reveal the level of direct health risk for this population. Future studies should take this into consideration. However, for this project, I was interested in whether or not a threat could exist among a population fishing and eating as they fishers on Elk do, more than if a threat did exist for this population at this time. Models of fish meal sizes might have also made the portion size data more accurate, but whether this method is more effective than size prompts remains to be studied. In addition, the questionnaire could have been shorter. I collected far more data than could be analyzed in one Masters program, and spent more time than necessary questioning fishers.

3.5 Results

3.5.1 Fisher demographics

Response rate was 76%. This is well above the accepted response rate for recreation population surveys of 65% (Dolsen 1991). Seventeen fishers felt the survey would take too much time; 8 simply did not want to be surveyed; and 7 cited language difficulties (Table 3.4). Subjects were more likely to agree to be interviewed if one individual was surveying alone (response rate of 87%) rather than with a partner (response rate of 63%).

Of those interviewed (N=99), 87% were male and 86% were Caucasian (Table 3.5). Only 12% were Asian, but 31% of all respondents were born outside of Canada. English was the primary language of 86% of respondents. Ages ranged from 12 to 76 years, with the mean at 38. The mean respondent had completed high school and earned $19,000 annually, even though 54% of people earned more than $20,000 annually. Only 6 fishers lived farther than 20 km from Elk Lake.

3.5.2 Fishing behavior and fish consumption

Fishers on Elk Lake spent an average of 40 days fishing per year. About 45% fished 10 times per year or less (Figure 3.3), 19% first timers, but 13% of respondents

reported fishing over 100 times each year. Males had been fishing on Elk Lake for an average of 9.2 years, whereas females had only been fishing on Elk for an average of 2.3 years (P= 0.003, Mann Whitney). Most fishers (76%) fished in other lakes and the ocean in addition to Elk Lake (Figure 3.4).

Only 47% of fishers gave "to eat" as a reason they fished (Figure 3.5). The majority of fishers fished to be outside, for relaxation, sport, and to be with friends and family. Four percent of fishers didn't eat fish at all. Among reasons given for not eating fish catch were that fishers didn't like the taste of fish from Elk Lake, they preferred catch and release, and they thought the lake was polluted (Figure 3.6).

Most fishers (76%) ate or intended to eat their catch from Elk Lake, but 24% of fishers had yet to catch fish from Elk (Figure 3.7). Fishers who had caught fish kept 33% of their catch on average (Figure 3.8).

Ninety two percent of respondents said they ate their catch from other lakes and the ocean (Figure 3.9). Fishers ate an average of 5.7 fish meals per month, with a range of 0 to "every day" (Figure 3.10). Seventeen percent of people ate 10 or more fish meals per month. An average of 2 meals per month were self-caught, 1.2 of those were from Elk Lake (Figure 3.11). Sixty three percent of fishers reported sharing their catch with friends and family.

3.5.3 Potential for risk

Aspects of demographic information and fish consumption behavior that might affect sensitive populations were analyzed. Sensitive populations included women of childbearing age (10), male fishers who said they had wives who could become pregnant in the near future (14), fishers who had children 14 years of age and younger (23), and fishers who were 14 years of age and younger (8). In total, 40% of fishers could be feeding fish to people who fall within the "sensitive population" for mercury exposure.

3.5.4 Concern regarding mercury

The majority of fishers (63%) were confident in their knowledge of the risks and benefits of eating fish, yet 67% wanted to know more. Most fishers (79%) would read a guide to the fish-mercury concentration in BC if it were available (Figure 3.12) and 32%

said they would even buy it. About half of fishers were worried or very worried about the health effects of mercury (Figure 3.13), whereas 75% were worried or very worried about cancer (Figure 3.14). There were no significant differences in the concern levels of those who might be at risk.

Before fishers were asked any questions regarding mercury in fish, they were asked what information they would like to know about fish or the lake (Figure 3.15). Forty six percent said they did not want to know anything, yet 45% wanted to know information scientists could provide, such as contaminants in the lake, fish in the lake, and foodweb dynamics.

Eleven percent of respondents said they already limited fish consumption due to mercury. Almost everyone (93%) said they would follow fish consumption guidelines if they were available. Eleven percent of respondents said they would be less likely to eat all types of fish if there were guidelines published regardless of what they recommended. And while 81% of fishers said they would stop eating fish if they were shown to contain high mercury levels, 36% said they would stop eating fish with any mercury in it at all.

3.5.5 Knowledge of mercury

Fishers showed varying degrees of knowledge about mercury in fish and associated human health effects. When asked which fish can be unhealthy to eat, 14% mentioned species of fish often associated with elevated mercury concentrations like tuna and shark (Figure 3.16). Fishers mentioned other reasons fish might be unhealthy such as bottom feeding, farmed fish, and poison fish.

When fishers were asked what fish pregnant women should avoid, 20% of people responded with species of fish commonly associate with high mercury concentrations (Figure 3.17). Without mentioning species names, 21% of respondents said pregnant women should avoid fish with mercury. Additionally, 28% responded, "I don't know" regarding pregnant women and fish, whereas only 17% claimed ignorance with general health.

Fishers were asked what they could say about mercury in general, in fish, and in humans in order to ascertain their level of mercury knowledge. Answers were coded and respondents were put into one of four groups: no knowledge, elemental (mercury is an

element, liquid, in thermometers, etc.), basic (mercury is bad for people, especially pregnant women; it can be found in fish) and advanced (mercury is most concentrated in old, large, predatory fish like tuna, shark, and tilefish; pregnant women should avoid these fish and others should limit consumption; consumption amounts and frequencies). Half of respondents had at least a basic understanding of the issues surrounding mercury in fish. Thirty five percent had advanced knowledge considered adequate for making informed diet decisions (Figure 3.18).

When respondents were grouped into those who had at least a basic understanding of mercury in fish and those who did not, we found that the less people know about mercury in fish, the more likely they were to have a low level of concern about the issue. This was found to be significant with a chi-square contingency analysis (χ^2= 10.49, df=2, P=0.005) (Figure 3.19).

3.5.6 Information sources

Fishers were asked where they got their information regarding mercury in fish and humans. Forty seven percent of fishers with at least a basic understanding of mercury mentioned a mass media outlet such as television news or newspaper and 35% learned about mercury in school (Figure 3.20). The main source of mercury information for those with an elemental understanding of mercury was school (Figure 3.21).

Yet when all fishers were asked where they would look to find out information about mercury in fish, 62% of them said they would look to the internet, 20% through a search engine like Google (Figure 3.22). Very few people mentioned traditional mass media.

When asked where they would look to find out general health information, 37% of fishers mentioned the internet, while a combined 43% would look to traditional media sources like newspaper and television (Figure 3.23). Thirty three percent said they would consult a doctor.

When asked directly, 71% percent of all fishers said they would visit a website that contained information on mercury concentrations in local fish. Forty percent of all fishers said they did not read any of the Freshwater Fishing Regulations Synopsis created to inform them about fishing in BC.

While respondents did not mention the scientific community with any frequency when discussing their sources or destinations for information on mercury in fish or human health, they overwhelmingly trusted "scientists" more than "the media" or "the government" to provide them with correct health information and to have their best health interest in mind (Figure 3.24).

3.5.7 Post-survey interest in mercury

While 67% wanted to know information about the risks and benefits of eating fish during the survey, 79% had questions regarding mercury in fish and people after the survey. Fifty one percent felt that they needed to know more about mercury to make better health decisions after the survey was completed. Forty six percent of people said they wanted a copy of the results of the study and 58% provided their contact information to follow up with them.

3.6 Discussion

3.6.1 Fishing behavior and consumption

The accessibility of Elk Lake to many Victorians makes it a popular recreational fishing spot. Even though 76% of fishers ate or intended to eat their catch, and 33% had succeeded in doing so at the time of interview, very few people surveyed were fishing with the sole purpose of food collection. Fishing was a social and personal form of relaxation or sport for Elk Lake fishers, as has also been shown among fishers in the United States (Toth and Brown 1997; Burger 2002a) and historically with fishers in BC (Aitzhanova and Rimmer 2003).

Fishers were more likely to eat fish caught in other lakes and oceans than the fish they caught in Elk Lake. So while Elk Lake fish have low levels of mercury, fishers could be consuming fish from water bodies with higher mercury concentrations. More than half of fishers eat fish at least once a week, and 17 people ate self-caught at least once a week. A full 13% of fishers fished more than 100 times each year, which would indicate a level of subsistence fishing in this mostly recreational population. So if there are high concentrations of mercury in any BC fish, fishers might be at risk of health damage.

Those fishers who are within a sensitive population, or could feed fish to a family member within a sensitive population, comprise a full 40% of fishers at Elk Lake. No significant differences could be found among the diet habits of those in sensitive and general populations,

Small mouth bass in Elk Lake have mean mercury concentrations of 0.35 ppm (Table 2.8), less than the Health Canada limit for unlimited consumption. Yet the largest bass tested (out of 9 total) had a mercury concentration well above 0.5 ppm (0.72 ppm). Given the propensity of fishers to keep and eat the largest fish that they catch, these fish could pose a health risk to Elk Lake fishers, albeit, a small one. Twenty-one percent of fishers reported eating small mouth bass occasionally, and almost all of them reported size as a factor in deciding whether or not to keep the fish. A member of the general population would have to eat 12.3 meals of Elk Lake small mouth bass to surpass the Health Canada recommendations, yet a member of a sensitive population would only need to eat 5.2 meals. Fortunately, no fishers reported eating this amount of small mouth bass. Although the potential for health damage is low in this population, meal frequency recommendations for small mouth bass would prevent sensitive fishers from health damage.

3.6.2 Mercury concern

It is not always the best strategy to issue fish consumption advisories and inform people about the risks of eating fish. Low levels of mercury are not necessarily harmful to everyone and the benefits of eating fish can be substantial (Gochfeld and Burger 2005). Studies have shown pregnant women eating less of all types of fish after advisories for high mercury fish were issued (Oken *et al.* 2003). The health of members of aboriginal communities have dropped after substituting market foods for traditional foods like fish (Receveur *et al.* 1997) and mercury warnings could drive native peoples away from traditional foods unnecessarily (Chan and Receveur 2000).

Many fishers on Elk Lake exhibited alarmist tendencies toward mercury in fish. Half of respondents were worried about mercury but 36% of fishers said they would stop eating fish if there was any mercury in them at all. This is an alarming response due to the trace amounts of mercury in all fish. Eleven percent of fishers said they would limit

their fish consumption if guidelines were published regardless of what recommendations were made. This indicates that any advisories that are created must include educational information explaining mercury in fish, as well as provide information on the benefits of eating fish.

Logically, participating in the survey made respondents curious and sometimes nervous about the risks of mercury in fish. Most people (80%) asked questions regarding mercury in fish, the lake, and humans after the survey. Eleven percent of people said that just answering the survey was making them nervous about eating fish. Respondents were provided with all the information they requested and offered more regarding both benefits and risks of eating fish, in order to inform and keep them from alarmist reactions.

Fishers were very interested in the issues surrounding mercury in fish, fishing in general, and the Elk Lake ecosystem. A full 71% said they even wanted to help out with scientific research in the future and were excited by the prospect of collecting fish for testing. It does seem that the average fisher on Elk Lake represents an eager and untapped resource for scientific research.

Risk assessors must take into consideration people's tendencies to overreact to health threats, especially when they are featured with regularity in the media (Oken *et al.* 2003). If advisories are created for BC, information on the benefits of eating fish and a thorough yet accessible explanation of the issues surrounding mercury in fish need to be communicated to fishers as well.

3.6.3 Mercury knowledge

More than one third of fishers on Elk Lake knew enough information about mercury in fish, recommended serving frequencies, and high mercury fish species to make well informed diet decisions. This could be attributed to their high education achievements or possibly the recent media attention regarding mercury. Yet even with such advanced knowledge of mercury in fish, these fishers do not have the information necessary to make educated decisions about consuming sport fish, given that advisories do not exist. Among those who were best informed, mass media was their most frequently reported source of information and can be utilized to communicate advisories.

There were also 65% of fishers who lacked the knowledge necessary to make healthy diet decisions. If this is an indication of the knowledge of British Columbians in general, a program to educate people as to the risks and benefits of eating fish is necessary in addition to providing guidelines for sport-fish consumption.

It is difficult to assess the effect of mercury knowledge on diet decisions from this survey. There was a correlation between knowledge of mercury and concern regarding mercury. This indicates that mercury knowledge may be affecting fishers' conception of the healthiness of fish, but there were no significant correlations among mercury knowledge, fish consumption behavior, demographic parameters, and at risk grouping. An increased sample size or a different statistical approach could improve these findings or make other correlations apparent.

3.6.4 Information sources and paths of communication

Currently, the main method of provincial communication with fishers is through the Freshwater Fishing Regulations Synopsis. It is a 40 page document with fishing information on each of BC's angled lakes. It is supposed to be given out by bait and tackle shops with fishing licenses, but many fishers reported not receiving one, and 40% of respondents did not read it. Many fishers did not even have licenses, but the delicate nature of this question prohibited it from being on the questionnaire. This may also have contributed to fishers refusing to be surveyed. These results were higher than in a BC-wide survey, which found 60% of respondents did not read the Regulations. While the Regulations would be an effective method for reaching a minority of fishers, other methods of communication need to be utilized as well.

Fishers on Elk Lake were curious about mercury in fish and were ready to hear what information could be provided. Most of them (67%) wanted to know more about the risks and benefits of eating fish and 77% had follow-up questions about mercury in fish, humans, the ecosystem, and Elk Lake, as well as general foodweb and other pollutant questions about the lake. More than two thirds of fishers said they would read guidelines and advisories if they were available and almost everyone (96%) indicated that they would follow guidelines. This is important because fishers are more likely to see risk as low when it is associated with activities they view as pleasurable. Because Elk Lake

anglers fished for so many reasons other than sustenance, there is a chance that they would deamplify the risks associated with consuming contaminated fish (Slovic 1987; Burger *et al.* 1998). In addition, the risk, if it is deemed present, would likely be moderately low, and when benefits are perceived as high and risks perceived as low, behavioral modification is also low (Knuth *et al.* 2003). While the positive intentions of Elk Lake fishers to read and follow advisories do not necessarily correlate with full adherence to guidelines, this does show that fishers are not very likely to reject or ignore advisories outright. If fishers on Elk Lake are an indication of the fishers elsewhere in BC, information on the risks and benefits of eating fish will be well received.

If guidelines are created and advisories disseminated, the best way to reach fishers with an active interest in mercury in fish is to create website that is well registered with Google. The best way to reach fishers who are only passively interested in mercury is through traditional media outlets. Medical care providers could also be an effective conduit for mercury health information, as fishers indicated that they would look to more conventional sources for health information. A website and media press releases are inexpensive and easy ways to reach fish consumers with information and should be used to communicate advisories if they are created. Pamphlets given to medical care providers to reach women of childbearing age are far more expensive and should only be used if future hair-mercury tests show high concentrations among sensitive populations.

In general, fishers trusted scientists more than the government or the media to provide them with health information and to have their best interest in mind. While it is unlikely that a scientific establishment would set out to inform the public directly, information provided to fishers through the internet, mass media, or the government could be formatted in such a way that scientists were obviously the authors. Scientists often work for the government to create and communicate advisories; this could be emphasized to create trust.

This research suggests that effective methods of communication to sport fishers of this nature would be a science driven website or media release. In addition, if risks were shown to be severe, a doctor education program would reach many concerned fishers of sensitive populations.

3.7 Conclusion

Freshwater fishers in British Columbia are at less of a risk of mercury contamination than in most other provinces. Yet fishers on Elk Lake eat sufficient fish from other lakes and commercial outlets that, if these fish have high mercury concentrations, the possibility of neurological damage exists for sensitive populations. Many Elk Lake fishers are well informed about mercury in fish, but all would benefit from fish consumption advisories if they were available. This population of fishers is concerned, curious, and would be receptive to more information on mercury in fish, humans, and the ecosystem. Fish-mercury levels in Elk and BC have been shown to surpass Health Canada guidelines for unlimited consumption and advisories for BC lakes should be created and distributed.

Tables: Chapter 3

Table 3.1. Gut content analysis of rainbow trout from Sooke and Shawnigan lakes.

Lake	Length	Weight	Weight Daphnia (g)	Weight other (g)	% Daphnia
Sooke	24.9	183.5	0.2528	0.1652	60.48%
Sooke	26.3	225.1	0.4945	4.165	10.61%
Sooke	27.4	241.0	0.0891	0.0381	70.05%
Sooke	26.7	226.0	0.1259	0.0627	66.76%
Sooke	28.4	256.8	0.1811	0.0582	75.68%
Mean:	26.7	226.5	0.22868	1.1265	56.71%
Shawnigan	25.0	150.4	0	0.0385	0.00%
Shawnigan	24.0	133.0	0.0344	0.0074	82.30%
Shawnigan	24.5	146.6	0.0856	0.0467	64.70%
Shawnigan	27.6	203.4	0	0.1384	0.00%
Shawnigan	42.0	819.0	0	3.3240	0.00%
Mean:	28.62	290.48	0.024	0.711	29.40%

Table 3.2. Fish-mercury concentrations for Elk Lake (wet weight) (Deagle unpublished data; Epps and Rieberger unpublished data).

Data source	Fish type	length (cm)	weight (g)	Hg (ug/g)
MoE unpublished data	small mouth bass	48.0	2041.0	0.34
MoE unpublished data	small mouth bass	45.5	1673.0	0.30
MoE unpublished data	small mouth bass	40.0	1191.0	0.28
MoE unpublished data	small mouth bass	45.0	1588.0	0.40
MoE unpublished data	small mouth bass	38.0	936.0	0.18
MoE unpublished data	small mouth bass	43.0	1389.0	0.34
MoE unpublished data	small mouth bass	39.0	1049.0	0.33
MoE unpublished data	small mouth bass	38.5	907.0	0.30
MoE unpublished data	small mouth bass	47.0	2013.0	0.72
Deagle unpublished	small mouth bass	28.0	409.7	0.06
			AVERAGE:	0.33
Deagle unpublished data	yellow perch	17.7	75.5	0.07
Deagle unpublished data	yellow perch	18.0	70.8	0.06
Deagle unpublished data	yellow perch	18.7	93.3	0.10
Deagle unpublished data	yellow perch	19.0	93.1	0.08
Deagle unpublished data	yellow perch	19.1	89.1	0.08
Deagle unpublished data	yellow perch	20.0	109.1	0.06
Deagle unpublished data	yellow perch	21.0	121.4	0.12
			AVERAGE:	0.08
Deagle unpublished data	rainbow	24.6	172.9	0.05
Deagle unpublished data	rainbow	25.0	182.7	0.07
Deagle unpublished data	rainbow	25.6	189.8	< 0.05
Deagle unpublished data	rainbow	28.0	246.4	0.05
Deagle unpublished data	rainbow	39.1	636.8	< 0.05
Deagle unpublished data	rainbow	43.8	623.8	0.06
			AVERAGE:	0.04
Deagle unpublished data	sculpin	10.7	13.7	
Deagle unpublished data	sculpin	12.8	23.7	0.05
Deagle unpublished data	sculpin	13.8	31.7	0.10
Deagle unpublished data	sculpin	15	64.1	0.10
Deagle unpublished data	carp	16.4	88.2	< 0.05
Deagle unpublished data	pumpkinseed	11.9	29.0	< 0.05

Table 3.3. Comparison of Anglers Fishing on Elk Lake to Vancouver Island and BC licensed Anglers (Jack *et al.* 2003).

	Elk Lake	Vancouver Is.	B. C.
Percent of total anglers	0.023%	11.6%	100.0%
Sex ratio (% male)	79.8%	87.1%[a]	79.0%
Average age	40.6[b]	43.8	46.5
Percent local fishers	95.6%	97.4%[c]	89.2%
% earning <$20K/a	34.4%	Note[d]	18.3%[e]
% completed university/college/trade	20.0%	n/a	55.0%
Avg. # days fishing / year	35[f]	15.2[g]	11.6
% of catch kept	25.9%	23.0%	26.8%
% rainbow trout	58.4%	36.2%	54.2%
% cutthroat trout	5.2%	37.7%	12.1%
% small mouth bass	13.7%	3.2%	1.5%

a. Highest for any region in B. C.
b. Younger than average for any region in B. C.
c. Highest for any region in B. C.
d. Household income levels for Vancouver Island fishers are slightly higher than the BC average, but personal income was not reported on a regional basis.
e. Income levels for BC fishers is taken from 1995 data.
f. BC Survey was done on all people who bought fishing licenses. Elk Lake survey was done on people that were actually found fishing, and so people who fished more often should have a higher representation.
g. Second highest for any region in BC.

Table 3.4. Response rate of fishers at Elk Lake and reasons for rejection.

	Alone	With partner	Total
Approached	68	63	131
Accepted	59	40	99
Response rate	87%	63%	76%
Total Rejected	9	23	32
Time constraints	3	14	17
Simple refusal	4	4	8
Language difficulty	2	5	7

Table 3.5. Selected demographics of responding fishers at Elk Lake.

	(%)	n=
Sex (N=99)		
Male	87%	87
Female	12%	12
Age in years (N=98)		
0-19	19%	19
20-29	19%	19
30-39	16%	16
40-49	19%	19
50-59	11%	11
60-69	7%	7
70-79	7%	7
80+	0%	0
Distance traveled to lake (N=97)		
<10 km	68%	66
10 to 20 km	26%	25
>20 km	6%	6
Education (N=93)		
No highschool	15%	14
Some high school	6%	6
Still in high school	9%	8
Finish high school	26%	24
Some college	27%	25
College degree	13%	12
Post graduate	4%	4

	(%)	n=
Income (N=86)		
<$20,000	47%	40
$20,000-$39,000	27%	23
$40,000-$59,000	17%	15
$60,000-$79,000	5%	4
>=$80,000	5%	4
Ethnicity (N=98)		
Euro-Can./caucasian	73%	72
European	7%	7
Asian-Canadian	5%	5
Asian	7%	7
Russian	2%	2
Native	2%	2
Other	3%	3
Country of birth (N=99)		
Canada	70%	69
Asia	7%	7
USA	5%	5
Europe	12%	12
Russia	3%	3
Other	3%	3
Primary Language (N=97)		
English	86%	83
Other	14%	14

Figures: Chapter 3

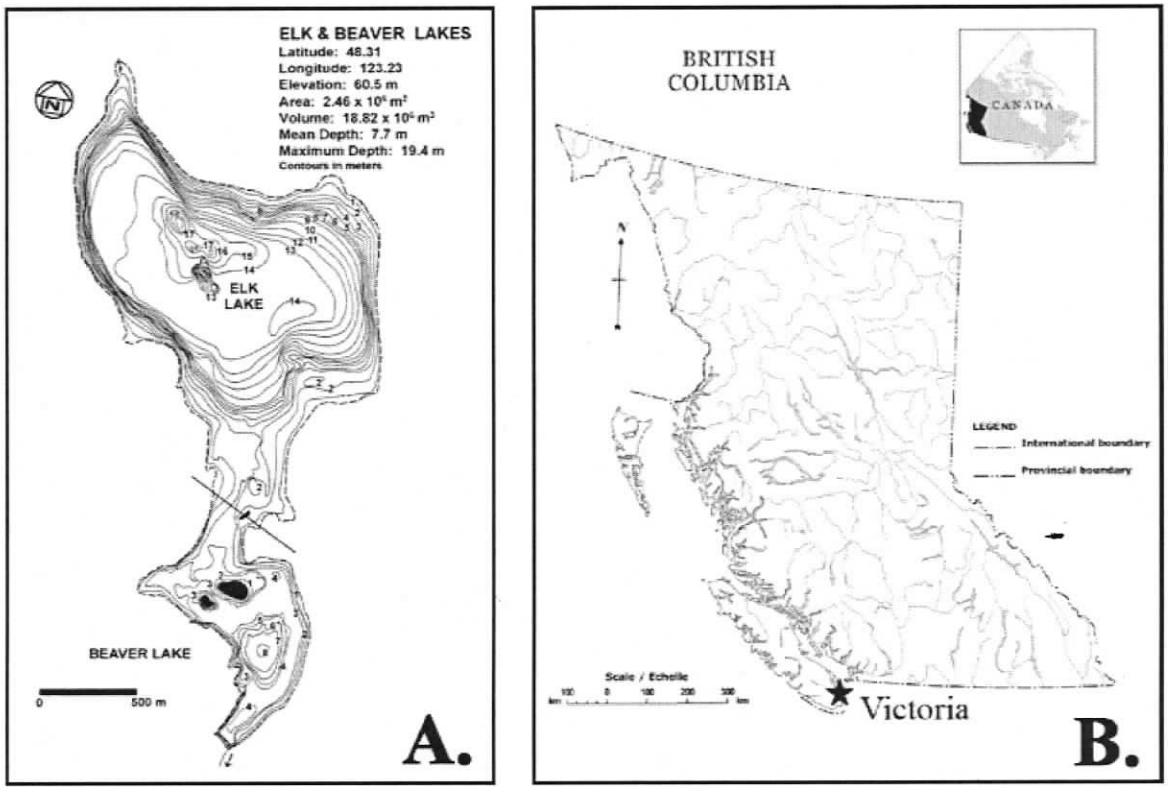

Figure 3.1. Maps of Elk Lake and area. Bathymetric map of Elk & Beaver Lakes (A.) (Source: Spafard 2002) and map of British Columbia showing location in province (B.) (Source: NRC 2002).

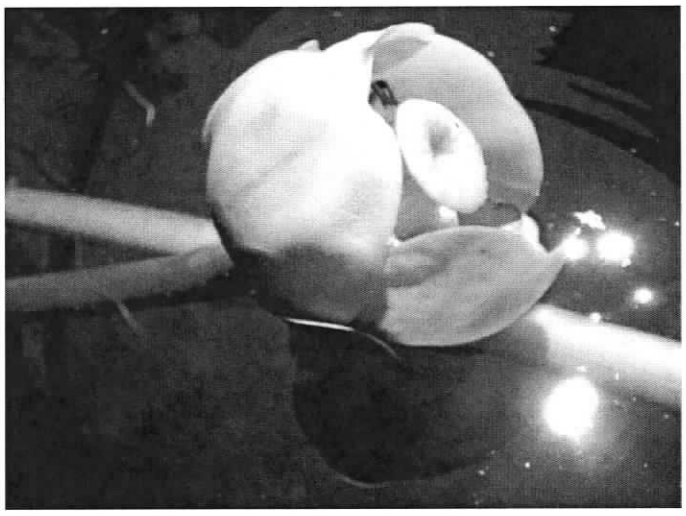

Figure 3.2. Photographs of Elk Lake taken by Spencer Eastabrooks. Top Left shows the boat launch looking north into the lake. Top Right shows the lead author in the midst of scientific research, without the pants she usually wore to conduct surveys. Bottom Right and Left shows two flowering macrophytes: *Nuphar luteum,* and *Nymphaea odorata*

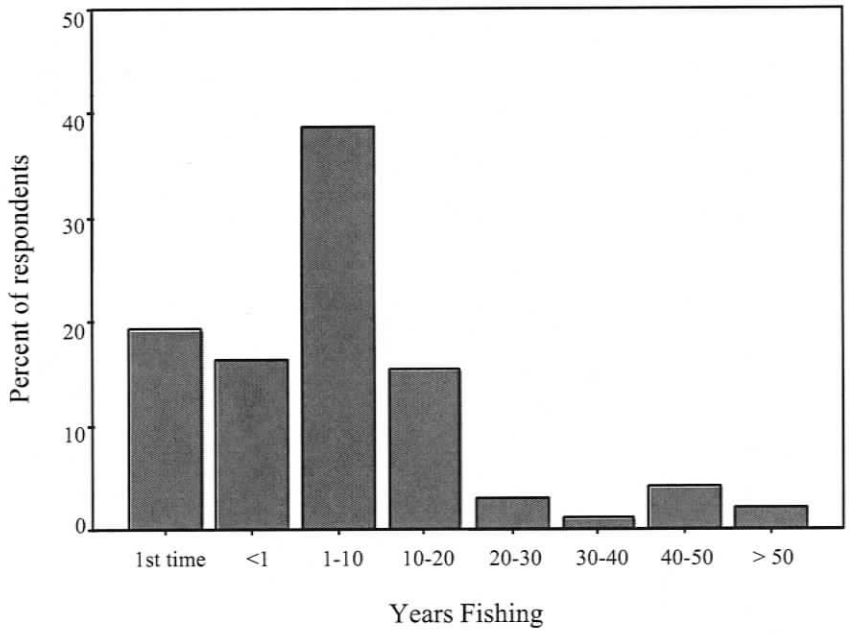

Figure 3.3. Number of years respondents had been fishing on Elk Lake.

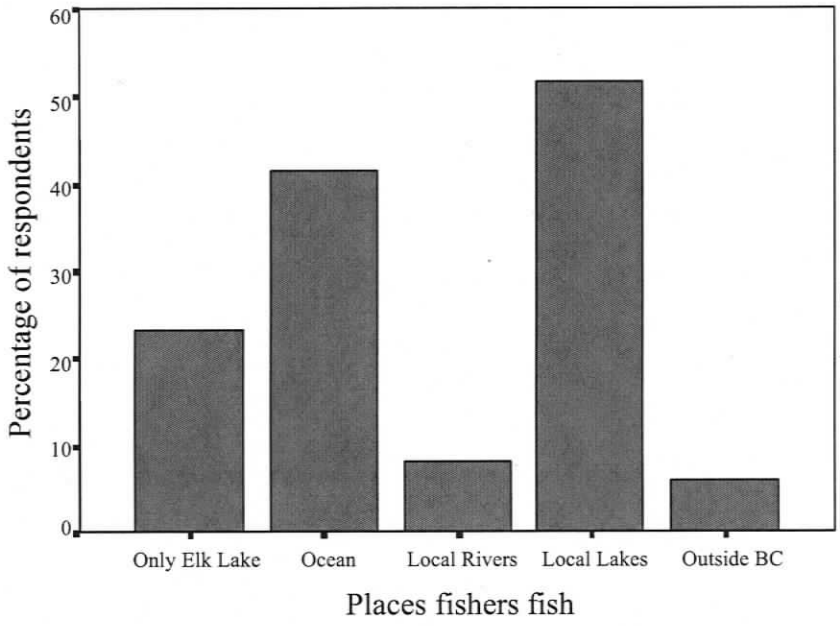

Figure 3.4. Locations where respondents currently fish.

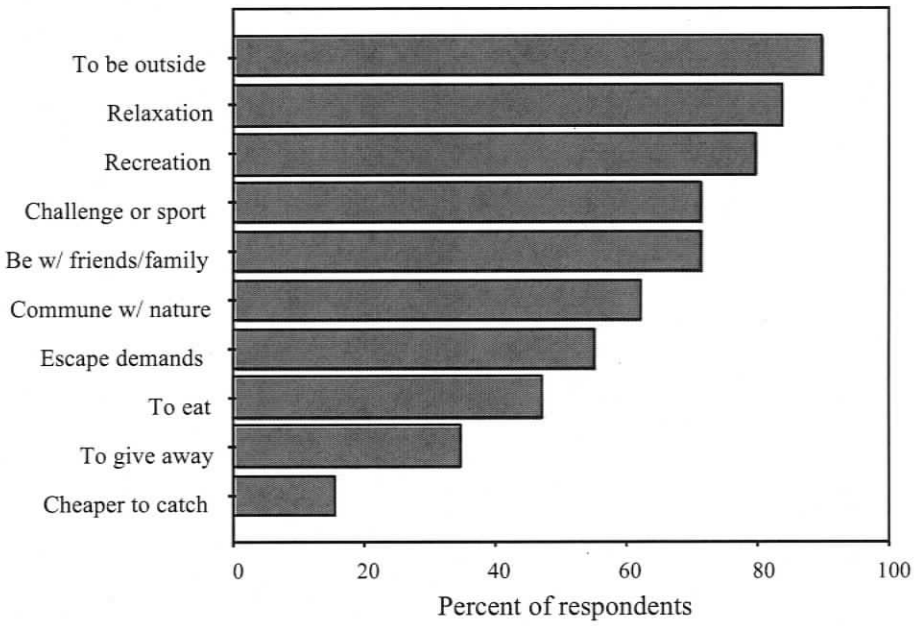

Figure 3.5. Reasons respondents gave for fishing.

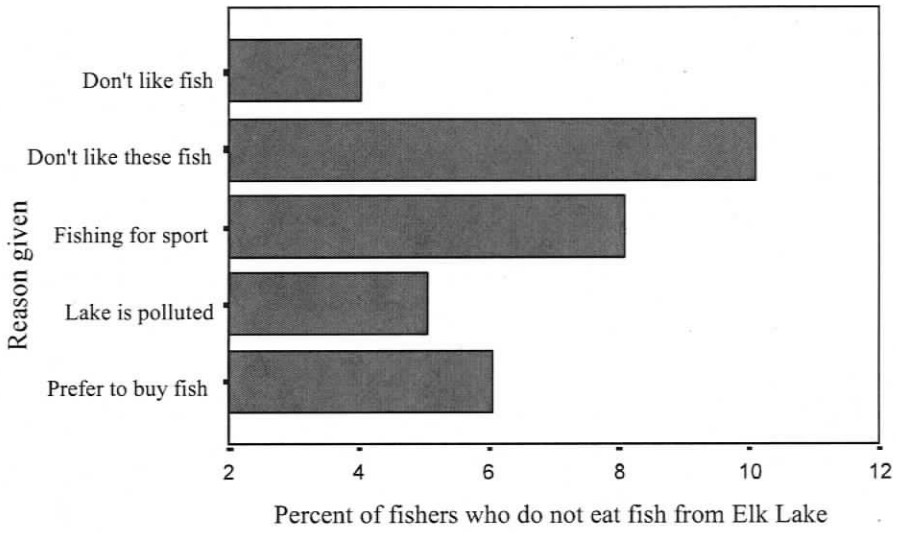

Figure 3.6. Reasons respondents who did not eat their catch from Elk Lake (24%) gave for not eating their catch.

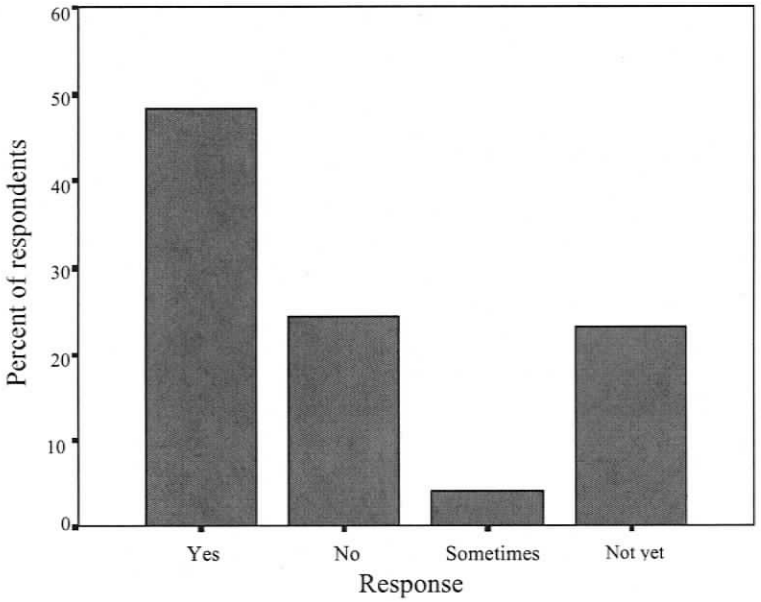

Figure 3.7. Answers of respondents when asked if they ate the fish that they caught at Elk Lake.

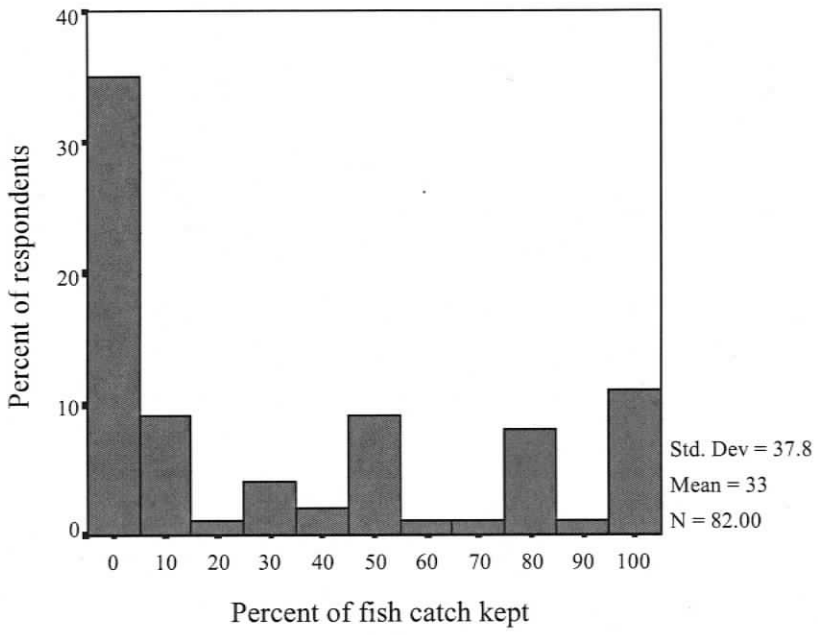

Figure 3.8. Percentage of the respondents that kept different amounts of the fish that they caught.

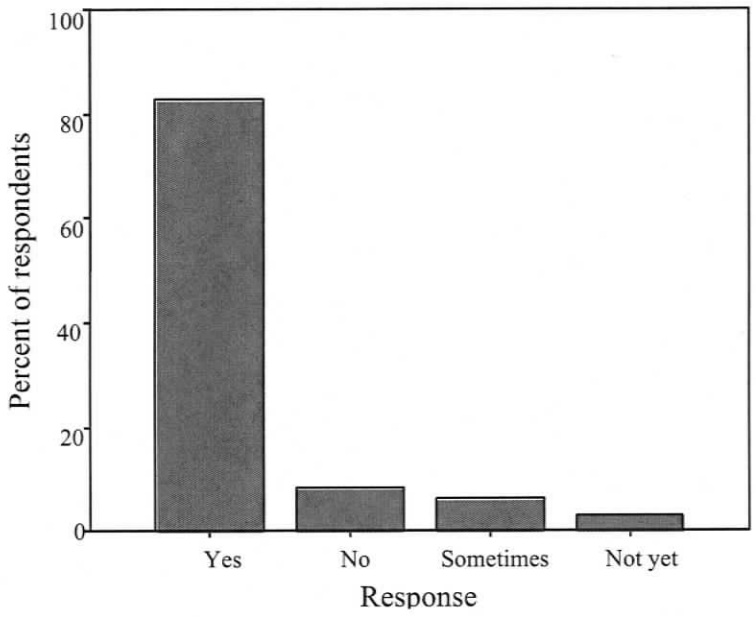

Figure 3.9. Answers of respondents when asked if they eat the fish that they catch in places other than Elk Lake.

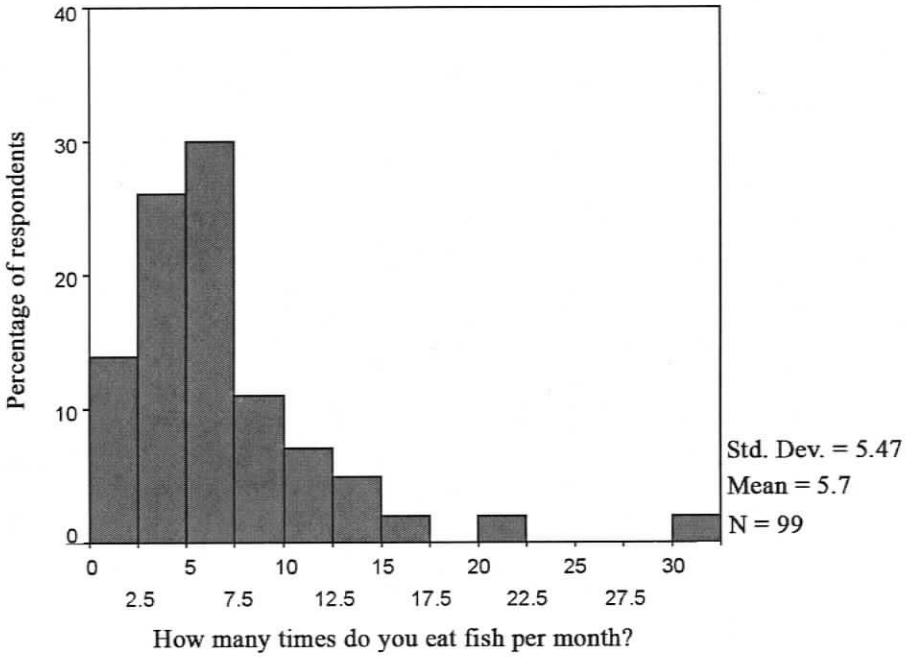

Figure 3.10. Percentage of respondents that ate different amounts of fish meals per month.

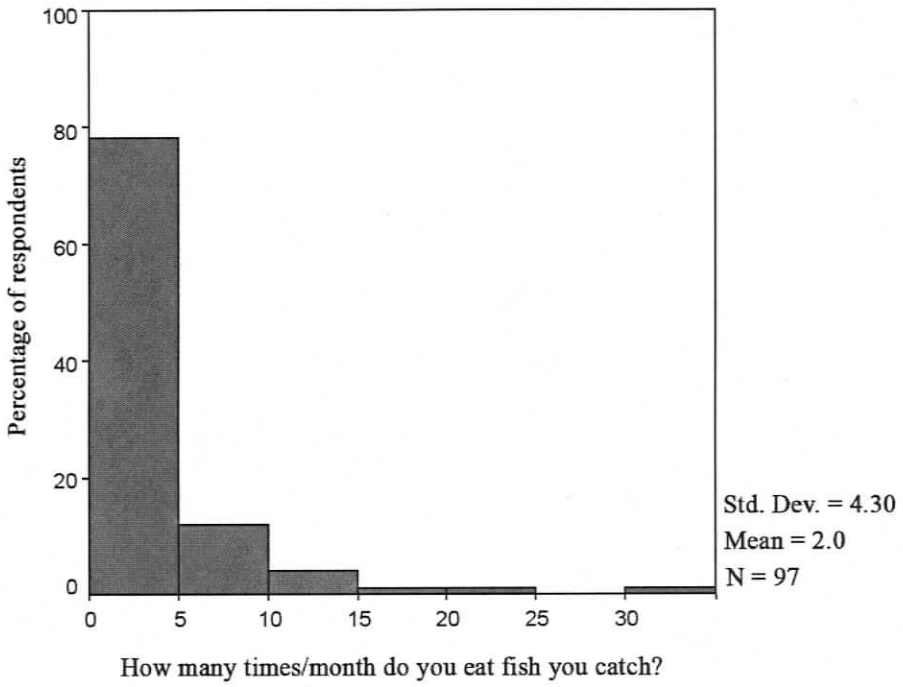

Figure 3.11. Percentage of respondents that ate different amounts of the fish that they caught themselves each month.

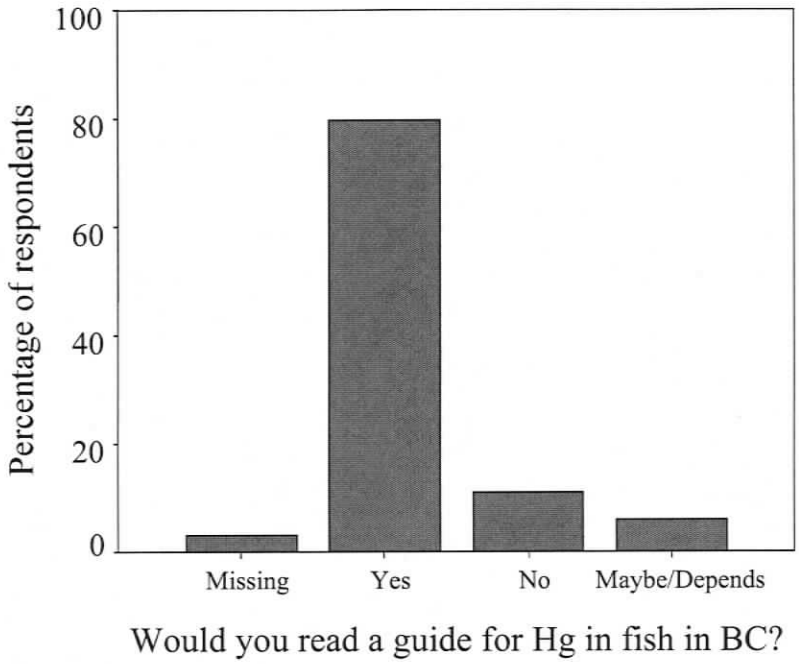

Figure 3.12. Amount of interest respondents expressed for a guide to mercury in fish in BC.

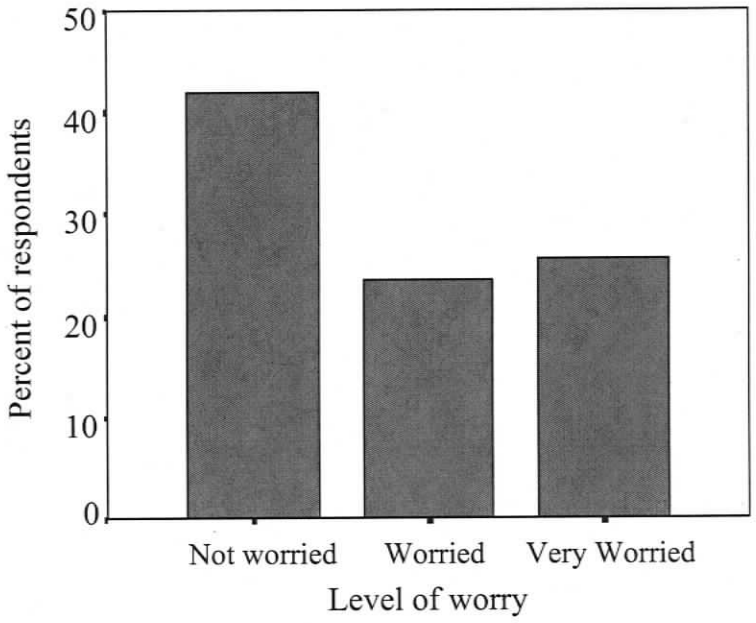

Figure 3.13. Level of worry of the respondents with regards to mercury.

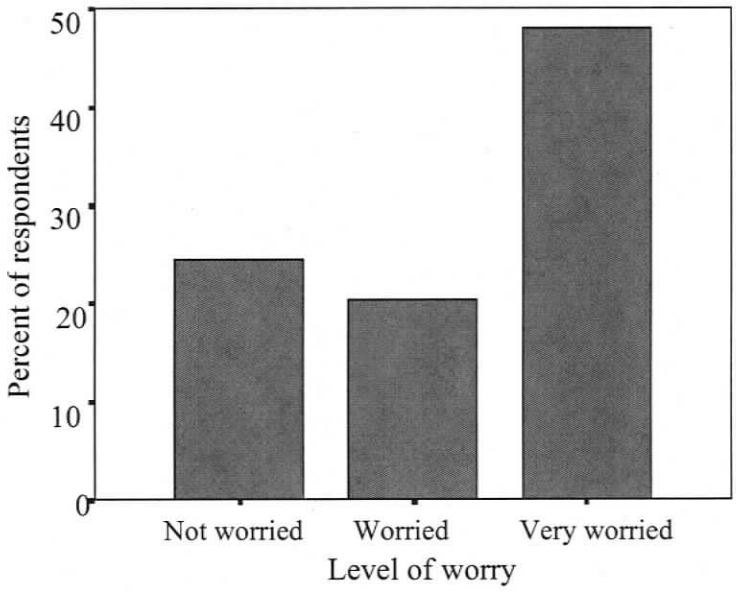

Figure 3.14. Level of worry of the respondents with regards to cancer.

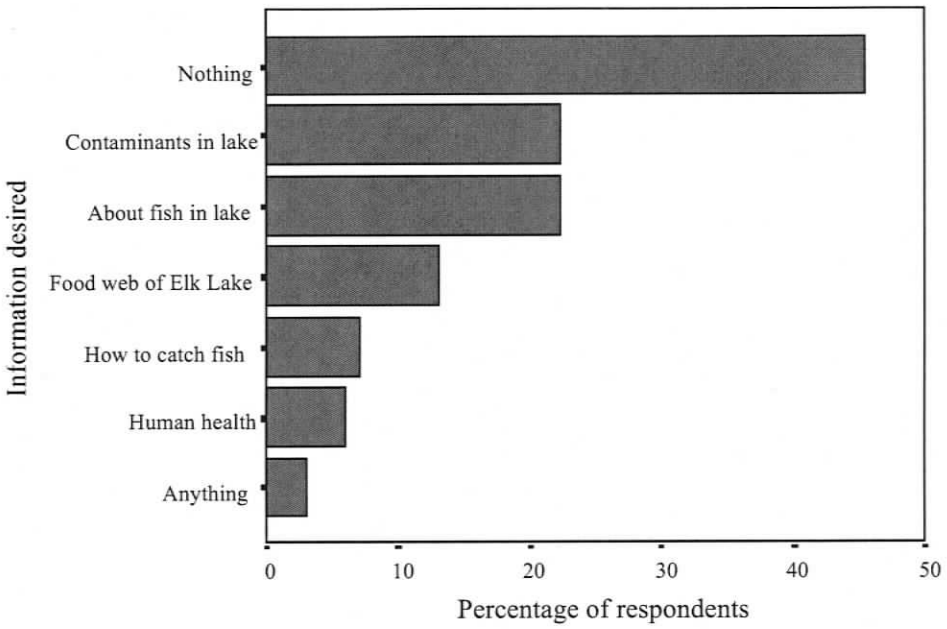

Figure 3.15. Answers that respondents gave to the question "What information would you like to know about Elk Lake?"

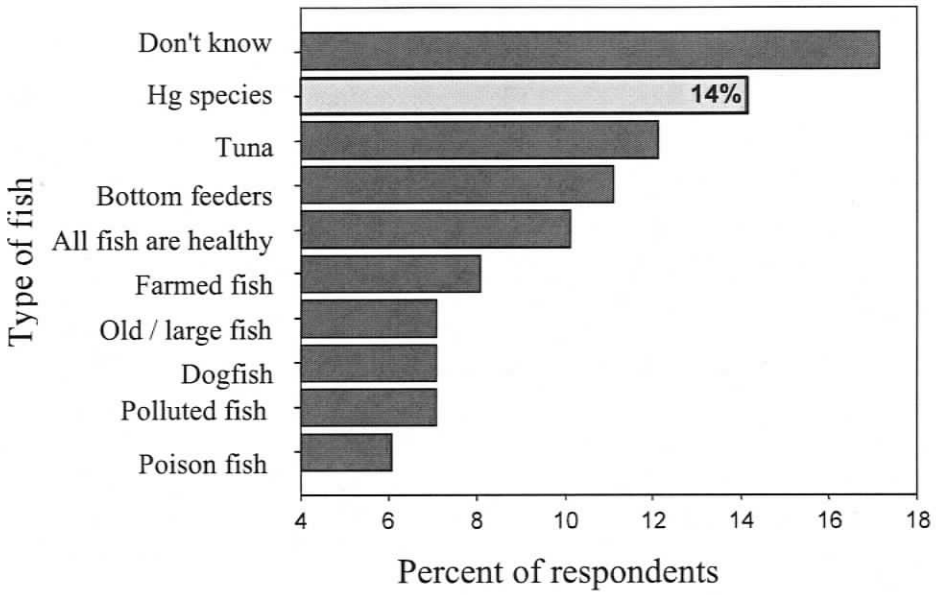

Figure 3.16. Answers that respondents gave to the question "Which fish can be unhealthy to eat?"

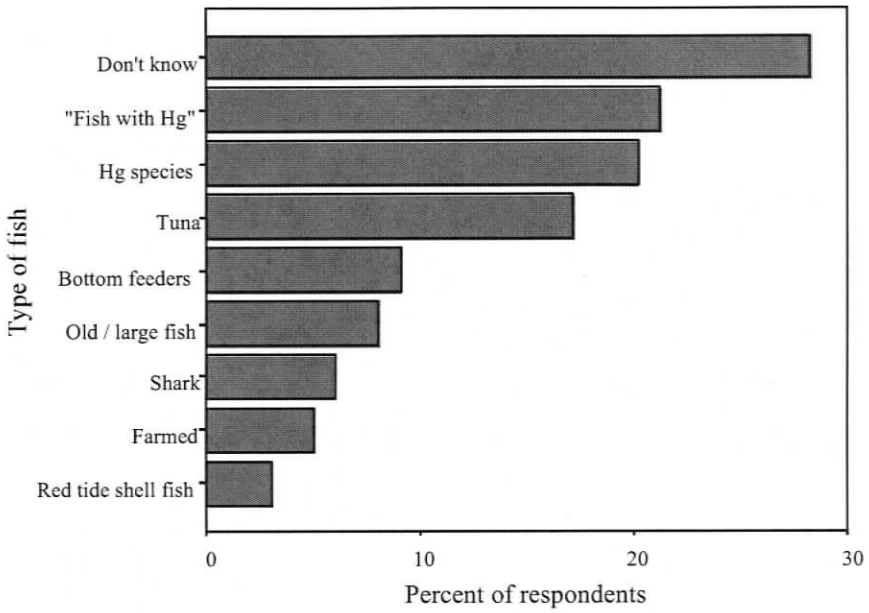

Figure 3.17. Answers that respondents gave to the question "What types of fish should pregnant women avoid or limit?"

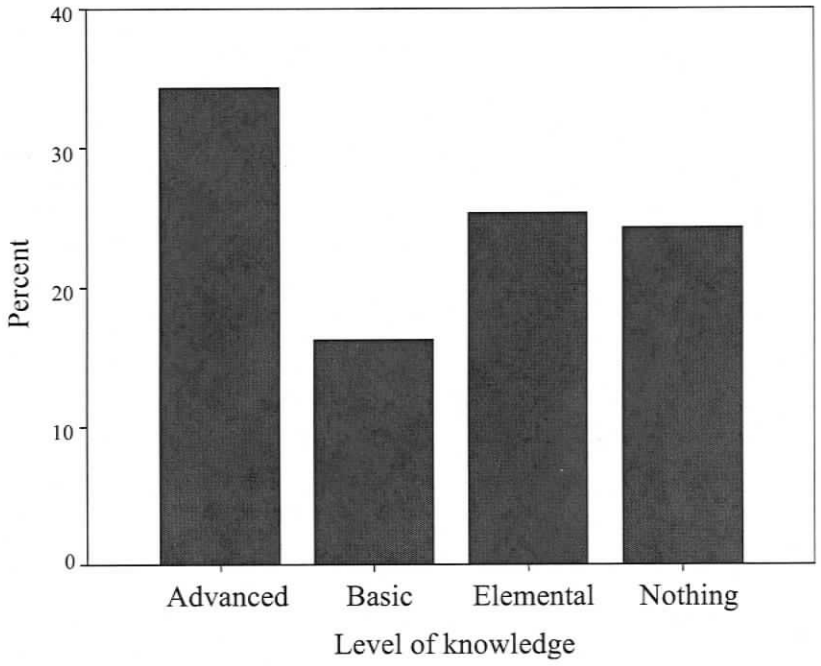

Figure 3.18. Level of Hg knowledge among respondents.

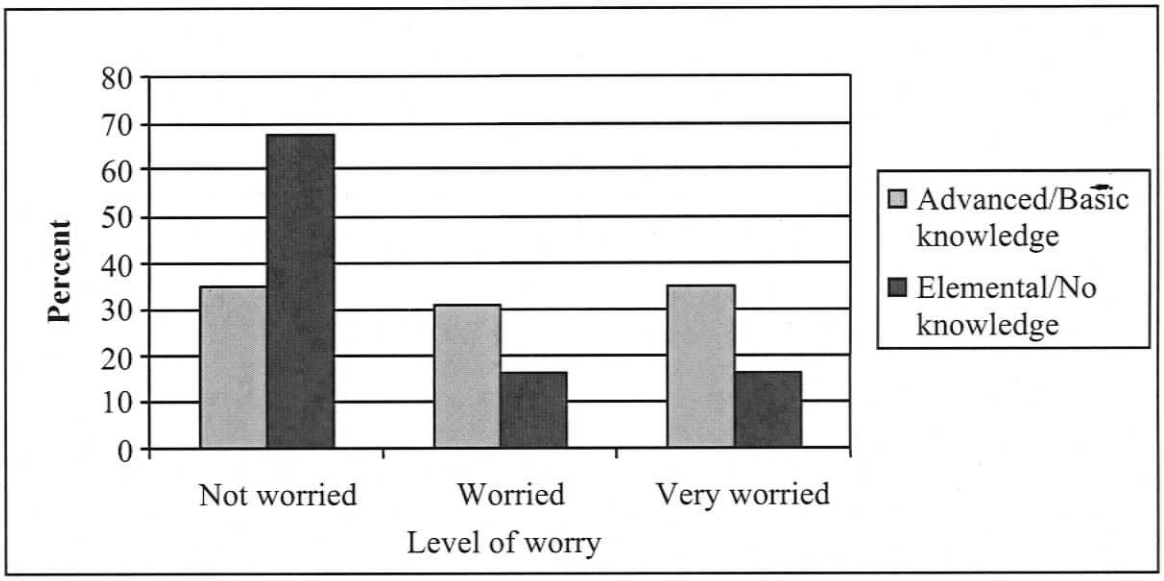

Figure 3.19. Level of worry about mercury among respondents with different knowledge levels of mercury in fish (chi-square contingency analysis: χ^2= 10.49, df=2, P=0.005).

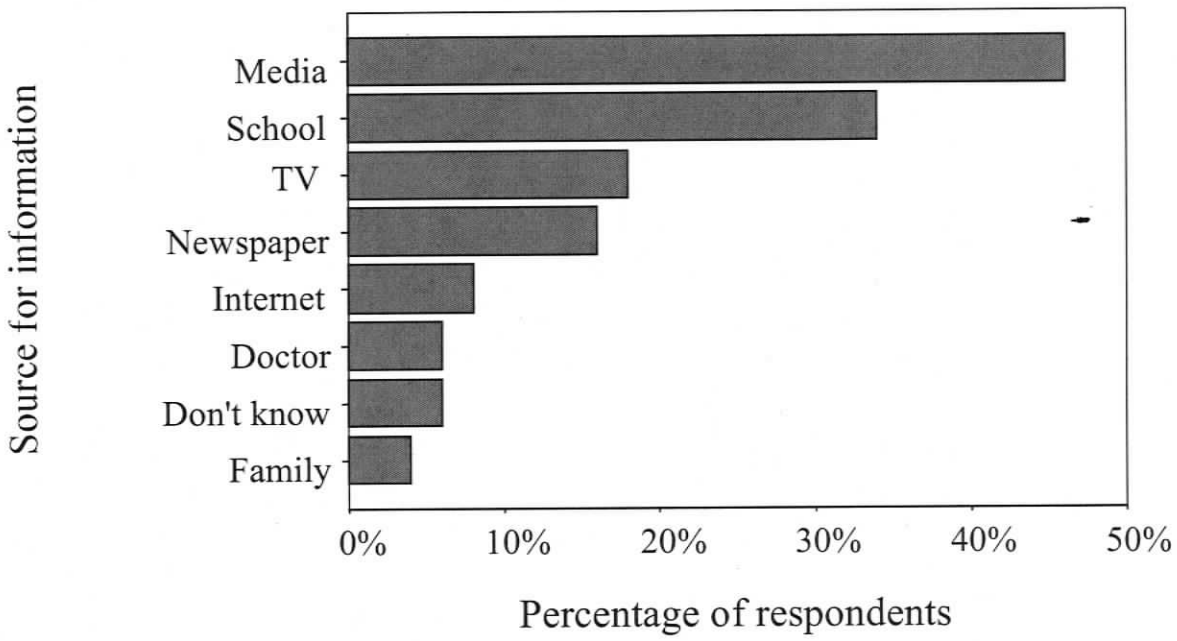

Figure 3.20. Sources of Hg information among knowledgeable fishers (49%).

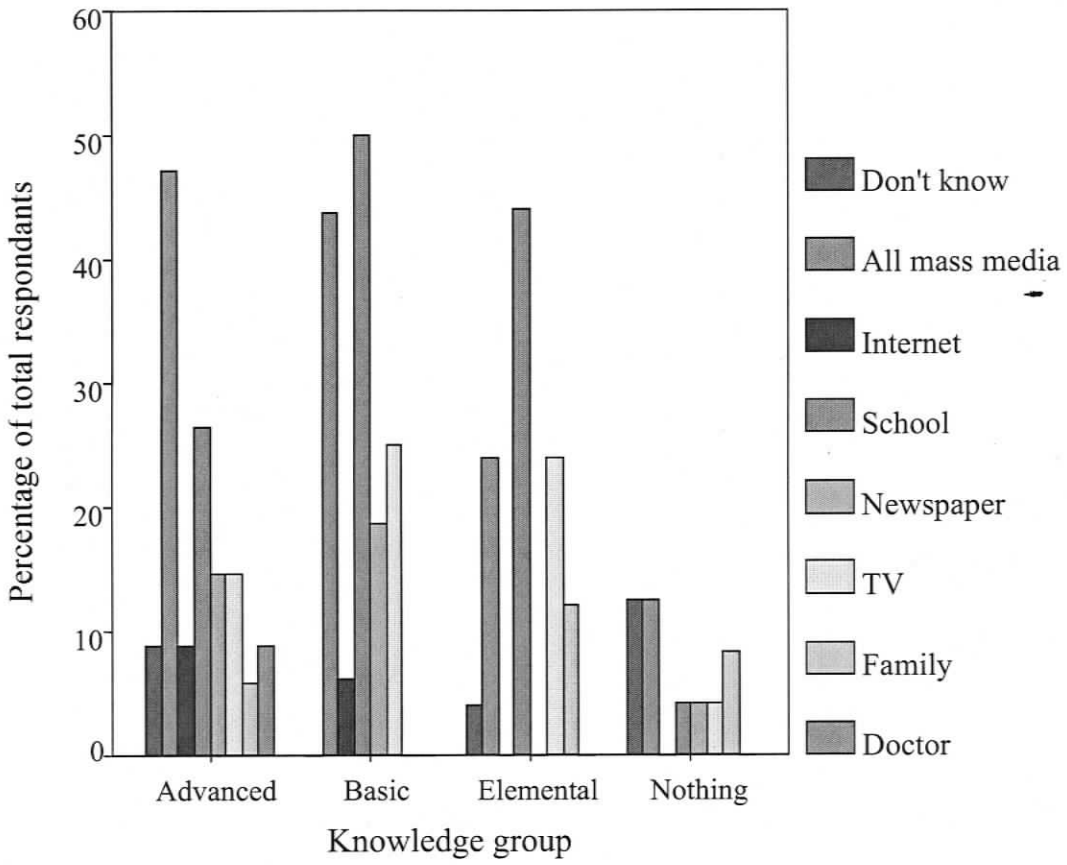

Figure 3.21. Sources of Hg information for respondents grouped according to level of mercury knowledge in fish.

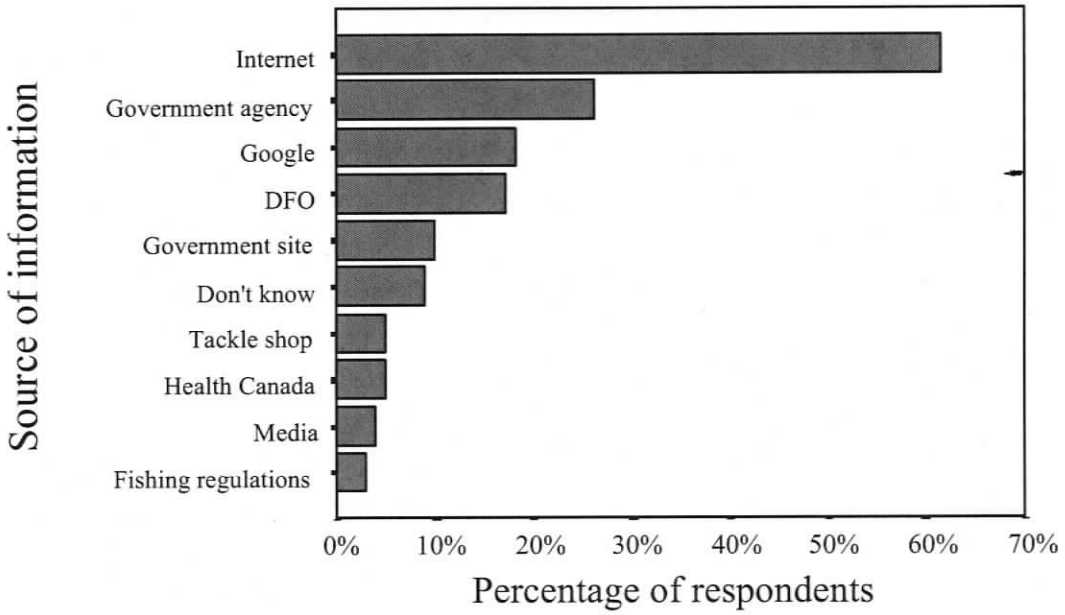

Figure 3.22. Places fishers would look to find general information on Hg.

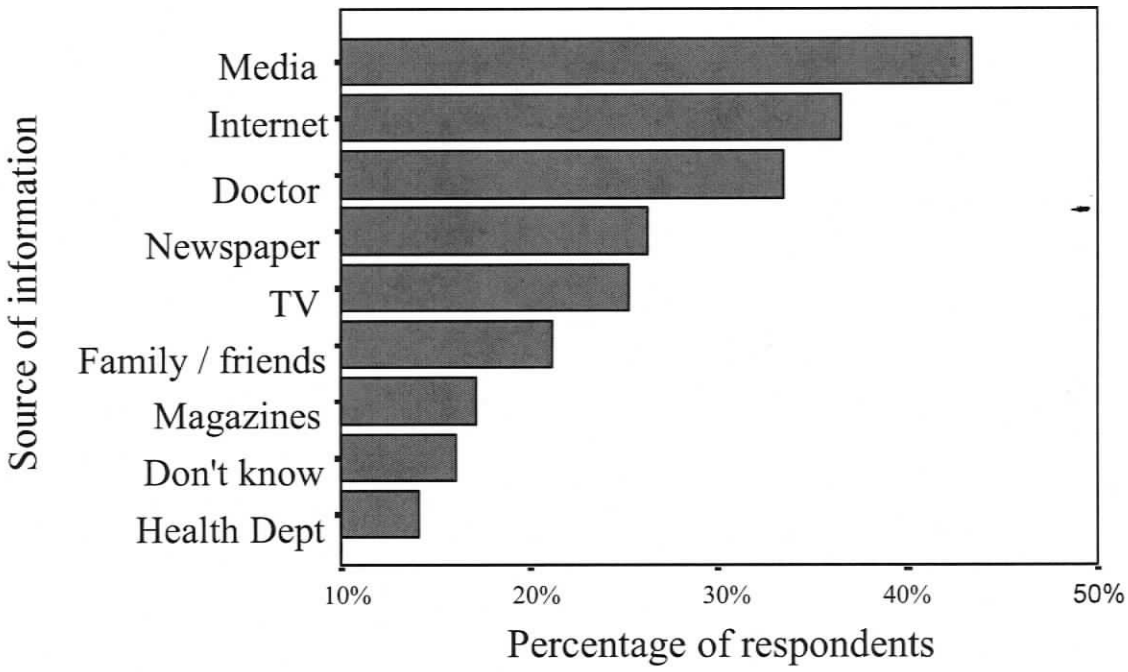

Figure 3.23. Places fishers would look to find health information.

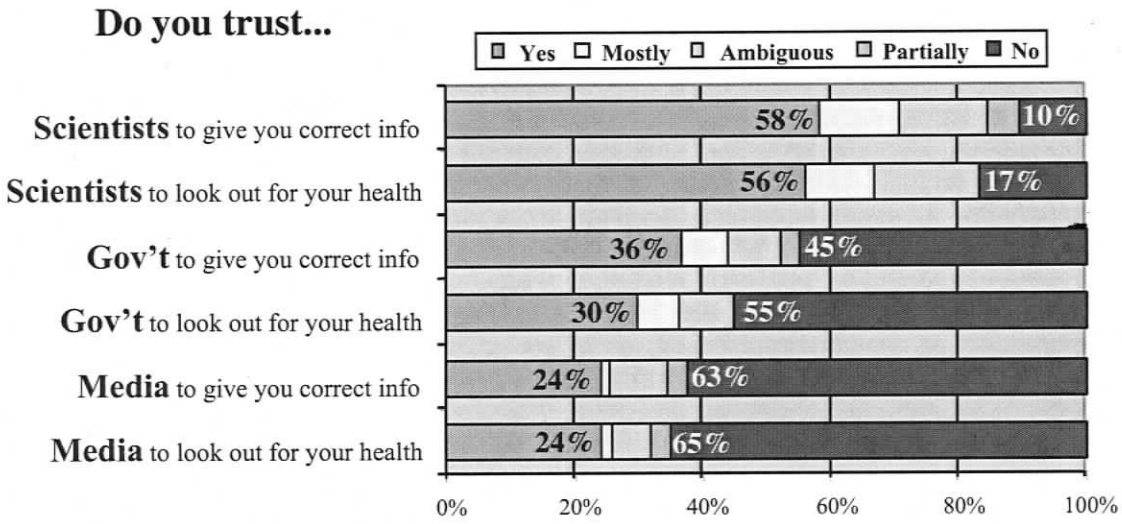

Figure 3.24. Level of trust that respondents had towards scientists, government, and media to provide them with correct information and have their best health interests in mind.

Chapter 4: Summary

4.1 Objectives

The objective of this project was to provide sound scientific research as part of the basis for policy development. I aimed to do this by evaluating what can be learned from a range of fish consumption policies in Canada and internationally to guide effective policy creation in BC, if it is deemed necessary by the government. In addition, I assessed the necessity of fish consumption advisories to protect public health among a sport-fishing population on Elk Lake, Vancouver Island, by evaluating fish consumption, the state of mercury knowledge among these fishers (current awareness), how mercury information reaches them (information flow), and how they use that information to make decisions about their diet (personal diet management).

4.2 Major findings and future research

4.2.1 Fish consumption guideline policy

4.2.1.1 Major Findings

British Columbia has fallen behind other similar provinces in protecting its consumers of freshwater sport fish with consumption guidelines and advisories. Given the potential health threat indicated by new fish-mercury data, guidelines should be created and advisories communicated. My research provideds recommendations for the policy framework required to do this by assessing policies and protocols used by other provinces.

British Columbia should conduct one large-scale, province-wide fish-mercury assessment to determine which fish from which lakes should be put under advisory. If fish are found with mercury concentrations greater than 0.5 ppm, that species, in that lake, should have consumption guidelines calculated and recommended to consumers. If certain species are consistently above 0.5 ppm, a province-wide advisory should be

issued. If fish breach 2 ppm, it should be recommended that consumption of that species stop.

If high fish-mercury concentrations are found in lakes used as subsistence fisheries by First Nations Communities, DFO should be alerted to work with them to instate and communicate advisories. Because First Nations people do not require fishing licenses, communication methods will have to be diverse and audience specific. Academic institutions could be utilized to work with these communities.

Guidelines should be created using the Health Canada Tolerable Daily Intake levels of 0.47 and 0.2 μg Hg/kg of body weight for general and sensitive populations respectively. By these standards, small mouth bass in many lakes should be limited to 4 (general) and 1 (sensitive) meal per month. Yet health damage has been shown when consumption levels are lower than Health Canada TDI's. While more precautionary TDI's would more effectively protect consumers from mercury, they may also scare people away from eating healthy amounts of fish. If the hair-mercury levels of fish consumers are tested and found to be over 2 ppm (general) and 1 ppm (sensitive), guidelines should instead use lower and more precautionary TDI's. If health damage is not quantified in this manner, precautionary guidelines could lead consumers to stop eating fish and lower overall health (Cohen *et al.* 2005).

Guidelines should be communicated through a prominent page in the Freshwater Fishing Regulations Synopsis, a short pamphlet, an easily found web page, and press releases to media. All of these methods are easy and inexpensive but will not reach all consumers. If health damage is quantified in sensitive populations, targeted messages to women of childbearing age should be distributed to Doctors' offices.

Information specifying fish species, fish sizes, lakes, and meal frequencies should be provided for both general and sensitive consumers. Advisories should specify that the age of "young children" is ≤15. Consumption pattern data, species–specific contaminant data, and body weight data need to be used together to make advisories more specific and encourage maximum safe fish consumption and restrict consumption only when necessary (Marien and Stern 2005). A cajoling rather than a commanding tone should be used (Connelly and Knuth 1998) and pictures and diagrams should be included (Burger *et al.* 2003). Information on the benefits of fish consumption and the basics of mercury in

the ecosystem must accompany guidelines in order to keep consumers from cutting back on net fish intake. Risk-risk comparisons should be used to put mercury consumption into perspective (Reinert *et al.* 1991). Recommendations and encouragement to eat low mercury fish should also be included. Communicators can also encourage catch-and-release in very contaminated waters where fishing has been shown to be a recreational and cultural activity. This would also keep fisheries and tourist industries from financial loss (Burger *et al.* 2001a). Advisories should be tested and updated accordingly.

This is the first assessment of fish consumption guideline policies conducted in Canada, and highlights the strong points and weaknesses of each province. Likewise, no assessment of fish-mercury policy has ever been conducted for British Columbia and this research, in combination with the work of others, provides a strong argument for the creation of guidelines and the methods by which to do so. Sound science can vastly improve fish consumption guidelines (Ashizawa *et al.* 2005), as can communication among stakeholders (Chess *et al.* 1995a; Chess *et al.* 1995b). This study was the product of cooperation among researchers, risk assessors, and policy makers, providing a base for future research and science-based policy formation.

4.2.1.2 Study Limitations

Each province and country has different fish-mercury and fish-consumption levels. Not all policies used elsewhere are applicable to British Columbia. However, lessons can be drawn to illuminate BC's lack of policy and provide recommendations. More information on how provinces use mercury data to create guidelines would help with BC's guideline formation.

4.2.1.3 Future Directions

In order to assess the risk of health damage from sport-caught fish in BC, more mercury data must be collected; this is simply unavoidable if public health is to be protected. If mercury levels in fish are found to be high in lakes where sport-fishing is also high, hair mercury testing should be conducted to ascertain the level of health damage present.

Recommendations from this study are being written up in a format conducive to policy making (see appendix 2). They will be provided to policy makers and those

involved with mercury and sport-fishing guidelines in BC. Policy makers are encouraged to use these recommendations and research in their guideline and advisory formation.

4.2.2 Survey of sport fishers on Elk Lake

4.2.2.1 Major findings

Many studies covering the process of instituting and communicating guidelines have expounded upon the importance of stakeholder participation throughout the entire duration of advisory formation (Chess *et al.* 1995a; Chess *et al.* 1995b). This project consulted sport-fishers to assess their concerns, information needs and desires, as well as the pathways and formats of advisory communication that would best suite their needs. This information can be used for other purposes than mercury related advisory formation, should the need for communicating with sport fishers arise. This project also incorporated policy makers into its structure and intent, creating issue oriented science, providing information requested by policy makers, incorporating their concerns, and producing research that predicts the science necessary for sound policy formation before that policy is urgently required (Meffe and Viederman 1995).

Two-thirds of fishers on Elk ate their catch and 33% succeeded in doing so by the time of interview. Few people surveyed were fishing with the sole purpose of food collection, as fishing has often been reported as a social and personal form of relaxation (Toth and Brown 1997; Burger 2002a). Mercury levels in Elk Lake are generally low but one very large small mouth bass had levels above the Health Canada guideline. Mean levels were below 0.5 ppm but consumption of this species should still be limited to 5 meals per month for sensitive populations. Fortunately, no fishers reported eating amounts of this species that would cause damage. Yet health damage could occur to Elk's fishers from sport fish eaten in other water bodies, as most fishers reported eating more fish from other lakes than from Elk.

Fishers on Elk Lake showed a high level of interest in fish consumption guidelines and 76% would read an advisory booklet. Almost everyone (96%) said they would follow guidelines recommended. While this does not necessarily mean fish consumers actually will follow guidelines, it does indicate a high level of interest and possibility that advisories will be well received. However, 36% fishers also reported that

they would stop eating fish that were shown to have any mercury in them at all. It is imperative that advisories do not scare people away from such a healthy food source, so advisories must be accompanied with educational information about mercury and the many health benefits of eating fish.

Only 60% of fishers on Elk Lake reported reading the Freshwater Fishing Regulations Synopsis, and only 40% read it in a BC-wide survey (Jack *et al.* 2003). A prominent page in the Regulations would be effective at reaching some fishers, but more diverse methods need to be utilized if the majority of fish consumers (many of whom are unlicensed or do not fish) are to be reached. A website and media press releases are inexpensive and easy ways to reach fish consumers with information and should be used to communicate advisories if they are created. Signs could also be placed on highly contaminated lakes. Pamphlets given to medical care providers to reach women of childbearing age are far more expensive and should only be used if future hair-mercury tests show high concentrations among sensitive populations. Because fishers trusted scientists far more than the government or the media to provide them with correct information and have their best health interests in mind, information provided to fishers through the internet, mass media, or the government should be formatted in such a way that scientists were obviously the authors.

A review of advisory formation found that, in order to communicate effectively with fish consumers, research must be done to assess the nature of the group or groups that need to be targeted, be they from a province, an economic class, a gender, or ethnic group (Velicer and Knuth 1994; Connelly and Knuth 1998; Knuth *et al.* 2003). This will enable the communication of advisories that are from a trusted source, transmitted through channels that will reach anglers, use language that is appropriate for the audience targeted, and incorporate the group's concerns and needs (Tilden *et al.* 1997; Burger *et al.* 2003; Fitzgerald *et al.* 2004). This can also increase fish consumers' confidence in the advisories when they are distributed. The Elk Lake study succeeded in following these steps required for effective advisory formation. This study painted a portrait of one fishing community in BC and can be used to supply policy makers and risk communicators with a general idea of the levels of knowledge and concern of fishers for potential incorporation into advisories or the bases for further research, as well as

pathways and methods of communication that would be most effective at reaching this population. The importance of stakeholder participation has also been widely reported by risk communicators (Chess *et al.* 1995a; Chess *et al.* 1995b). This study worked with fish consumers from the beginning of the advisory formation process to assess their needs, desires, and concerns surrounding fish consumption advisories.

4.2.2.2 Study limitations

One of the limitations of this study was the sample size of 99 fishers on Elk Lake. Many fish consumption studies are conducted with 100 respondents or less. However it would have been easier to detect patterns among mercury knowledge, consumption behavior, and demographic parameters if more respondents were available to survey. There were many apparent correlations in my data where the effect size was too small to be statistically significant. These may have been significant correlations with a larger sample size. In addition, different statistical approaches might have been able to uncover correlations that eluded me. Had I this project to complete over again, one more person would have been surveyed and fewer questions asked of fishers, as I collected far too much data for a Masters program.

Dietary recall methods have been shown to return unreliable data, so consumption data in this study might not accurately reflect mercury intake. However, tests were done to check the accuracy of responses and measures were taken and processes followed that have been shown to improve reliability of dietary data. Size prompts were given for meal amounts and questions were asked and ordered to decrease bias. Because portion size is almost always estimated wrong in recall surveys (Smith 1993), I disregarded portion size data and focused on meal frequencies.

In addition, sport fishers on Elk Lake do not necessarily represent all fishers in BC. Many disparities exist that could influence the format of advisories (Table 1.3). Elk Lake fishers seem to eat more sport fish and fish more often that their regional counterparts questioned in province-wide surveys. If this is the case, information from Elk Lake fishers and this research would be more relevant to the creation of fish consumption advisories than from a cross section of licensed anglers. Because this survey was conducted among all anglers actually fishing rather than mailed to licensed anglers

16 years and older, this study could represent more accurately people consuming sport fish. Yet even then, Elk Lake fishers might not be representative of BC fishers on the whole. Larger scale studies of fishers and fish consumers would be required it assess if this was the case.

4.2.2.3 Future Directions

Additional work could still be done with the data collected from Elk Lake. There is weight, age, gender, and fish consumption by species information. Along with mean mercury concentrations in commercial and sport caught fish, these data could be used to conduct a risk analysis for fishers in this population. This study would clearly define the potential for mercury related damage within this population and could be used to extrapolate the amount of risk currently facing British Columbians without adequate knowledge of the risks and benefits of eating fish.

Fishers surveyed have a low risk of mercury-related health damage from Elk Lake fish given their consumption habits and fish-mercury levels. But a full risk-assessment, considering consumer weight, sensitivity levels, and sport-fish and commercial fish mercury levels, has not been conducted. More fish-mercury testing is required to assess the extent of the guidelines necessary, especially considering data showing fish-mercury levels high enough to cause a health risk. Once provincial fish-mercury levels are known, a full risk assessment can be conducted with the fish consumption data provided here. If the risk is found to be high, the necessity of target group communication and the extent of advisories can be assessed. Regardless of the outcome, the data currently available is enough to require BC to create and institute consumption guidelines for fish consumers.

While this research indicates that fish consumption could cause health damage to BC fishers, fish consumption surveys are not reliable methods of assessing mercury burdens in individuals (Stern *et al.* 2001; Loranger *et al.* 2002; Canuel *et al.* 2006). Hair-mercury testing of sport-fish consumers, especially those from lakes with high fish-mercury levels, would be beneficial for discerning the extent of health damage and health damage potential. If levels are found to be above 1 ppm and 2 ppm for sensitive and

general populations respectively, steps should be taken immediately to alert consumers about healthy guidelines.

Information from this study will be used to create recommendations for policy makers (see appendix 2), which will be distributed to them. Policy makers are encouraged to use these recommendations and research in their guideline and advisory formation.

Fishers who participated in this study and requested information (46%) have already been sent the basic demographic, fishing behavior, and knowledge results of this study. Further information providing recommendations for sport-fish consumption and wallet cards for commercial fish will be sent out in the future. This survey, and abbreviated forms of it, can also be used if further fish consumption studies on other populations in BC are found necessary. Risk communicators and policy makers are encouraged to continue to work with these fishers and others in order to involve all stakeholders in the advisory process of creating comprehensive and effective advisories.

4.2.3 Summary

British Columbia requires fish consumption guidelines for sport-caught fish in order to effectively protect public health. Data from the Ministry of the Environment shows that fish-mercury levels in BC are high enough to cause health damage if eaten in large enough quantities or by sensitive populations. Data from Elk Lake fishers shows that consumers are eating amounts of fish that could cause damage if mercury levels in BC lakes are high. Large-scale, province-wide fish-mercury testing must be conducted to assess risk and calculate guidelines. Fish should be caught by angling large fish rather than netting and testing all fish. Fish consumption guidelines should be created using the Health Canada TDI's of 0.47 0.2 μg/kg bw/day for the general pubic and sensitive populations respectively. If hair-mercury testing is conducted and health damage found to be high, more precautionary TDI of 0.06 μg/kg bw/day should be used.

Advisories should be created that contain species- and lake-specific meal frequency recommendations for the general public and sensitive populations, as well as various body weights. Advisories should be comprehensible, with diagrams and educational information about mercury. Advisories should contain risk-risk comparisons

for consuming mercury, as well as information on the benefits of eating fish. Advisories should be communicated with a visible and informative page in the Freshwater Fishing Regulations Synopsis, a website, and media press releases. It should be made evident in the advisory that the information is the result of scientific research and press releases should include quotes from scientists.

If health risks are found to be high, hair mercury testing should be conducted of sport fish consumers, and tower TDI's and pamphlets targeting sensitive populations should be considered. If mercury levels over Health Canada guidelines of 0.5ppm are found in lakes used by First Nations Communities for sustenance fishing, the DFO should be alerted and more research conducted.

4.3 Conclusion

This study succeeded in laying a scientifically based platform for the creation and dissemination of fish consumption advisories in British Columbia. All stakeholders, policy makers, fisheries managers, researchers, fishers, and fish consumers, were consulted and concerns incorporated from the very beginning of the advisory formation process. The most beneficial Tolerable Daily Intake Levels were determined for the creation of guidelines and sport-fish consumption guidelines were calculated for the fish-mercury available. The methods and protocols used by other provinces to create and disseminate guidelines and advisories, as well as the strengths and weaknesses thereof, were analyzed and lessons were drawn to make recommendations for British Columbia. The target audience was loosely defined and described. A survey of sport fishers on Elk Lake concludes that advisories are necessary to protect the health of this population, even though health risks appear low for the consumption of Elk Lake fish. Effective formats of advisory presentation were provided so that consumers would be able to make educated diet decisions while maintaining net fish intake. Proper advisory pathways and formats of communication that fishers could understand, reach, and trust were determined.

It is my greatest wish that the findings of this project be constructive for those seeking to implement fish consumption advisories and guidelines for British Columbia; I would love to help with this process in any way necessary to make this information more useful.

Appendices

Appendix II. Questionnaire administered to sport fishers on Elk Lake.

Questionnaire Questions for Fishers in Shawnigan and Elk Lakes:

I am a grad student at Uvic doing a research project on fish knowledge and health. I will ask you a lot of questions and do not want to give away too much information (least it bias you) until the end. But after the survey, you can ask me as many questions as you like. Your answers will remain completely confidential and your personal information will be stored separately from those answers. You do not have to provide me with answers to all the questions. You can just answer some of them.

Date: Research partner
Time:
Location:

General:
Age:
Height:
Sex:
Weight:
Married:
Children: Ages:
Is it possible that your wife/you could become pregnant in the near future? [**yes no**]

Fishing Behaviour:
How many years have you been fishing here?
How many times do you fish here per year?
Where else do you fish?
Why do you fish in this lake specifically?
Are there certain months you fish? Which?
What time of day and week do you fish?
What types of fish do you catch here? [Rainbow Trout - Cutthroat trout – Smallmouth Bass - Yellow Perch –Sunfish]
How many of each do you catch per year?
How many fish total do you catch per day/week/month/year?
What percentage of fish do you keep versus throw back?
What dictates your decision? [Size, bycatch, unhealthy looking, restrictions like spawning, fishing for sport alone]
Why do you fish?
Relaxation
To be outdoors
To get away from demands
Commune with nature
Challenge or sport
Be with friends
Recreation
To eat

To give away
It's cheaper to catch fish than to buy it.
For frys or socials
To trade

Fish Consumption Behaviour:

Do you eat fish? [**yes no**]
Do you eat fish that you catch? [**yes no**]
Do you eat fish that you catch here? [**yes no**]
If not, why? [**Pollution, Catch and release, Prefer to buy fish, Don't like it**]

How many times total do you eat fish per month?
How many times per month do you eat fish that you've caught?
How many times per month do you eat fish you've caught here?
Do you only eat certain species of fish that you catch here? Which?
[**Rainbow Trout - Cutthroat trout – Smallmouth Bass - Yellow Perch –Sunfish**]
How many times per month do you eat from a **store**?
What types of fish do you buy from a store?
How many times per month do you eat from a **restaurant?**
What types of fish do you eat at restaurants?
Who else eats the fish you catch? [**Family – Children - Wife/husband - Friends**]
Has she/you ever been pregnant when she/you ate the fish here? [**yes –no-maybe–don't remember**]
Who prepares the fish you eat from here? [**me – spouse – children – other**]
How do you generally prepare the fish you catch here? [**Fry - Broil – BBQ**]
How much fish do you eat in one sitting on average?

Knowledge in General:

Is there any information would you like to know about freshwater fish that the scientific community could provide?

How would you like that information communicated?

General Health Awareness:

How worried are you about the health affects of Hg? (**1-10**)
How worried are you about the health affects of cancer? (**1-10**)
Do you smoke? [**yes – no**]
Do you eat organic? [**yes – no - sometimes**]
Do you wear sunscreen? [**yes – no**]
Do you eat farmed salmon? [**yes – no**]
How many times per year do you visit a doctor?

Are fish healthy to eat? [**yes – no – depends – don't know**]
How much fish is healthy to eat?
Are there fish that are unhealthy to eat?
Do you ever limit your fish consumption? Why?

Did you or your wife change your fish consumption behaviour when pregnant? [**yes – no – don't remember**]
Are you confident that you know enough about the risks and benefits of eating fish to make good health decisions? [yes – no – don't know]
How confident are you that what you know is correct? (5 is most confident)
Would you like to know more? [**yes – no**]

Hg Knowledge:
If you do limit fish consumption, is Hg a contributing factor? [**yes no**]
If you found out that the fish you were eating had high Hg levels, would you stop eating them?
If you found out that the fish you were eating had any Hg in them, would you stop eating them?
If you found the fish in this lake to have high Hg levels, would you switch to another lake?
Can you tell me about Hg?
Where did you learn what you know about Hg?
Are you aware that fish can have high levels of Hg? [**yes – no**]
Where does the Hg in fish come from?
Do you know that there are health risks associated with Hg? [**yes – no**]
Does Hg cause:

- Increased Cancer risk? [**yes – no – don't know**]
- Neurological problems? [**yes – no – don't know**]
- Increased health risks to unborn children? [**yes – no – don't know**]
- Increased health risk to young children? [**yes – no – don't know**]

Should women who are pregnant or may become pregnant, eat **more** or **less** fish? [**depends**]
What types of fish should pregnant women avoid?
How many servings of fish would a person have to eat per week to be at risk?
Are you worried that the fish in this lake could have high mercury concentrations?
Why?
Are you aware of any fish consumption advisories? [**yes no**]
Have you ever sought out fish consumption advisories? [**yes no**]
Where would you look if you did?
Would you comply with advisories if they told you to limit your consumption? [**yes no depends**]
Is there a risk of Hg contamination in BC? [**yes – no – don't know**]
Do we need more thorough and accessible fish consumption advisories? [**yes no don't know**]

Information Sources:
If you wanted to find out about Hg in fish in general, where would you look?
If you wanted to find out about Hg in fish in this lake, where would you look?
Do you read the newspaper? [**yes no**]
Which one? [**Times Colonist – Globe and Mail – local**]
Do you take any actions to update yourself on the latest health related discoveries? [**yes/no**]
Were you given the Freshwater Fishing Regulations Synopsis with your license? [**yes no**]
Did you read the freshwater fish advisories issued with your permit? [**yes no don't remember**]

Where do you look for health information?

- Friends
- Doctor
- Health Department
- Other
- Newspapers
- TV
- Magazines
- Radio
- Internet

Where do you look for fishing information?

- Other fishermen
- Bait and Tackle
- Newsletter
- Internet
- Magazine: [**Sport Fisher**]

Do you follow fisheries policy? [**yes no -sometimes**]
Do you find environmental and pollution regulation information would be difficult to find and understand?
If a guide were published to the various levels of Hg in fish in lakes in BC, would you read it? [**yes - no**]
Would you buy it? [**yes - no - depends on price - don't know**]
If you knew one politician would take actions to prevent Hg from getting into the atmosphere, would you be more inclined to vote for him/her? [**yes no depends**]
Are you interested in recent scientific research on watersheds and fish? [**yes no**]
If there was a conference or workshop on local watersheds and fish, would you go? [**yes no**]
If there was a website with information on local watersheds and fish, would you visit it? [**yes no**]

If an advisory cautioned against more than "one serving of fish" per week, how big would you imagine this serving?
What if it cautioned against "heavy consumption", how much is this?
What about "normal consumption"?

If you had the means to help with scientific research by testing water or fish or collecting samples to test, would you? [**yes no**]
If you found a problem with the water or fish, who would you go to?

Is this survey making you nervous about eating fish? [**yes no**]
Would the knowledge that fish consumption guidelines existed make you less likely to eat fish? [yes no]
Do you still think fish are healthy to eat? [**yes no**]

Theoretical:
Do you trust scientists to provide you with correct information?
Do you trust that scientist have you best health interests in mind?
Do you trust the government to provide you with correct information?
Do you trust that the government has you best health interests in mind?
Do you trust the media to provide you with correct information?
Do you trust that the media has your best health interests in mind?

Please do not feel obligated, but can I have your contact information to follow up with you and possibly ask you more questions and send you Hg related information?

Name:
Contact rout:

General:
Ethnicity:
Country of birth:
Education Level:
How many kilometres do you live from the lake?
Income:
Is English your primary language?

Is there any information would you like to know to make more informed health decisions?
[No - yes: Hg - fish - lake]

Is there anything you would like to know from me about this project or anything else?
[my project - Hg in ecosystem - Hg in lake - Health concerns]

Would you be interested in finding out my results when I get them? **[yes no]**

Appendix II. Recommendations for policy makers

- Data from the Ministry of the Environment shows that fish-mercury levels in BC are high enough to cause health damage if eaten in large enough quantities or by sensitive populations (women of childbearing age, pregnant women, nursing mothers, and children less than 15 years of age).

- Large-scale, province-wide fish-mercury testing should be conducted to assess risk. Fish should be caught by angling large fish rather than netting and testing all fish.

- Fish consumption guidelines should be created using the Health Canada Tolerable Daily Intake (TDI) values of 0.47 and 0.2 μg of mercury /kg body weight/day for the general pubic and sensitive populations respectively.

- If health damage is found to be high, the more precautionary TDI of 0.06 μg/~~kg~~ bw should be used.

- Advisories should be created that contain species and lake specific meal frequency recommendations for the general public and sensitive populations, as well as various body weights.

- Advisories should be comprehensible, with diagrams and educational information about mercury.

- Advisories should contain risk-risk comparisons for consuming mercury, as well as information on the benefits of eating fish.

- Advisories should be communicated with a visible and informative page in the Freshwater Fishing Regulations Synopsis, a website, and media press releases.

- It should be made evident in the advisory that the information is the result of scientific research and press releases should include quotes from scientists.

- If health risks are found to be high, hair mercury testing should be conducted of sport fish consumers and lower TDI's and pamphlets targeting sensitive populations should be considered.

- If mercury levels over Health Canada guidelines of 0.5ppm are found in lakes used by First Nations Communities for sustenance fishing, the DFO should be alerted and more research conducted.

For more information please contact Rebecca McMackin, Masters student, University of Victoria (mcmackin@uvic.ca).

Appendix III. Human Research Ethics Committee Certificate of Approval

University of Victoria

Human Research Ethics Committee
Office of the Vice-President, Research
University of Victoria
Room 425 Business and Economics Building
Tel (250) 472-4545 Fax (250) 721-8960
Email ovpthe@uvic.ca Web www.research.uvic.ca

Human Research Ethics Committee
Certificate of Approval

Principal Investigator	Department/School	Supervisor
Rebecca McMackin Graduate Student	BIOL	Dr. Asit Mazumder

Co-Investigator(s):

Project Title: **Communication, Conflicts, and Information Flow Potential Between Scientific Institutions, Policy Making Bodies, and Watershed Users in British Columbia**

Protocol No.	Approval Date	Start Date	End Date
249-04	23-Jul-04	23-Jul-04	22-Jul-05

Certification

This certifies that the UVic Human Research Ethics Committee has examined this research protocol and concludes that, in all respects, the proposed research meets appropriate standards of ethics as outlined by the University of Victoria Research Regulations Involving Human Subjects.

Dr. Martin Taylor
Vice-President, Research

This Certificate of Approval is valid for the above term provided there is no change in the procedures. Extensions or minor amendments may be granted upon receipt of "Request for Continuing Review or Amendment of an Approved Project" form.

249-04 McMackin, Rebecca

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