VALUING FISHING IN THE SOUTHERN CANADIAN SHIELD

ASSOCIATED MONETARY VALUES OF ECOLOGICAL SERVICES IN ECOREGION 5E AND MUSKOKA

BRAD JENNINGS, SPENCER LAROCQUE, JOSH ANDERSON, NICK CHAMPMAN, NICHOLAS SCHWASS

U-Links

Muskoka Watershed Council

TRENT UNIVERSITY

Valuing Fishing in the Southern Canadian Shield: Associated Monetary Values of Ecological Services in Ecoregion 5E and Muskoka

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Brad Jennings, Spencer Larocque, Josh Anderson, Nick Champman, Nicholas Schwass

Section 1.0: Spencer Larocque
Section 2.0: Brad Jennings
Section 3.0 (3.1-3.4): Nicholas Schwass
Section 3.0 (3.5): Josh Anderson
Section 4.0: Nick Champman
Section 5.0: Brad Jennings
Editing and Graphics: Brad Jennings
Photos: 2010-2012 Brad Jennings

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1.1: BACKGROUND ECONOMICS OF FISHING IN THE REGION

1.0: Introduction

Since the Earth's surface is composed primarily of water, it makes sense that humans would use it and the numerous aquatic species that call it home. Canada is lucky to have an abundance of freshwater systems when compared to the majority of other countries across the globe. This abundance of freshwater then translates into an abundance of fish and other aquatic animals that either live in or in close proximity to the water. In fact fish are one of Canada's most essential natural resources and are one of its greatest exports.

Ontario itself has a plethora of lakes, rivers and streams that helped shape not only the geography of the area but also its history. Waterways not only served as transportation routes but also as bountiful food sources. Fishing once began as a way to feed tribes and families and from that point it has continued to grow. People now fish to catch food, for the sport and adventure of it, to reconnect with the outdoors and also simply for fun. In fact, fish are one of the most heavily monitored resources in Canada, in order to ensure that we do not decimate their population numbers. In order to properly manage its water bodies and fish populations, Ontario is divided into twenty fishery management zones of different sizes according to the number of water bodies and the human population density (Hogg *et al,* 2010). Muskoka is located in zone 15 and is one of the most stunning and beautiful places in Ontario. This beauty and abundance of water systems has made it a popular destination for people to go visit for a large variety of reasons. One of the major attractions to the area is the excellent fishing prospects that it presents from its excellent variety of fish species and angling opportunities. In fact, recreational fishing is one of the larger industries in the area and is a significant source of income.

Placing an exact dollar value on the economic impacts of recreational fishing in an area is an incredibly difficult task. There are numerous factors that must be taken into account when trying to come up with an approximate figure as the fishing industry encompasses much more than the cost of a rod and reel. Avid anglers will plan fishing trips, spend thousands of dollars on boats and boating equipment and this only begins to scratch the surface of the fishing industry. The following pages will attempt to place an approximate figure off the economic significance of recreational fishing in Muskoka. In order to do so the economic factors and values of recreational fishing, the benefits of healthy waterways, native aquatic biodiversity and healthy habitats for the key fish species in the area will all be examined.

1.1: Background Economics of Fishing in the Region

Fishing can and is often seen as a very inexpensive activity that is simply used as a pastime and a way of getting in touch with nature and the environment. Although this description can still apply to certain cases, recreational fishing as evolved at an unimaginable rate over the past century. What began as simply attaching a small hook to a thin line and tying it to a stick has evolved into a multi-million dollar industry that is now heavily managed, monitored and studied.

The evolution of fishing from its very primitive beginnings signifies that recreational fishing itself has become its own industry and provides large economic benefits to a large number of regions. The real cost of fishing now incorporates the costs associated with; fishing licenses, fishing gear and tackle, vehicles, boats, all other forms of boating equipment (life jacket, GPS, fish finders etc.), gas, food, lodgings, bait shops and fishing guides. These additional factors are simply a rough guide to the costs that can be attributed to the recreational fishing industry.

Muskoka is part of eco-region 5E which is a large zone which is primarily composed of fishing zone 15. Fishing zone 15 composes roughly 85% of eco-region 5E and as a result all figures and data that will be presented will be from zone 15 but one must remember that the actual amounts will be slightly larger due to the additional 15% that is being left unaccounted for. All of the data being analyzed is from the Ministry of Natural Resources 2005 survey of recreational fishing. The data collected is part of their Survey of Recreational Fishing in Canada which is conducted every 5 years. In 2005, 23,993 licensed anglers, which represented 1.8% of licensed anglers. Approximately 36% of those surveyed responded and from there the data underwent spatial stratification in order to estimate the information that will be presented in the following paragraphs.

Zone 15 has a surface area of 37,700,000 hectares which is roughly 3.5% of all of the fishing zones in Ontario. Zone 15 is average size when compared to the 20 zones that Ontario is divided into and yet contains 407 unique water bodies, which is the most out of any zone. The typical angler in the area is a male with an approximate age of 45 which is one of the lowest average ages of all zones. These anglers spent nearly 19 days fishing and invested nearly 4 hours per day which translates to 76 hours per year invested in zone 15. This means that 7,500,000 hours have been invested in angling in 2005 or 22 hours per hectare making it one of the heavier fished zones in Ontario. In fact, only zones 16, 17 and 18 had higher intensities and those areas are Guelph, Kawartha Lakes and Eastern Ontario respectively and only the Kawartha Lakes region has a dramatically higher intensity. Ontarians make up 93% of the anglers in zone 15, 1% is from other provinces and 6% are from other countries. This trend indicates that the majority of the money brought into zone 15 is from resident anglers, which in turn means that the residents are investing into the local economy. This is fairly significant as it helps secure the economy by investing into local industries and businesses

In 2005, roughly 7.1 million fish were caught in the zone and 1.2 million fish were harvested and kept. Based on the number of fish caught in the zone, it is the 6th most productive zone in Ontario. It has the highest proportion of small mouth bass caught in all regions with 27% of the 7.1 million fish caught. It has the second highest proportion of largemouth bass caught and the third highest for panfish. Please refer to figure 1 to view the species composition for all fish caught in zone 15. Evidently, these species make up the vast majority of the fish caught in the area and therefore the economic success of the fishing industry in this area are highly dependent on the success of these fish species. The trend for fish harvested is very similar to that of the proportion of fish caught. The small mouth bass proportion of fish harvested of 14% is tied for the third largest proportion in Ontario. The largemouth bass proportion of 8% is second highest and the 33% for panfish is the third highest rate for all zones in Ontario. Please refer to figure 2 to view the species composition for all fish that were harvested. According to the 2005 survey, anglers most desired catches in order are walleye, small mouth bass and largemouth bass. As a result, one can safely assume that these three species in addition to panfish are the most influential species on the fishing economy in zone 15.

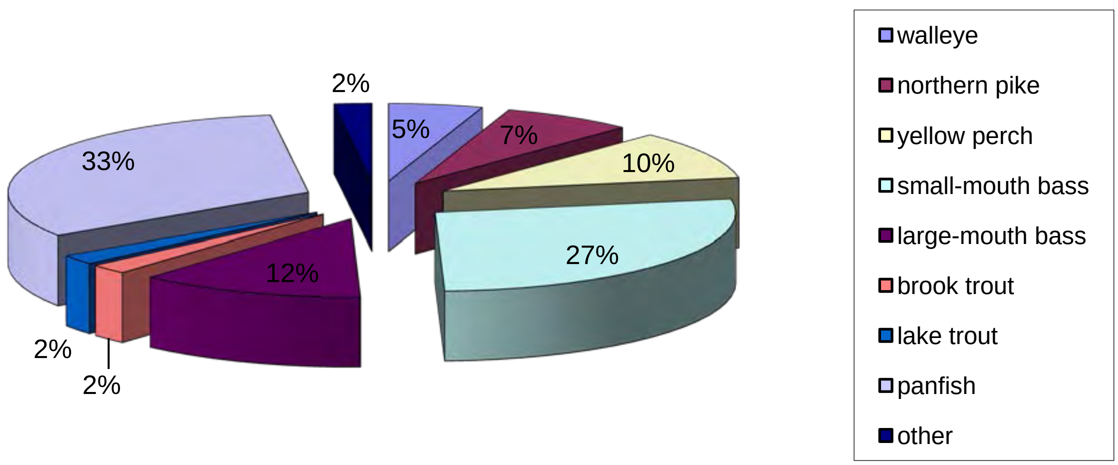

Figure 1: Species compositions of fish caught in zone 15 in 2005

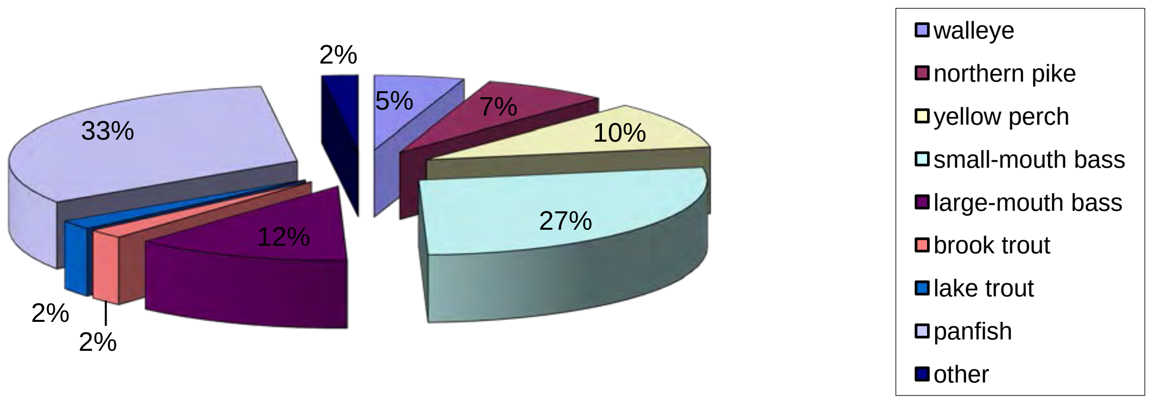

Figure 2: Species composition of fish harvested in zone 15 in 2005

Based on the angling related expenditures in zone 15, it becomes quite apparent of the importance and significance of recreational fishing to the economy. In 2005, over 231.5 million dollars were spent in zone 15. From the 231.5 million, 81.8 million dollars were spent on consumable goods and services, which is the third highest of all zones. Consumable goods are composed of meals, lodging and license fees to name a few examples. For Ontario residents to fish legally, they must purchase an outdoors card which costs $9.68 along with a one year fishing license tag which can cost either $15.90 or $27.76 depending on the chosen license (Ontario Ministry of Natural Resources, 2012). An additional 4.9 million dollars were spent on package angling deals which sits at eighth in the province. The remainder of the money spent in zone 15 on the angling industry is on investment goods. 144.8 million dollars were spent in 2005 on goods that can either be wholly or partially attributable to fishing which ranks as the third highest of all zones. From the 144.8 million dollars, 75.4 million were invested on goods such as boats and docks that are 100% attributable to recreational fishing which is also the third highest amount in Ontario.

When reviewing the monetary values in this report it is very important to note that it is based off of data collected in 2005. The exact values for today are still unknown but it is safe to say that they have most likely increased along with the average rate of inflation. It is also important to note that the results from the 2005 Survey of Recreational Fishing in Canada may not accurately reflect all aspects of recreational fishing in Muskoka. Although lake trout represented only a very small percentage from the fish caught in 2005, they are in fact one of the most important species in the area and a large portion of local management focuses on their success. The Haliburton Highlands Outdoors Association has been stocking water bodies in the area with lake trout since 1998 and since 2000 over 450,000 fish were raised and stocked (Haliburton Highlands Outdoors Association, 2012). With this in mind, I believe that more recent data and figures are required to properly determine the true value of recreational fishing in the area. The 231.5 million dollars that was brought in, in 2005 would be a conservative estimate now that lake trout, a highly regarded fish species, are much more prominent in water bodies in Muskoka.

2.0 HEALTHY WATERCOURSES

SUBSECTIONS

2.0 Healthy Watercourses

When analyzing the economic benefit of healthy water courses, it is crucial to understand how human inputs and disturbances could potentially affect the amount of fish, habitat or prey within a water body. Therefore if an input or disturbance would potentially lower the amount of fish in a waterbody it would a negative economic value attached. One such disturbance is acid rain, which has historically been known to deplete fish stocks.

2.1: Acid Rain

Acid rain came to the scientific forefront during the 1960's when SO_2 emission around the Sudbury region were at an all time high. The smelters in Sudbury released vast amounts of SO_2 which eventually descended into the nearby landscape via acid precipitation that resulted in lakes undergoing dramatic chemical changes. Acid rain had affected some of the regions lakes so severely that the lakes were devoid of all life, and some to this day remain lifeless while a great many are slowly improving but are lacking species richness and diversities of the past (Schindler, 1988). Studies have shown that lakes with a low pH (≤6.0) contain significantly fewer fish species than lakes with high pH (>6.0) (Rago & Wiener, 1986). This would mean that the food chain of these lake are significantly impaired and the available amount of fish for anglers has decreased, representing a loss of economic benefits. A dead or severely impaired lake would have a pH below 6.0 and would therefore not be fished as anglers would likely return empty handed. These lakes would therefore contribute zero dollars to the economy. This would imply that an acid impaired waterway is worth zero dollars, so a waterway that hasn't been acidified is of top value.

As ecoregion 5E is quite large and expansive, the historic acid rain deposition of the Sudbury area would seem to be only a small area impacted, yet acid rain deposition is still ongoing and threatens many lakes throughout the ecoregion. Further south, the Muskoka lake drainage basin continues to receive between 30 and 40 kg/ha per year of sulphate from acid precipitation each year. This has caused lake Muskoka to be placed in the moderate risk class in regards to the potential for lake acidification to occur (International Lake Environment Committee, 2008). The Muskoka Watershed Council has also stated that some 95,000 lakes in Eastern Canada stretching from Central Ontario through Southern Quebec still receive 15-20 kg/ha per year of acid deposition (Black, 2008).

Differing species of fish have differing tolerances to changes in pH. Studies in Finland have shown that northern pike are tolerant of a low pH (4.5) yet whitefish are killed at pH 4.25. It is often the young fry which are most susceptible to low pH and as a result species richness may decline gradually overtime with future generations (Howells, 1994). However individual species tolerance to acidity does not solely determine the abundance of the given species as their food supply will often dictate survival. Take perch as an example. This sought after panfish is hardy and can survive at pH's lower than 4.5, though they will be smaller in stature (United States Environmental Protection Agency, 2008; Howells, 1994). Yet the prey of perch have differing tolerances. Snails only have a pH tolerance that above 6.0 while mayflies and crayfish tolerate up to a pH of 5.5. Salamanders can tolerate a pH of 5.0 while frogs are quite hardy and can tolerate levels around pH 4.0 (United States Environmental Protection Agency, 2008). The acidification of a lake is also dependent upon the aquatic systems ability to buffer acid inputs and such buffering capacitates are affected by underlying geology (Howells, 1994). Therefore the survival of fish species in acidified environments is wholly dependent upon numerous factors.

Applying an economic value associated to acid rain is extremely difficult, as limited data makes it hard to understand how slight pH changes may affect the richness and diversity of fish in a given lake. US studies conducted in the mid eighties attempted to determine the mean loss of fish by percent in acidified lakes. Over 100 lakes with a pH ranging/fluctuating from 5.0-6.5 were studied to examine changes from pre to post acidification. Results showed that species populations declined for the acidified lakes. When only considering the commonly angled fish in the Southern Canadian Shield, The US study determined that Brook Trout experienced the biggest decline (13.9%), followed by Lake Trout

(11.8%), Largemouth Bass (1.6%), Smallmouth Bass (1.5%) and Yellow perch (0.7%) experienced the least (Haines & Baker, 1986). When these figures are applied against the $81.1million dollar profits of zone 15 in 2005, a total loss of $924,540 can be observed. This can be further broken down by species; Smallmouth Bass ($332,510), Brook Trout ($227,080), Lake Trout ($194,640), Largemouth Bass ($162,200) and Yellow Perch ($8 110). These represent maximum figures when applied to the entirety of zone 15, the losses would therefore in reality be much lower as acidification and pH values would be only applicable on a lake by lake basis. Yet this represents just how significant waterways with healthy pH values are for the recreational fishing industry. It can therefore be stated that lakes with healthy pH levels could be worth an approximate value of $924,540, and this has the potential to increase with a decrease in acid rain and acidified lakes within the region. As dead lakes are worth $0 to the recreational fishing industry it can further be stated that the current pH of lakes supporting angled fish communities would be worth the maximum value of $81.1 million.

2.2: Dams

2.2.1: Dams and Mercury

One very visible human disturbance to natural waterways are dams of which the MNR estimates Ontario to contain 2600. Many of the dams within the southern Canadian Shield vary in functions from water control structures to hydro development (Ontario Ministry of Natural Resources, 2011). However these dams can be the potential cause of factors which may hamper the fish productivity of lakes and rivers. Dams on rivers have the potential of raising water levels and causing overland flooding, a popular example being the Trent Severn Waterway (Wildlife Conservation Society Canada, N.D; Parks Canada, 2009). Lake levels on this popular waterway and associated feeder lakes fluctuate between seasons so as to provide the safe passage of boats with an optimal lake depth (Parks Canada, 2009). Other dams such as hydroelectric structures create upstream reservoirs where an unnatural capacity of water has pooled due to the downstream obstruction altering natural stream flows. This posses a potential problem as flooding of land can add increased concentrations of mercury to the aquatic ecosystem (Wildlife Conservation Society Canada, N.D). Conditions present within reservoir lakes and flooded areas of land are ideal for increasing the mobility of organic and inorganic matter. These conditions stimulate the transformation of inorganic natural and anthropogenic mercury into toxic methylmercury (Silk & Ciruna, 2004).

As mercury is the leading cause of fish consumption advisories for boreal lakes in central Canada, advisories specific to species or area would deter anglers primarily fishing for consumption (Johnston et. al 2009). 2005 saw an estimated 7.1 million fish caught within zone 15 and of those, 1.2 million fish were harvested and kept for consumption (Hogg *et al*, 2005). This represents roughly 17% of all fish caught equating to $13.79 million dollars. Therefore, in a worst case scenario where all southern Canadian Shield lakes issued mercury advisories for all species, the fishing industry could be missing out on a potential $13.79 million dollars. However this is an extreme figure and is highly unrealistic. Looking towards Lake Muskoka as an example, advisories have been in place for mercury contamination for Lake Trout, Rock Bass and Smallmouth Bass with the suggestion that lake trout larger than 45 cm and small mouth bass larger than 35 cm should not be eaten (International Lake Environment Committee, 2008). These three species represent 52% of all fish harvested within Zone 15, or 660,000 individual fish (Hogg *et al*, 2005).

With 1.2 million fish having a worth of an estimated $13.9 million, this would translate into approximately each harvested fish being attributed to $11.58. As increased mercury from dams is to an extent area specific, it would be necessary to obtain creel surveys from areas where advisories are/aren't present to determine how an advisory could potential result in an economic loss for the area. This would be determined by multiplying $11.58 by the amount of advised fish caught for consumption. As these figures would be hypothetically lower when an advisory has been issued, it may be ideal to compare findings with past creel surveys in order to fully asses potential losses. However it is easy to see that at $11.58 per fish any mercury advisory that deters anglers with consumptive goals would quickly add up into larger figures. It can be assumed that at current consumption levels of fish, the current health of watercourse is $13.79 million, a figure that has potential to rise if mercury decreases in some lakes prompting the removal of advisories and allowing for more anglers to consume harvested fish.

2.2.2: Dams and Temperature Changes

Temperature changes within aquatic ecosystems both up and downstream of dams have been reported as common occurrences. Associated temperature change due to a dam would therefore be anthropogenic in nature and has the potential of impacting fish communities. A US study analyzed the affects of lowberm dams on water temperature and associated communities of fish and invertebrates in streams. Results showed warmer summer temperatures were present below dams and may slowly return to pre-impoundment temperatures over the course of the waterway (2-3km downstream). Factors influencing the magnitude of the temperature change included the size of impoundment (depth and surface area), residence time, whether or not the impoundment stratifies, and the release depth. The warmer summer temperatures found downstream of impounds had a significant impact upon the trout communities which prefer colder temperatures. Brook trout populations decreased 96% while brown trout saw a 54% decrease downstream of the studied dams. Other species did not notice a decrease and the fish communities as a whole saw an increase in richness (Lessard & Hayes, 2003). A 96% decrease in brook trout for the entirety of zone 15 would represent a monetary loss of $1,557,120 while a 54% decrease in brown trout is unmearsurable as this species is not heavily angled. In short, dams may be detrimental to trout communities on affected streams, but the overall downstream affect of an increase in species richness may counteract this from an economic standpoint. As temperatures increase below dams it could be speculated that sought after warm water species such as smallmouth bass would experience an increase in species richness. Studies should be conducted upon which species observe increases in richness as it may be wholly possible that the richness is attributed to fish commonly ignored by anglers and thus is a poor reflection upon the economic benefits or setbacks. It is also hard to indentify the true economic impact of dams upon trout within zone 15 as data is needed to determine how many current or potential trout streams are dammed or planned for damming. It can be stated that current impoundment free streams supporting healthy populations of brook and brown trout could be worth an approximate value of $1,557,120 and this has the potential to increase with a decrease in dams.

2.3: Boat Gas

The lakes and rivers of the southern Canadian Shield provide many opportunities for motorized recreational boating. Yet this activity has potential degrading effects upon the waterways and has the potential to adversely affect fish populations. Volatile organic compounds (VOCs), especially gasoline-related compounds such as methyl tert-butyl ether (MTBE), are being inputted into waterways from the operation of marine engines (Bender *et al*, 2003). MTBE is utilized as a fuel additive and has become increasingly present within aquatic ecosystems where motorized boating occurs. The chemical compound directly affects fish health and studies have shown that certain species exhibit increased larval mortality, deformed eyes, mouthparts, and spinal cord as a result of higher concentrations (50mg/L+) (Moreels *et al*, 2009). Recent reports from the U.S have found MTBE concentrations of some lakes as high as 31 ug/L, though lake averages appear to hover around 0.5-2ug/L (Schmidt *et al*, 2003). Many studies focus on short term lethal dosages (LC96) of MTBE, and very few studies have delved into long term effects of moderately elevated concentrations. Reports have stated that the compound is difficult to biodegrade but does not appear to bioaccumulate at any severe levels. Lethal dosage for most fish species exceeds 350mg/L . If elevated concentrations were to occur, they would be first noted within primary trophic levels where select bacteria and small invertebrates experienced decreased growth and mortality at concentrations ranging from 7.4-57mg/L (Werner *et al*, 1999). It is recommended that the testing of highly utilized recreational lakes within the southern Canadian Shield, particularly the Muskoka region, be conducted to determine levels of MTBE, though it is highly unlikely that lethal dosage would ever occur. Future studies should focus on long-term effects as current data on this matter is scare. Two stroke engines are the worst emitters of MTBE's, therefore if high levels of MTBE was detected within a lake a wise course of action would be to ban such motors (Bender *et al*, 2003). The exact value of an ecosystem with minimal MTBE remains unknown, but the current ecosystems without apparent hazardous amounts of MTBE bring in $81.1 million of economic value.

3.0 FISH HABITATS AND SHORELINES

SUBSECTIONS

3.0 Fish Habitats and Shorelines

Healthy shorelines are vital to maintaining the overall health of lakes and other bodies of water. Shorelines help filter pollutants, protect against erosion and provide habitat for fish and other forms of wildlife. Shorelines are some of the most ecologically productive places on Earth. They support plants, microorganisms, insects, amphibians, birds, mammals and fish. The first 10-15 metres of land that surround lakes and rivers is responsible for 90% of lake life which are born, raised and fed in these areas (MLA-Muskoka Lakes Association,2011). In addition, these areas are up to 500% more diverse than other areas upland from lakes and rivers. There are many major environmental concerns which have been addressed by concerned environmentalists regarding watersheds. Foremost, water quality has become a pressing issue as recreational property buyers continue to develop cottages along popular lakes and rivers in Ontario (Parks Canada (B), 2009). The result of high population densities and construction/development is an alteration of natural shorelines and a higher rate of disturbance of the lakebed and water. Shoreline health is directly affiliated with the quality of water in a given lake or stream. The more disturbances a shoreline experiences, the more the water will be contaminated and natural systems affected. When plants and root systems are removed, particulate matter (soil, vegetation, and other aggregate) is eroded into the water causing siltation. Siltation is a major concern in many of Ontario's waterways due to its negative effect on spawning, and the visual implications associated with cloudy water. Since the health of a shoreline determines the quality of the water, it is essential that both are protected and kept as natural as possible. The various land use practices occurring in Canada are having an impact on water quantity and quality, fish and wildlife populations, and are raising resource sustainability issues. Watersheds are "riparian areas", which are strips of land with special vegetation that is commonly found alongside standing and moving water bodies (Fisheries and Oceans Canada, 2010).

The issue associated with shorelines in cottage regions is people generally do not find the “natural” shoreline visually appealing. Any obstacle obstructing a clear view of the waterway is often removed whether it is trees shrubs or other vegetation. Additionally, people tend to extract weeds, cattails, and reeds from in-water regions surrounding their recreational properties. These actions relay detrimental harm to the aquatic and shoreline habitats and affect native biodiversity (Healthy Shorelines, 2008).

There are many groups that have been focusing on maintaining shorelines and ensuring better water quality. The Muskoka Lakes Association has begun focusing more on monitoring and promoting water quality, addressing land use planning issues and advocating for responsible spending and fair taxation through conducting and reviewing surveys. A great level of interest is present among members of the MLA to better such issues. Their main goals are currently; protecting and promoting water quality, Advocating for responsible government spending and fair taxation, promoting responsible land use, and taking the lead on important Muskoka issues. Generally, an area’s waterways/wetlands are governed by the local conservation authority and must be contacted before any alteration occurs on a shoreline or around a wetland (MLA-Muskoka Lakes Association, 2011).

Another issue that has historically raised controversy across Ontario is deforestation along waterways which has a significant impact on water quality and shoreline biodiversity/well being. Without adequate root structures to retain soil, erosion quickly occurs resulting in further siltation and sedimentation of waterways. Deforestation also leads to additional loss of shoreline biodiversity as well as habitat fragmentation.

3.1: What does a healthy shoreline offer?

1. Help Maintain Clean Water/Water Quality

The shoreline vegetation that is present around a body of water is vital in retaining, treating, and filtering surface runoff before it can reach the water. Runoff can contain pollutants such as fertilizers, pesticides, sediment, manure, pet feces, trash, motor fluids (oil, grease, gas), and road salt.

These various pollutants have negative effects on our waterways with nutrients acting as fertilizers and stimulating algae and plant growth; pathogens can contaminate your drinking water and sediment impacts fish habitat and nursery areas (Nature in Deed, 2011).

2. Prevent Soil Erosion

Shoreline vegetation and plants help keep soil in place with their underground root systems and prevent topsoil from being exposed and washed away (Nature in Deed, 2011).

3. Reduce Impacts of Flooding

Well-vegetated shorelines provide barriers against moving water by slowing the movement of water downstream, and by reducing the force, height, and volume of floodwaters. This allows them to spread out horizontally across the floodplain therefore reducing the potential of damage to the area (Nature in Deed, 2011).

4. Provide Wildlife with Food and Habitat

Shorelines are vital to many different animals throughout their development and life. Shorelines protect wildlife from weather and predators; woody debris, such as tree trunks or roots in the water provide cover for fish to hide, basking areas for turtles, and resting sites for waterfowl (Nature in Deed, 2011).

3.2: Different Zones

Upland Zone: Higher and drier ground containing various shrubs and trees as well as animals that prefer shoreline habitat. (Usually the area where a residence is built)

Riparian Zone: Transitional area between dry land and water. Riparian zones often offer a variety of plants and wildlife species due to the presence of water which provides organisms with food and excellent shelter. Vegetation helps with runoff, soil erosion and shades and cools shallow water.

Littoral Zone: Extends from the water's edge to the area in the lake where sunlight no longer penetrates and is home to organisms such as algae and aquatic plants, as well as aquatic organisms (fish, amphibians, and waterfowl)

3.3: Shoreline Health

Common Signs of a Healthy Shoreline

- Lots of native vegetation
- Different levels of vegetation
- Dead snags and stones
- Birds, fish and other wildlife are present

Common signs of an Unhealthy Shoreline

- Area is stripped of all or most vegetation
- Lawn extends right to the water's edge
- Natural shoreline has been replaced by an opposing structure such as a break-wall or gabion baskets
- Erosion may be apparent (water may become "muddy" during rain)
- Algal blooms and excessive weed growth are prominent

Common Human Induced Erosion

- Removal of shoreline Vegetation
- Runoff
- Boat Wake- Unnaturally large waves created by boats eat away at the shoreline soil bit by bit. In Ontario, the law is; boats must slow down to 10km/hr when within 30ft. From shore.
- Construction- Construction activity often exposes soil which is very susceptible to erosion

- Foot Traffic-when the same route is walked time and time again, soil is exposed making that area susceptible to erosion.
- Shoreline Alterations

Erosion is responsible for more than just natural habitat degradation, erosion also causes; loss of property since the land is slowly eroding into the water, unstable slopes, reduced water clarity, an increase in water temperature, chemical contamination since the soil that is washed into the watershed usually contains harmful chemicals, siltation, and ultimately leads to biodiversity loss for both aquatic and terrestrial shoreline species (Fisheries and Oceans Canada, 2010). The best method to protect a shoreline from erosion is to keep the natural characteristics intact. This entails natural vegetation remains and landscaping is minimal. Changing the location of rocks and boulders is a major contributor to erosion; therefore such activity should be reduced. Dead branches, stones, and boulders along the shoreline form a natural retaining wall. When water passes over the soil instead of infiltrating into it, erosion occurs. This can be prevented by establishing less hard surfaces on a property which are usually in the form of; patios, decks, and driveways. Runoff from the roof can be captured in a rain barrel. If a property owner is conducting a construction project, it is advised that they practice erosion control methods such as laying hay bales, silt screen fences and filter cloths around the jobsite (Fisheries and Oceans Canada, 2010).

3.4: Bioengineering to Solve Water Erosion

There are many methods of Bioengineering that are used to help prevent above water erosion;

Live Staking- Willows, dogwoods, viburnums, and poplars can be generated from cuttings taken from new growth. These can be distributed along a shoreline (Nature in Deed, 2011).

Fascines- Fascines are created using live plant material, and are made into a roll or bundle. Once they are placed along the ground, the cuttings will begin to root and take hold of the soil. There are variations of this method where a trench is dug and loose bundles are placed along the trenches. This method is referred to as a brush layer (Nature in Deed, 2011).

Brush Mattress- These are used to cover large open soil areas. Secured firmly as an anchor, they can withstand considerable waves (Nature in Deed, 2011).

Bioengineering Techniques in the water are similar to on-land although instead of preventing erosion the aim is prevent wave damage.

Shoreline Buffers- A buffer is a permanent row of trees, shrubs, grasses, or groundcover along a watercourse which assists in protecting the water body from impact human or natural impacts. An ideal buffer strip is at least 30 meters wide, extending from the lake and heading upland. It is not realistic to have a buffer strip of this size in all areas due to property sizes although any size is better than none (Healthy Shorelines, 2008).

3.5 Shoreline Development and Fish Habitat Integrity

The sensitivities of fish habitats and water quality extend beyond simply the depths of a body of water. Shorelines are an integral component of all aquatic ecosystems and hold much influence on the waters they surround. Since the spiking trend of exurban development, several human activities on shorelines have been shown to have detrimental effects on the water's ecosystems, including: construction of cottages, boathouse, docks, dredging lake bottoms, dumping into waters, and clearing on-shore vegetation (Innis, 2008). These actions also greatly increase the amount of runoff entering the lake (Innis, 2008). The Muskoka region is no exception to this trend of development. In a 1995 mapping of the three largest lakes, it was shown that roughly 12% of Lake Joseph, 16% of Lake Rosseua, and 17% of Lake Muskoka were developed shorelines (Brown, 1998). Shoreline development can have major detrimental effects on water quality, fish habitat, fish populations, and ecosystem integrity (Hansen et al., 2005). It is estimated 72% of foraging fish species can be found within 2.5 metres from the shoreline

(Brown, 1998). The threats imposed by shoreline development offer much threat to tourism and fishing industries of the Muskoka region. Millions of dollars are brought into this region each year directly from the draw that it's fishing provides. The following examines journals both within and external to the Muskoka district that displays the impact shoreline development can inflict on surrounding ecosystems and an estimate to the monetary values this has cost the area.

The effects of shoreline development have not gone unnoticed by anglers of the Muskoka region. A 2005 MNR survey showed that fish habitat loss and threats were the most frequent concern of Zone 15 anglers (which covers a majority of the Muskoka region). Although shoreline development has spiked in recent decades, the Muskoka Region is not without law and regulations pertaining to any development and infractions to shorelines. The Muskoka Lakes Township passed a bylaw in 2008 to enforce that no less than 75% of waterfront be left unchanged on new developments and any exisiting developments that would push them over this 75% (Vipond, 2008). Many lakes in the Muskoka Lake region are also putting a stop to the development of boathouses in general. The importance of large plants and trees within 25 metres of shoreline is also emphasized, as removing natural vegetation can severely increase runoff into bodies of water, affecting not only fish habitats but general water quality (Hansen *et al*, 2005). Although it is not enforced yet in the Muskoka Region, it is recommended that areas within this distance from shoreline keep a minimum of 5 large trees at intersects per 30 metres of shoreline for new developments (Brown, 1998). An example from Bracebridge ON, within the Muskoka Lakes Region, will be used to exemplify the magnitude of enforcement on shoreline development infractions. Brian Jones of Bracebridge ON, was fined $5000 after pleading guilty to violating the Federal Fisheries Act (DFO, 2003). Mr. Jones had been caught dredging the bottom of the shoreline and shallows near his property on Gibson Lake (DFO, 2003). In addition to the $5000, it is estimated it will cost another $10,000 of Mr. Jones's money to rehabilitate the shoreline to its natural state. Such an act of simply scraping a few plants in the shallow waters of your property is held in such regard as to cost someone up to $15,000 for a few square metres of dredging. This shows that the importance of shoreline habitats is recognized in the township.

The Department of Oceans and Fisheries has a no net loss policy in place for shoreline development as well that Muskoka Region developments must follow (Brown, 1998). There is however a lack of precedent for habitat replacement on Ontario shorelines. An estimated 80% of the Great Lakes shoreline is privately owned and more than 40% of the Canadian shoreline is covered by development from commercial, industrial, and residential sectors, and more than 17 % by agricultural means (Lawrence, 1995). Less 32% remains "natural" or forested shorelines on Canadian sides (Lawrence, 1995). With well over 50% of shorelines being developed in the Great Lakes it is impossible for reestablishment of an equivalent amount.

Several papers have been written exemplifying the detriments of shoreline development on fish habitats. Paul Keddy produced a paper with particular relevance to the Muskoka Region. His work was completed on Axe Lake, near Parry Sound, ON. The study focused on different levels of shore disruption and the effect of the exposure limits of the biodiversity it effects. Keddy's work incorporated looking at aquatic plant biodiversity, and the biodiversity of small foraging fish that inhabit those plants (including those that are prey to targeted game species). By studying sections of shoreline with different exposure gradients Keddy was able to produce different biodiversity scores for different levels of shoreline vegetation and natural cover. Species richness was found at its lowest in areas of highest shoreline exposure (Keddy, 1983). Species richness was found to highest in areas of 'intermediate' or most natural levels of exposure (Keddy, 1983). Keddy's finding support the notion that upholding pristine shorelines, and minimizing development will help sustain healthy waters and fish habitats.

A study on Lake Iowa showed similar results, when studying shoreline development effect on abundance and diversity of juvenile fish and fish larvae. Information was gathered along the shoreline of Lake Iowa comparing areas of development (cottages, docks, boathouse etc.) and areas in a natural state. Information was recorded on twenty species of fish including smallmouth, largemouth bass, and panfish varieties, which are major draws of the Muskoka region fishing sector, as noted by the MNR, as well as several prey species. In 18 of the 20 species, larvae and juvenile fish abundance were much higher in natural-state shorelines compared to developed ones (Bryan & Sarnecchia, 1992). Fish species biodiversity was also greater in non-developed areas (Bryan & Sarnecchia, 1992). Bryan and Sarnecchia suggest that the common practice of removing phragmites species in developed areas may be a major part of why natural shorelines are richer in fish abundance and diversity (Bryan & Sarnecchia, 1992). Removal of shoreline shoreline vegetation is destructive fish breeding and feeding grounds, and an essential habitat for stages of numerous species lives (Bryan & Sarnecchia, 1992).

Eadie and Keast also produced similar results when comparing lakes in Southern to Northern Ontario. The study included species diversity comparisons, taking note of any developments causing habitat complexity. Similar to the previous example studies, Eadie and Keast found species diversity to excel on shorelines of most pristine conditions, as opposed to developed shorelines. This again supports to need for integrity in shorelines in Muskoka region lakes to ensure fish habitats and water quality.

Macrophyte communities are one of the most essential habitats for young fish, and keystone fish species. Macrophyte growths are also one least desirable aesthetically for many cottagers, and one of the most common targets of habitat and shoreline destruction (Brown, 1998). Dredging and the excavation of macrophytes is done to make room for docks, boathouses, swimming areas or to make a clearer view of the lake (Brown, 1998). However these areas are critical fish habitats, and bountiful environments in the health of a whole lake ecosystem. Macrophyte abundance in lakes can be associated with high fish abundance and richness, and high nursery and reproductive success of fish (Brown, 1998). These littoral zones are important in juvenile fish growth and are also associated with high invertebrate abundance and richness, a main food source of juvenile and small fish species (Brown, 1998). Macrophytes are also a key part of wind exposure protection. Several small species, juvenile fish and their food and habitats are sensitive to high prevailing winds (Brown, 1998). Macrophytes as well as trees, shrubs and other shoreline vegetation provide exposure protection for many sensitive species, and their removal is determintal (Brown, 1998).

Maintaining high diversity and abundance of fish species is important for ecosystem health and integrity. This is essential to uphold to any community, not just the Muskoka Lakes region. Along with natural prestige thou, maintaining fish diversity and abundance is an essential aspect of the economy of the Muskoka Lakes region. In 2005 fishing goods and services alone brought roughly $81.8 million to zone 15, the Muskoka Lake region. Any habitat lost attributed to shoreline development is detrimental not only to natural integrity of the region, but also its economy. Lake Joseph has shoreline development coverage of 12%, Lake Rosseua 16%, and Lake Muskoka 17%, an average of 15% for the three major lakes (Brown, 1998). Through research it conclusive that several major target species of the Muskoka region rely on shoreline habitats for breeding and/or feeding, focusing on; walleye, northern pike, smallmouth bass, and largemouth bass. Taking the $81.1 million brought in by fishing in 2005, and the catch percentage of these species for the same year, the following values can be produced for each species; Walleye (rated number one targeted species for Muskoka anglers) bring in $4,055,000, Northern Pike $5,677,000, Smallmouth Bass $21,897,000, and Largemouth Bass $9,732,000, (grand total of $41,361,000 from these species alone). If we assume that the average of 15% shoreline development of the three major lakes is applicable as an average to all lakes in the Muskoka Lakes region, we can produce monetary values for these lost habitats. 15% habitat loss from shoreline development could be worth $6,204,150 lost from these four species alone. ($608,250 lost from lost walleye habitat, $850,050 from lost pike habitat, $3,284,550 from lost smallmouth habitat, and $1,460,700 from lost largemouth habitat). Each percent of habitat loss can result in $811,000 in lost revenue to the fishing industry.

This Table from Browns research on Lake Joseph exemplifies typical development on lakes in the Muskoka District and how much land habitat they are taking up (Brown, 1998).

Summary information of human-induced shoreline alteration of Lake Joseph from OMNR survey, 1995.

Total Shoreline		Main	Island	
	m	130884	82075.5	

Structure and Type		Number	Width (m)	Area (m^2)
Docks	Crib	697	5338	51559
	Pillar	48	215	1411
	Floating	53	200	2215
	Fill	46	330	2129
	Cantilever	5	24	215
	Covered	39	415	4575
	Combination	13	119	1240
	Other	1	2	30
	Total	902	6643	63374
Wet Boathouses	Crib	640	9944	132409
	Pillar	5	50	435
	Fill	24	354	4429
	Other	8	205	4425
	Total	677	10553	141698
Ramps	Wood	26	88	387
	Cement	6	32	109
	Pillar	0	0	0
	Other	11	54	293
	Total	43	174	789
Manicured Lawns	Unbuffered	0	3490.5	
	Buffered	0	6454.5	
	Total	139	9945	
Shorewalls	Stone	82	1489	
	Wood	29	412	
	Cement	4	32	
	Other	123	1637	
	Total	238	3570	
Man-made Beaches		31	571	
Other		21	109	1519
Total altered shoreline (m)			25110.5	
% of shoreline altered			12%	

4.0: NATIVE AQUATIC BIODIVERSITY

4.0: Native Aquatic Biodiversity

In 2005 the amount of money spent on recreational fishing, including that spent on consumable goods and investment goods wholly attributed to the recreational fishing industry exceeded $150 million in Ontario Fisheries Management Zone 15 alone (Hogg *et al*, 2010). The value of native aquatic biota in the southern portion of the Canadian Shield offers many ecosystem services for use by the general public and has many forms of economic value such as those intrinsic in nature, and quantitative such as revenue generated by recreational fishing . These services range from the dollar value of a piece of trout on a dinner table, to less tangible values such the aesthetics provided for recreational enthusiasts. One of the goals of this project is to estimate the absolute fiscal benefit that we as humans derive from our existing native biodiversity, and the costs associated with abuse and loss of these natural resources by analyzing existing data provided by various government agencies and special interest groups. Through this, we will identify key species of native biota and taxa which are instrumental for sustaining the fisheries of the region by examining which species are most sought after by recreational anglers, as well as the species on which they depend to support their respective populations, thereby becoming vital to regions' economy. By examining species that are vital to the sustainability of our fisheries, we can attempt to develop estimates of their value quantitatively rather than monetarily or intrinsically, which can allow us to provide the public with a better understanding of the value of the fisheries found in the southern portion of our great Canadian Shield.

The species most sought after within fisheries management Zone 15 (Ontario Ministry of Natural Resources, 2012), are smallmouth bass, largemouth bass, walleye, and northern pike (Hogg *et al*, 2010). After panfish, smallmouth bass were estimated to be the most frequently caught fish in the southern Canadian Shield with the total number of catches exceeding 1.9 million in a single year (Hogg *et al*, 2010). While smallmouth bass were not the most sought after fish by recreational anglers who visiting the region, the species provides seemingly endless fishing possibilities to anglers and are a nice by-catch to most. For this reason it will be assumed that smallmouth bass are native to all lakes that currently sustain populations of the species.

While many lakes in the region support healthy, self-sustaining populations of smallmouth bass, it is necessary to understand the aquatic food chain that smallmouth bass depend on in order to thrive. Unlike walleye and northern pike, smallmouth bass generally feed on crayfish and cyprinids, and rely on these species in most lakes for a large portion of their diet, thereby making crayfish and cyprinids of great importance to the local economy (Cabana *et al*, 1994). The invasive rusty crayfish, (*Orconectes rusticus*) has invaded many lakes in the state of Wisconsin and has changed the littoral zones in several of these lakes by reducing macrophyte abundance and lakes with high densities of crayfish can undergo drastic ecological changes (Roth et. al 2007). It has also been suggested that smallmouth bass selectively consume fewer rustic crayfish than there native forage such as *O. propinquus* or *O. virilis* (Roth & Kitchell, 2005).   In order to ensure that smallmouth bass numbers do not decline as a result of lost habitat due decreases in macrophyte densities or decreases in overall health due to loss of forage, we must ensure that value is given to crayfish and other cyprinids (Roth *et al* ,2007)

If the number of smallmouth bass were to decrease drastically over a relatively short period of time, this could greatly impact the fishing industry in the area. In 2005 almost 2 million smallmouth bass were caught in Zone 15 alone, and they (smallmouth bass) are one of the most sought after recreational species in the region (Hogg *et al*, 2010). Due to angler success in the region, over 70% of recreational anglers rated their fishing experience as “good”, “very good”, or “excellent”, and it is likely that smallmouth bass are responsible for a large portion of these responses (Hogg et. al 2010). If people experience “good” or better angling success in the area, it is likely that they will return to the area in the future or perhaps even invest in property, fishing gear such as boats and rods, and the revenue generated by the fishing industry will continue to grow. For this reason, It is estimated that 15% of the total money spent annually on recreational fishing in Zone 15 relies on the smallmouth bass fishery in the region, and since smallmouth bass depend directly upon the health of crayfish populations in the region, It is estimated that nearly all of the total benefit derived from the fishery can be directly linked to crayfish and other aspects of the littoral food chain including aquatic macro-invertebrates, and the macrophytes they rely on as habitat and forage. There for the total value of littoral native biodiversity to the recreational fishing industry is estimated to be $15 million annually.

Walleye (Stizostedion vitreum), the most sought after species in recreational fishing Zone 15, is another crucial component of the fishing industry in the region with over 360,000 of this species caught annually by recreational anglers (Hogg *et al*, 2010). To date, mercury is the leading cause of fish consumption advisories in boreal lakes in central Canada, and while anthropogenic sources of mercury continue to decrease, bioaccumulation continues to be a growing problem in our fisheries (Johnston *et al,* 2009) Recently there have been studies to suggest that the introduction of non-native, invasive species could increase the rate of bioaccumulation of contaminants that have been shown to have adverse effects on fish populations and human health (Johnston *et al* 2009). Rainbow smelt (*Osmerus mordax)* is one species that is responsible for increased bioaccumulation of mercury in not only walley, but lake trout and northern pike as well, who account for a substantial portion of fish caught (nearly 10%) in Zone 15 (Johnston *et al*, 2009, Hogg *et al*, 2010). By lengthening trophic pathways, introduced forage fish such as rainbow smelt could raise mercury levels in pelagic fish such as walleye to a point that consumption could have negative effects on human health and could cause fish consumption advisories to become common place in this region (Johnston *et al*, 2009).

While walleye feed primarily on various species of minnows and small fishes once they have reached maturity, during the juvenile stages of their life they rely heavily on crustacean zooplankton, mayflies, and midges (*Chaoborus sp.*) (Mathias & Li, 1982). All of these species are instrumental in established strong populations of walleye for our recreational fisheries and therefore vital to the economy of the region. As walleye are the most sought after species by recreational anglers in the region, and juvenile walleye depend on the health of various trophic levels in aquatic ecosystems, the native biodiversity carries with it great economic value. Although walleye only amount to just over 5% of the total number of fish caught in Zone 15 on an annual basis, they are the most sought after species in the region, making them perhaps the most economically important fish stock in the fishery (Hogg *et al,* 2010). For this reason it is estimated that walleye, the native biota they depend on, and the taxa that support these communities, are worth $22.5 million, or approximately 15% of the total revenue created in the region by the recreational fishing industry.

While invasions of non-native species can alter food chain dynamics and potentially threaten or fisheries resources in the southern portion of the Canadian Shield, other anthropogenic stressors are also taking their toll and are threatening our fisheries. Habitat loss, changes in productivity, and over harvesting are the three most common stressors that effect our freshwater fisheries (Hogg *et al*, 2010). Due to theses stressors, entire populations have been reduced to but a fraction of what could be found historically, and in order to maintain strong recreational fisheries, fish stock enhancement programs have become a vital source of recreational fishes. In 1999 over 4.3 million fish from provincial fish culture centers were stocked in Ontario inland waters, and between the years 2007-2010 over 750, 000 fish have been stocked in the Bancroft area alone (Kerr & Lasenby 2001, Ministry of Natural Resources, 2010). The cost of rearing fishes in hatcheries is an example of what can happen when our native aquatic biodiversity suffers due to anthropogenic stressors, giving weight to the argument that more must be done to conserve the native populations which occur naturally rather than bear the costs associated with rehabilitation of these communities.

By identifying the ecosystem functions carried out by all aspects of intricate inland aquatic food chains, it is possible to begin quantitatively assessing the value of these native biota and taxa and derive meaningful economic values for these species. For the purposes of this report, it is assumed that nearly 100% of recreational angling in Ontario Fisheries Management Zone 15 is a result of the abundance of native biodiversity in the region. We therefore conclude that without this native biodiversity there would not be any recreational fishery for anglers to enjoy, and the economic benefits provided by the fishery would cease to exist, making the native aquatic biodiversity of the region worth approximately $150 million.

5.0: CONCLUSION

5.0 Conclusion

This report is far from conclusive and is meant to allow for a basis for which future studies can be based upon. Many area specific studies are lacking and this should be considered in the future for devising more accurate figures and estimates. What is apparent is that the recreational fishing industry of Ecoregion 5E and Muskoka is a multimillion dollar industry of great importance to the region. Often overlooked are the ecostystem services that allow for the recreational industry to continue and thrive. Their healthy continuation is ultimately worth the profits of entire industry and breaking it down to a component basis we begin to see how they are often intertwined and complex. The monetary values we have estimated for various services within this report need to be maintained as failure to do so will have drastic economic consequences.

6.0: SUMMARY TABLES

6.0: Summary Tables

Table 1: Issues facing the ecological services of the region and the associated monetary value of an intact system

Issue	Impact on Ecological Services	Associated monetary Value	Monetary value of the Intact Ecological Service
Acid Rain	Lower pH resulting in a lower abundance of available fish or worst case scenarios; lakes devoid of fish	Lake by lake basis, but a dead lake is worth $0 to recreational fishing. Impaired lakes of pH 5.0-6.5 have the potential to experience $924,540 in losses (maximum figures when applied to the entirety of zone 15, the losses would therefore in reality be much lower as it would be on a lake by lake basis)	It can therefore be stated that lakes with healthy pH levels could be worth an approximate value of $924,540, and this has the potential to increase with a decrease in acid rain and acidified lakes within the region. As dead lakes are worth $0 to the recreational fishing industry it can further be stated that the current pH of lakes supporting angled fish communities would be worth the maximum value of $81.1 million.
Increased aquatic bound mercury from Dams and fluctuating water levels	Bioaccumulation of mercury in fish species resulting in mercury warnings and potential loss of anglers seeking consumable fish. Affects a $13.79 million dollar component of the recreational fishing industry for the area.	No exact figures but at a value of $11.58 per harvested fish, potential economic loss on a lake by lake basis could be obtained by multiplying this amount by creel surveys for affected species	Current value is unknown and an exact value may be impossible to obtain. It can be assumed that at current consumption levels of fish, the current health of watercourse is $13.79 million, a figure that has potential to rise if mercury decreases in some lakes prompting the removal of advisories and allowing for more anglers to consume harvested fish

Table 2: Issues facing the ecological services of the region and the associated monetary value of an intact system

Issue	Impact on Ecological Services	Associated monetary Value	Monetary value of the Intact Ecological Service
Increased water temperatures downstream of dams	Loss of crucial cold water habitat for coldwater fish species such as brook and brown trout.	When applied to the angled figures of brook and brown trout this represents a loss of $ assuming that all angled streams where to undergo damming	It can be stated that current impoundment free streams supporting healthy populations of brook and brown trout could be worth an approximate value of $1,557,120 and this has the potential to increase with a decrease in dams.
Boat gas inputting MTBE into aquatic environments	Can lead to mortality and defects, though in amounts that are greater than those found in current lakes and rivers	Current data suggests minimal to none	The exact value of an ecosystem with minimal MTBE remains unknown, but the current ecosystems without apparent hazardous amounts of MTBE bring in $81.1 million of economic value.
Increased Shoreline Development	Loss of feeding and breeding habitat	A loss of $811,000 per % of habitat loss. If shorelines are developed an average of 15% on all of Zone 15's waterbodies, this represents a loss of potentially $6,204,150 due to the degraded ecosystem.	Undeveloped shorelines can be worth upwards of $6,204,150 (only factoring in Walleye, Pike and Large/Smallmouth Bass). Each % of habitat is worth an estimated $811,000.
Shoreline Degradation, (I.e dredging)	Loss of feeding and breeding habitat	Potentially may cost $10,000 to rehabilitate a few square meters of shoreline with an additional fine of% 5,000	DFO views a few square meters of fish habitat to be worth a cost of $15,000

Table 3: Native Biodiversity and associated estimated monetary value

Native Biodiversity	Estimated Monetary Value
Littoral native biodiversity	$15 million annually
Communities of native biota dependent upon by walleye	$22.5 million
Native aquatic biodiversity	$150 million

7.0: REFERENCES

7.0: References

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