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Andrea M. McGregor

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ARTICLES

Of Fur and Fins: Quantifying Fur Trade Era Fish Harvest to Assess Changes in Contemporary Lake Whitefish *(Coregonus clupeaformis)* Production at Lac La Biche, Alberta

Andrea M. McGregor

ABSTRACT

The history of fisheries exploitation in Canada has significant ties to the development and westward expansion of the fur trade. Understanding the scale and nature of this relationship is important when assessing the developmental or evolutionary history of a system. This study uses estimates of human population size and subsistence lake whitefish (Coregonus clupeaformis) *consumption to estimate annual fish harvest at Lac la Biche, Alberta (54°52'N, 112°05'W) during the fur trade era and to assess the magnitude and potential influence of historic harvest on contemporary harvest potential. Historic (1800-1911) lake whitefish harvest increased approximately 10-fold, from 74,000 kg in 1800 to 811,000 kg in 1875, immediately preceding a lake whitefish population collapse in 1878. Following the initiation of a formal commercial fishing industry, contemporary (1912-2009) harvest peaked at 424,000 kg, about one half the previous estimated maximum. The persistence of low contemporary harvest biomasses suggests a shift from a system of high- to low-lake whitefish productivity, likely resulting from decreasing ecosystem resilience with increasing harvest pressure. Knowledge of historic fish harvest can minimize the impacts of the shifting baseline syndrome by elucidating the magnitude and impacts of historic harvests on future harvest potential and potential production.*

INTRODUCTION

Since humans first set foot in western North America almost 11,000 years ago (McCullough and Maccagno 1991:1), they have been changing the landscape and the fish and wildlife resources it supports. The earliest changes to both aquatic and terrestrial systems were the direct result of overharvest, but habitat alteration, pollution, and species introductions have also impacted ecosystems from historic to contemporary times (Jackson et al. 2001). Since the westward expansion of the fur trade in the mid-1700s, the rate of change has increased and the implications of change have become more severe, resulting in the prevalence of highly modified or degraded ecosystems. When altered systems can no longer satisfy the social demand

for the provision of goods and services, they often become candidates for restoration projects. Such projects offer ecologists and managers an opportunity to respond to past ecological degradation from anthropogenic disturbances, such as overharvest. To do so, however, managers require knowledge of the predisturbance conditions or the 'historical range of variability' of the targeted ecosystem, as well as knowledge of the magnitude and type of disturbance that influenced the system's development and evolution (Landres et al. 1999; Moore et al. 1999; Seastedt et al. 2008). Without this knowledge, managers, scientists and citizens are likely to assume that ecosystem conditions of the intermediate and distant past resemble those of their own remembered history and thus can be ignored—a classic characteristic of the shifting baseline syndrome (Humphries and Winemiller 2009; Papworth et al. 2009; Pauly 1995).

Lake whitefish (*Coregonus clupeaformis*) was the fish of the fur trade; it was easy to prepare, highly palatable, and had great nutritional quality (Richardson 1836:195-196; Tyrell 1916:111). Much literature exists documenting the early use of lake whitefish in the Great Lakes of eastern North America (see Casselman et al. 1996; Ebener et al. 2008; Ebener 1997; Wells and McClain 1973). Generally, Native Americans exploited lake whitefish until the late 1700s when European settlers developed their own subsistence fisheries. In the mid-1800s commercial harvest dominated lake whitefish production, and by the late 1800s or early 1900s, many lake whitefish populations had collapsed due to overfishing, habitat loss, and introduced species. Throughout the mid-1900s, lake whitefish populations remained at low densities in the Great Lakes, reportedly due to weather conditions affecting recruitment, exploitation stress from commercial fishing, high predation on larval fish, and cultural eutrophication (Casselman et al. 1996). Such detailed accounts of lake whitefish production do not generally exist for lakes in western Canada. However, a similar story of aboriginal reliance on lake whitefish followed by subsistence use by European settlers and the development of a commercial fishing industry is equally applicable to Canada's western provinces but with a delay of nearly a century as the fur trade moved west. Ebener (1997) reported that many lake whitefish populations throughout the Great Lakes are recovering with commercial harvests "…larger than any time this century," and Casselman et al. (1996) attribute this resurgence with "…the species' remarkable resilience." However, at Lac la Biche, Alberta, Canada, the lake whitefish population has not experienced a similar recovery thus raising questions over the resilience of this population with respect to historical and contemporary changes to the fishery as well as the ecosystem that supports it.

In this article, I aim to demonstrate that historic fish harvests, influenced by the westward advancement of the fur trade, resulted in overharvest of lake whitefish at Lac la Biche, Alberta. To do this, I explore the role of fur trade era fish harvest in shaping the evolutionary history of a large inland lake and subsequently, to place the magnitude and potential impact of historic harvests in context by comparing with contemporary harvest. The objectives of this study were to: 1) estimate historic fish harvests and compare historic subsistence harvests to harvests resulting from the growth of a commercial fishing industry; 2) explain potential effects of historical fish harvests on future harvest potential; and 3) to place historic lake whitefish harvests within the context of current production.

LAC LA BICHE AND THE DEVELOPMENT OF THE FUR TRADE

Lac la Biche (54°52'N, 112°05'W) is a large (223 km^2), shallow (average depth 8.4 m, maximum depth 21.3 m) eutrophic lake located on the southern edge of the boreal forest in northeast Alberta, Canada (Figure 1). There are 13 species of fish in the lake (Table 1) of which the lake whitefish has the longest reported history of targeted harvest. This study site was chosen because of the recent (2005) development of a fisheries restoration program at the lake focused mainly on recovering the walleye (*Sander vitreus*) population. However, the availability of historical data pertaining to the fur trade era, as well

as archeological and anthropological reports on the evolutionary history of the land and its people, aided in model development.

Native settlement of the area around Lac la Biche began approximately 11,000 years ago, following the retreat of the Laurentide Ice Sheet (McCullough and Maccagno 1991:17). The original occupants of the area, thought to be the Beaver-Sarcee-Sekani and the Blackfoot Indians (McCullough 1982:56), were forest dwellers, seasonally transitioning between forest and parkland habitats in response to the availability of bison (*Bison bison bison*) herds (McCullough 1982:46,48). Occupancy of the area remained more or less constant until the mid-1700s when Cree middlemen from eastern Canada made their way to present-day Alberta.

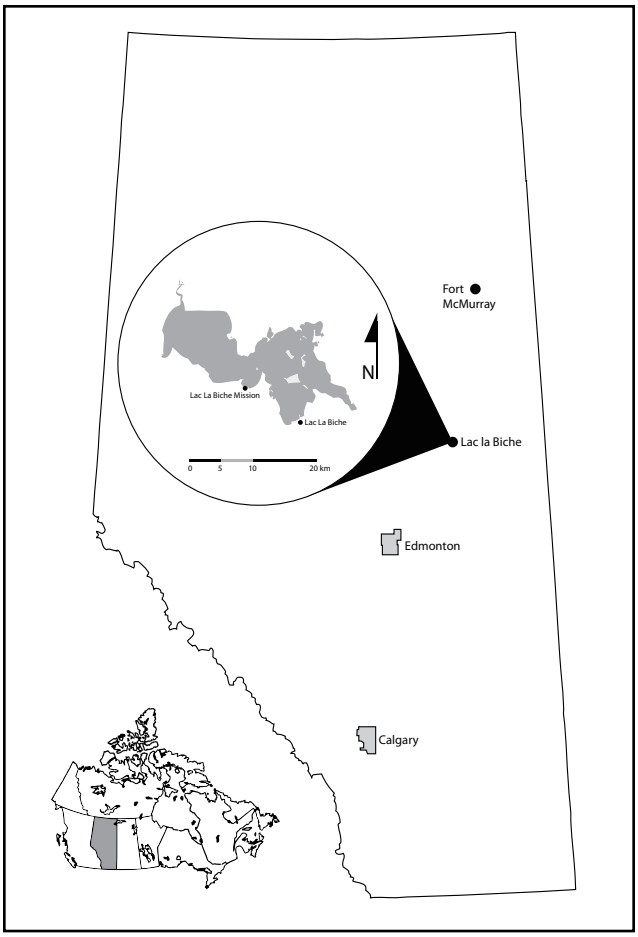

FIGURE 1. Map of Alberta showing the location of Lac la Biche relative to major cities. Subset map of the lake indicates the location of the Lac la Biche mission and the Town of Lac la Biche.

TABLE 1. List of all fish species occurring in Lac La Biche, Alberta, Canada.

Common name *(Latin name)*
Walleye (*Sander vitreus*)
Northern pike (*Esox lucius*)
Yellow perch (*Perca flavescens*)
Cisco (*Coregonus artedii*)
Lake whitefish (*Coregonus clupeaformis*)
Burbot (*Lota lota*)
White sucker (*Catostomus commersoni*)
Longnose sucker (*Catostomus catostomus*)
Ninespine stickleback (*Pungitius pungitius*)
Brook stickleback (*Culaea inconstans*)
Spottail shiners (*Notropis hudsonius*)
Trout-perch (*Percopsis omiscomaycus*)
Iowa darters (*Etheostoma exile*)

The Cree were the frontiersmen of the fur trade. Equipped with firearms and superior equipment acquired through trading, they were able to expand rapidly through western Canada where they occupied the best fur trade sites by pushing the less advanced tribes into more marginal areas (McCullough 1982:39). The advancement of the Cree, and with them the fur trade, had important implications for the development of resource exploitation in the west. The presence of Cree settlements eventually attracted peddlers, freemen, and traders to the area. The two big trading companies of the time, the British owned Hudson Bay Company and the French owned North West Company, were attracted to the lake because of its proximity to the Portage la Biche (Beaver River Route), which provided an important connection between the Athabasca and Churchill drainage basins. Between 1798 and 1799, three trading posts were

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built at Lac la Biche drawing many new people to the area. Even after the closure of the posts in 1802, the Portage la Biche maintained a steady flow of traders, 'vagabonds', and freemen through the country, many of whom took up permanent residence on the shores of the lake (McCullough and Maccagno 1991:83). By 1817, the North West Company and the Hudson Bay Company were back operating in the area but in 1824, the Portage la Biche was abandoned by the Hudson Bay Company, and with that abandonment the closure of a permanent trading post in Lac la Biche. No post existed in the area until the 1850s when the La Biche Post was opened, remaining active in the area for over 50 years (Maccagno 1988:46).

Despite the lack of an active trading post for most of the early 1800s, Métis freemen and Native Americans settled on the shores of the lake. By 1840, this population had attracted the attention of missionaries and in 1852, Our Lady of Victories Roman Catholic mission was officially founded on the southern shore of the lake. Between 1862 and 1899, the Sisters of Charity, also known as the Grey Nuns, operated a boarding school at the site of the mission, which remained an active force in the area until its closure in 1963. The development of the mission and its boarding school attracted still more people to the area and the introduction of agriculture by the missionaries further stabilized the sedentary lifestyle initiated by the fur trade.

THE CHANGING LIVES OF FISHERS

The reliance of the early occupants at Lac la Biche on fish resources has been debated, with McCullough (1982) suggesting that fishing was an integral part of the lives of forest dwelling tribes, and others reporting that fishing played a minor subsistence role with moose (*Alces alces*) hunting being the dominant preoccupation (Forbis 1970; Jenness 1932; Ridington 1968 as cited in McCullough 1982:58,60). Regardless, the reliance on both hunting and fishing to sustain early populations is likely, with fish being an important subsistence resource during times of wildlife scarcity (Curtis 1970:19; Goddard 1916:216) and in the spring and fall when spawning species were abundant and easy to catch (McCullough 1982:64). In the winter, gillnets made from rawhide cord or willow root bark and hooks made from antlers were the main technologies for fish harvest, while bone-pointed spears, weirs, and seines were used during the spawning season (Curtis 1970:20,62; Goddard 1916:216; Skinner 1912:27). Northern pike (*Esox lucius*) and lake whitefish were caught in the winter (Curtis 1970:19) and presumably consumed fresh. It can also be assumed that lake whitefish and cisco (*Coregonus artedi*) would have been harvested during the fall spawn while walleye, northern pike, white suckers (*Catostomus commersonii*) and longnose suckers (*Catostomus catostomus*) would have been consumed during the spring.

With the westward expansion of the Cree, the relationship between fishers and the resource experienced some subtle changes. The Cree generally fished for the same species and in the same ways as the Beaver-Sarcee-Sekani and Blackfoot Indians; however, the Cree had improved some of their fishing technologies through trade with the Hudson Bay Company (Skinner 1912:27), making them more efficient harvesters. Seasonal and long-term patterns of settlement and occupation by the Cree might also be different than previously experienced. For instance, in the Cree culture, women and children were left year round in large village settlements to fish while the men engaged in moose and beaver hunting activities (Thwaites 1959:227). In contrast, earlier tribes were presumably more nomadic, occupying lakes less frequently and more seasonally (Ridington 1968:39-42 as cited in McCullough 1982:58).

The arrival of the explorers and brigades of the fur trade, followed soon after by the Roman Catholic missionaries, solidified the change in the settlement pattern of the area that was initiated by the Cree; the populations had become centered around the lake (Champagne 1992:141) and the harvest pressure on the fisheries resource rapidly increased. Fish resources were important for satisfying subsis-

tence needs of the trading posts. In fact, this relationship was so important that David Thompson wrote "…when a new trading House is built which is almost every year, every one is anxious to know the quality of the fish it contains for whatever it is they have no other for the winter." (Tyrell 1916:111). Lac la Biche proved to be an appropriate location for an inland post owing to the quality of its fisheries.

In 1798, during the first year of activity for the Hudson Bay Company post at Lac la Biche, David Thompson reported that net sets on Lac la Biche "…gave us fish of pike, White fish, Pickeral [walleye] and Carp [white suckers] for about one third of our support…" (Tyrell 1916:305). Though no data exist for describing the abundance proportions of different fish species in Lac la Biche, from 1798 to 1799 a fur trade post harvest summary reported 2,126 lake whitefish harvested to 190 walleye, 749 northern pike, and 229 white suckers (Hudson Bay CompanyA,PAM,B104/a/1.fo.36 as cited in McCullough and Maccagno 1991:71). By 1819, lake whitefish was the main food of the Hudson Bay Company post (Hudson Bay CompanyA,PAM,B.115/e/1,fo.3d as referenced in McCullough and Maccagno 1991:101), and in 1864 William Traill wrote that "Fish is the staple article of the diet…" (McCullough and Maccagno 1991:132) at the fur trade post and he described how "…fish were eaten three times a day or as often as required" (Traill 1874 as referenced in McCullough and Maccagno 1991:135). Similarly, at the mission, fish were required to meet the subsistence needs of the Fathers, Brothers, and nuns, as well as the orphans, boarders, and students attending the mission school (Champagne 1992:32,51).

The fall fishery was critical for providing food to both the post and the mission. During this time, lake whitefish were harvested on their spawning grounds in large quantities by lighting the area with birchbark **flambeau** (torches) and spearing the fish (Moberly and Cameron 1929:86). These fish were either boiled fresh, dried, salted, split and smoked, frozen, or in some way preserved for use over winter (Tyrell 1916:111; Traill 1874 as referenced in McCullough and Maccagno 1991:135). In the winter and through the summer, gill nets were set to supplement the fall spawn or to provide a source of fresh fish (Champagne 1992:51). Of all the available fish species, the lake whitefish was judged to be the most important food source due to its versatility in preparation, palatability when eaten plain, and the nutritional quality of its meat (Richardson 1836:195-196; Tyrell 1916:111).

Following the lake whitefish collapse in 1878, the relationship between the fish and the fishers changed. Lake whitefish could no longer be relied upon to meet the subsistence needs of the people without an increase in harvest effort (Young 1882 as cited in McCullough and Maccagno 1991:150). In 1892, control of the fisheries began and in the fall of 1895, heavy restrictions were implemented and the first fishing permits given out (Champagne 1992:240,246). Despite these restrictions, the Department of Marine and Fisheries (1895:359) reported that the fisheries continued to fail and "…it has been found to be difficult to do anything towards protecting them." This conclusion was reached based on claims that despite fish being necessary for subsistence, the people of Lac la Biche made no preparations for the closed season such as drying fish, and all fish other than whitefish were wasted (Department of Marine and Fisheries 1895:359-360). In 1895, the Department of Marine and Fisheries (1896:191) commented that the fish populations at Lac la Biche were "…at a critical stage for [they] have been largely reduced in numbers." Despite this warning, by 1912, commercial fishing was introduced as an industry (Champagne 1992:282) and in 1915, the Hudson Bay Company shifted its business focus away from fur to fishermen (Hudson Bay CompanyA,PAM,D.FTR/3 as cited in McCullough and Maccagno 1991:185).

The development of the rail line and the inauguration of freight service in 1915 sped up the development of the commercial fishing industry and in 1916, the first fish plant was opened at Lac la Biche (Lac la Biche Heritage Society 1975:29). Rapid devel-

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TABLE 2. Summary of methodology for calculating annual historic (1800-1911) lake whitefish (*Coregonus clupeaformis*) harvest by season (winter or summer), time period, and harvester (subsistence, fur trade, Mission) for Lac la Biche, Alberta, Canada, including anecdotal references and assumptions underlying calculations.[1]

Harvest Type	Years	Season	Calculation	Support	Source
Subsistence	1800-1877	Winter	# families x 2000 fish (min), 3000 fish (max), 2500 fish (avg)	"Every one kills fish for the winter (Traill 1874d)…Most families have from 2 to 3 thousand [fish] according to the number of persons and dogs for all keep at least one train of dogs and as each dog must have a fish per day they require a good stock (Traill 1874d)."	McCullough and Maccagno 1991: 135
Subsistence	1878-1912	Winter	# families x 1000 fish (min), 2000 fish (max), 1500 fish (avg)	1892 - "The fisheries began to be controlled during this period. …The fisheries that fall were quite good, at least better than the previous year, but the numbers are much lower than those of twenty years before."	Champagne 1992: 240-241
Subsistence	1800-1912	Summer	# families x 5 fish/day (min), 10 fish/day (max), 7 fish/day (avg), x 142 days	Daily fish allotment assumed similar to fur trade post allotments. "The daily allowance of a Man is eight pounds of fish…" "The ordinary ration…at any of the Hudson Bay Company posts is either three large lake white fish, or three rabbits…per day per man."(McDougall 1902:110-111). "One whitefish was allowanced to each woman and a half to each child, if the fish were obtainable... Train dogs were fed two fish or four pounds of fresh meat daily." Assumes fish were generally more attainable than rabbits.	Tyrrell 1916:112; McDougall 1902:110-111 as cited in Kulle 1993:66; Moberly and Cameron 1929:83
Fur Trade	1800-1801	Winter	1970 fish (min), 1970 fish x 2 (max), 1970 fish x 1.5 (avg)	Minimum estimate of 1970 lake whitefish based on the number of fish caught by Peter Fidlers crew from October 15, 1799 to May 10, 1800 (HBCA,PAM,B104/a/1,fo.36). Maximum estimate assumes equal harvest by Northwest Company (NWC) and Hudson Bay Company (HBC). Average harvest estimate is half way between minimum and maximum.	McCullough and Maccagno 1991:71
Fur Trade	1802-1817	Winter	0 fish (min), 1000 fish (max), 500 fish (avg)	Maximum and average harvests represent conservative harvest estimates for fur trade brigades moving through the area en route to other posts. "There appears to have been no permanent trading posts in the Lac la Biche region between 1800 and 1817...However, the transportation route through Portage La Biche remained in use by both companies on their brigades to the Athabasca country."	Kulle 1993:21

Fur Trade	1818-1820	Winter	11,000 fish (min), 15,000 fish (max), 13,000 fish (avg)	"The main food at Red Deers Lake House II was whitefish, and elevan thousand were laid up for the winter." Maximum and average estimates represent undocumented harvests by NWC and random fur brigades before merging of HBC and NWC in 1819.	McCullough and Maccagno 1991:101
Fur Trade	1821-1853	Winter	2000 fish (min), 3000 fish (max), 2500 fish (avg)	No fur trade post was active at this time; however, one trader and his family remained at the post during this time so harvest estimates represented as subsistence needs for a single family.	McCullough and Maccagno 1991:103, 109
Fur Trade	1853-1864	Winter	9000 fish (min), 10,000 fish (max), 9500 fish (avg)	"We had now to lay in the winter supply of whitefish for the women, children and dogs. Nine or ten thousand was considered a sufficient quantity."	Moberly and Cameron 1929:86
Fur Trade	1865-1877	Winter	10,000 fish (min), 15,000 fish (max), 12,500 fish (avg)	"Between 10,000 and 15,000 whitefish were required to support the Lac la Biche post through the winter…"	McCullough and Maccagno 1991:135
Fur Trade	1878-1911	Winter	2000 fish (min), 3000 fish (max), 2500 fish (avg)	No estimates available. Calculated as ~1/5 of the previous periods estimates based on reports from Lake St. Ann. "…Lake St. Ann's, which was famed for its whitefish, which they need to catch in large quantities. The Hudson Bay Company, from this lake, used to get from forty to fifty thousand fish each winter to feed their men and train dogs, but at present it is doubtful if eight thousand could be caught there. I only mention this as an example which will apply with equal force to Whitefish Lake, Lac la Biche, Saddle Lake, Pigeon Lake, Whale Lake, and others."	Dominion of Canada. Annual Report of the Department of Indian Affairs. 1884:137
Fur Trade	1800-1801	Summer	0	Included in winter harvest estimate	
Fur Trade	1802-1817	Summer	0 fish (min), 1000 fish (max), 500 fish (avg)	No fur trade post was active in the area. Maximum and average harvests represent conservative harvest estimates for fur trade brigades moving through the area en route to other posts.	Kulle 1993:21

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Fur Trade	1818-1911	Summer	1/3 of winter harvest	No data were available for summer harvests during this period. Assume a conservative harvest represented as a proportion of the winter harvest.	
Mission	1800-1852	Winter	0	Not active	
Mission	1853-1854	Winter	200 fish (min), 1000 fish (max), 600 fish (avg)	Only a single Father residing at the Mission. Harvests represent 1/5 of harvest estimates from next time period with 5 to 7 residents.	Champagne 1992: 31
Mission	1854-1861	Winter	1000 fish (min), 5000 fish (max), 3000 fish (avg)	Minimum estimate from "The fall fishing has been good, with one thousand pieces from three visits to the nets." Maximum estimated based on an increase in number of Mission residents to ten during this period. Average is the middle of the minimum and maximum estimates.	Champagne 1992: 40
Mission	1862-1863	Winter	65 fish/day x 36 days fishing (min), 10,000 fish (max), 6000 fish (avg)	Minimum estimate from "…34 or 38 days in making the Fall Fishery as the fish was not in abundance, we had six nets in water in visiting the six nets we had not more than 50, 60, 80 etc.,..." Maximum estimate is double the minimum estimate to represent a doubling in the number of Mission residents at this time. Average estimate is assumed to be part way between the minimum and maximum.	Champagne 1992:51
Mission	1864-1877	Winter	9000 fish (min), 15,000 fish (max), 12,000 fish (avg)	Average estimate based on value from the period 1881-1884 during which the Mission achieved their needed supply of whitefish. This value was reduced to represent the smaller number of residents at the Mission during this time. Maximum estimate based on knowledge of the statement "Good fishing in the fall [of 1888] I took 14000" and the assumption that total winter harvest would be higher than this value.	Champagne 1992:229
Mission	1878-1880	Winter	9000 fish (min), 15,000 fish (max), 12,000 fish (avg)	"The fisheries were not very good… Of fifteen nets which had been set, they had caught only nine thousand fish, not enough for their needs." Maximum and average estimates assumed to be close to values from neighbouring periods.	Champagne 1992:174

Mission	1881-1884	Winter	10,000 fish (min), 15,000 fish (max), 12,500 fish (avg)	Average estimate based on the comment that the "...mission had achieved its needed supply," and the claims in the next two periods that harvests of 12,000 and 14,000 whitefish were large enough to supply the Mission.	Champagne 1992:178
Mission	1885-1911	Winter	12,000 fish (min), 15,000 fish (max), 13,500 fish (avg)	"The fisheries were good that fall, they got about twelve thousand white fish." Maximum estimate remains constant while average estimate is half way between the minimum and maximum estimates.	Champagne 1992:219
Mission	1800-1852	Summer	0	Not active	
Mission	1853-1911	Summer	# of residents x 1 fish/day (min), 3 fish/day (max), 1.5 fish/day (avg) + # school children x 0.5 fish/day (min), 1.5 fish/day (max), 1 fish/day (avg) x 142 days	In the absence of summer harvest data, daily fish quotas were approximated from fur trade rations for men, women, and children. "The ordinary ration…at any of the Hudson Bay Company posts is either three large lake whitefish, or three rabbits… per day per man." (McDougall 1902:110-111). "One whitefish was allowanced to each woman and a half to each child, if the fish were obtainable.."	Tyrrell 1916:112; McDougall 1902:110-111 as cited in Kulle 1993:66; Moberly and Cameron 1929:83

[1]Methodology section provides estimates for the number of lake whitefish harvested. To calculate biomass harvested multiply counts by 2 kg—the average weight of lake whitefish harvested in 1819 (Hudson Bay CompanyA,PAM,B.115/e/1,fo.3d, as cited in McCullough and Maccagno 1991:101).

opment of the export market prompted the building of four fish plants and by 1918, over 200 fishermen were harvesting and processing walleye, northern pike, cisco and lake whitefish (Lac la Biche Heritage Society 1975:29). However, two years later, "…the bloom was off the lake and many fish companies formerly based on Lac la Biche moved to Lake Athabasca" (Chipeniuk 1975:20). While the Hudson Bay Company was left responding to the downturn of the commercial fishing industry, rapid settlement of the area by Catholic and Orthodox families wishing to adhere to the custom of eating fish on Friday, drove a resurgence of the fishery (Lac la Biche Heritage Society 1975:31). Between 1928 and 1929, fish prices increased as a result of this demand and every storekeeper and farmer began peddling fish in response to the high prices (Lac la Biche Heritage Society 1975:31).

In 1930, the market switched again as mink (*Mustela vison*) ranching became popular in the area and the demand for cisco, the staple of the mink diet, increased (Champagne 1992:284). Nets set to capture cisco were not selective and large biomasses of big yellow perch *(Perca flavescens)* and small walleye, lake whitefish and northern pike were removed as by-catch. As these were not targeted species, much of the by-catch would likely have been

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TABLE 3. Estimates of lake whitefish (*Coregonus clupeaformis*) harvest (kg•10³) by subsistence, fur trade post, and Roman Catholic mission harvesters in winter and summer seasons, including minimum, maximum, and average harvest estimates.

	SUBSISTENCE - KG HARVESTED (x10³)						FUR TRADE - KG HARVESTED (x10³)					
	Winter			Summer			Winter			Summer		
YEAR	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg
1800	20.4	122.4	51.0	7.2	57.9	20.3	4.0	8.0	6.0	0.0	0.0	0.0
1805	20.4	122.4	51.0	7.2	57.9	20.3	0.0	2.0	1.0	0.0	2.0	1.0
1810	20.4	122.4	51.0	7.2	57.9	20.3	0.0	2.0	1.0	0.0	2.0	1.0
1815	20.4	122.4	51.0	7.2	57.9	20.3	0.0	2.0	1.0	0.0	2.0	1.0
1820	20.4	122.4	51.0	7.2	57.9	20.3	22.4	30.6	26.5	7.5	10.2	8.8
1825	20.4	122.4	51.0	7.2	57.9	20.3	4.1	6.1	5.1	1.4	2.0	1.7
1830	28.6	153.0	76.5	10.1	72.4	30.4	4.1	6.1	5.1	1.4	2.0	1.7
1835	28.6	153.0	76.5	10.1	72.4	30.4	4.1	6.1	5.1	1.4	2.0	1.7
1840	40.8	183.6	102.0	14.5	86.9	40.6	4.1	6.1	5.1	1.4	2.0	1.7
1845	49.0	214.2	102.0	17.4	101.4	40.6	4.1	6.1	5.1	1.4	2.0	1.7
1850	49.0	214.2	102.0	17.4	101.4	40.6	4.1	6.1	5.1	1.4	2.0	1.7
1855	61.2	244.8	102.0	21.7	115.9	40.6	18.4	20.4	19.4	6.1	6.8	6.5
1860	81.6	336.6	204.0	29.0	159.3	81.1	18.4	20.4	19.4	6.1	6.8	6.5
1865	183.6	489.6	331.5	65.2	231.7	131.8	20.4	30.6	25.5	6.8	10.2	8.5
1870	326.4	673.2	459.0	115.9	318.6	182.5	20.4	30.6	25.5	6.8	10.2	8.5
1875	408.0	697.7	535.5	144.8	330.2	212.9	20.4	30.6	25.5	6.8	10.2	8.5
1880	204.0	469.2	324.4	144.8	333.1	214.9	4.1	6.1	5.1	1.4	2.0	1.7
1885	204.0	489.6	339.7	144.8	347.6	225.1	4.1	6.1	5.1	1.4	2.0	1.7
1890	204.0	530.4	355.0	144.8	376.6	235.2	4.1	6.1	5.1	1.4	2.0	1.7
1895	204.0	591.6	370.3	144.8	420.0	245.4	4.1	6.1	5.1	1.4	2.0	1.7
1900	204.0	632.4	385.6	144.8	449.0	255.5	4.1	6.1	5.1	1.4	2.0	1.7
1905	204.0	693.6	400.9	144.8	492.5	265.6	4.1	6.1	5.1	1.4	2.0	1.7
1910	204.0	754.8	416.2	144.8	535.9	275.8	4.1	6.1	5.1	1.4	2.0	1.7

dumped back into the lake and almost certainly the vast majority would not have been reported. The small mesh nets (70 and 76 mm stretch measure) of the cisco fishery are thought to have had a large negative impact on the sustainability of the walleye population (Valastin and Sullivan 1997:6).

While commercialization of the fishery was occurring, another new type of fishing pressure appeared—the angler. In 1935, Lac la Biche was marketed to tourists as a "sportsmen's paradise" and angling for walleye and northern pike was promoted (Johnson 1999:262-263). Local reports on fishing conditions between 1920 and 1975, summarized in Valastin and Sullivan (1997), frequently describe the abundance of the walleye, the ease of catching northern pike and the size of yellow perch, at the same time describing how these species were regularly wasted. There was no market for walleye in the earliest years of the fishery so they were dumped or "thrown out" (Valastin and Sullivan 1997:6,7) and during the spring spawn northern pike were pulled from the

The winter season was from October 1 to May 10, and the summer season was from May 11 to September 30.

MISSION - KG HARVESTED (x10^3)

Winter			Summer		
Min	Max	Avg	Min	Max	Avg
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
2.0	10.2	6.1	1.4	4.3	2.2
2.0	10.2	6.1	2.0	6.1	3.0
18.4	30.6	24.5	7.0	20.9	11.9
18.4	30.6	24.5	5.5	16.5	9.0
18.4	30.6	24.5	10.7	32.2	17.2
18.4	30.6	24.5	15.9	47.8	25.3
24.5	30.6	27.5	9.8	29.5	15.6
20.4	30.6	28.6	13.3	40.0	23.6
20.4	30.6	28.6	15.5	46.5	25.8
20.4	30.6	28.6	3.8	11.3	5.6
20.4	30.6	28.6	2.6	7.8	3.9
20.4	30.6	28.6	4.3	13.0	7.4

creek with pitchforks and the smaller fish were fed to the pigs while the children played with the large ones (Valastin and Sullivan 1997:8). Yellow perch were removed in huge quantities (113,000 kg to 318,000 kg) by the cisco fishery (Valastin and Sullivan 1997:12) and, though they were not wasted, they represent a potentially unsustainable biomass removal as bycatch. During the same period, harvests of lake whitefish were reported at only a fraction of the historic levels and the loss of "jumbo" individuals (3.2 kg – 3.6 kg) was described (Valastin and Sullivan 1997:13-14). Despite the apparent abundance of sport fish through the first half of the twentieth century, by 1970 walleye were extirpated and in the latter half of the century, both the northern pike and yellow perch fisheries had declined (Valastin and Sullivan 1997:22-23).

Since the mid-1990s both commercial and recreational harvest regulations have become more restrictive and subsistence harvest by First Nations, though not limited per se, has been minimal, likely due to significantly reduced catch rates. While a spring commercial fishery for lake whitefish still exists, there are only two active fishermen and fish are peddled with local demand largely driving involvement in the fishery. Angling for northern pike (spring) and yellow perch (winter) dominate the recreational fishery while a large-scale, multi-year restoration program initiated in 2005 is focused on recovering the walleye population.

QUANTIFICATION OF HISTORIC LAKE WHITEFISH HARVEST

To explore the hypothesis that historic subsistence fishing was capable of overharvesting the resource, it was necessary to quantify the magnitude of this harvest. The settlement of the area around Lac la Biche through the 1800s, and the resulting changes affecting the abiotic and biotic resources of both the terrestrial and aquatic communities, can be attributed directly to the expansion of the fur trade and the development of the Roman Catholic mission. As the main forces influencing the population of the area through the 19th and early 20th centuries, the information recorded by these groups proved incredibly valuable for estimating potential harvests. Reports of the number of fish harvested, approximate locations of harvests, harvest techniques, methods of fish preparation, daily rations or allotments for the men, women, children and dogs (from dog teams) associated with trading posts, plus the predicted subsistence needs of Metis and Native American families were all discussed in the journals of the fur trade

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posts, and especially in the narratives of David Thompson (Tyrrell 1916). Similar harvest information for the mission was regularly reported in the journals of the Oblate Fathers and has been translated and referenced in reports by Champagne (1992), Kulle (1993), Maccagno (1988), and McCullough and Maccagno (1991). In addition, general comments on the success of the fishery, utilization of the fish resources, management, and environmental conditions were found in historic newspaper articles and reports from the Department of Indian Affairs.

To generate estimates of the total number of lake whitefish harvested during the historic period, including minimum and maximum estimates, I summarized all pieces of information that were available from the above mentioned sources into three categories: fur trade harvest, mission harvest, and subsistence harvest. Subsistence estimates include harvest by Metis, Native American, and other families not associated with the fur trade post or the mission. I estimated harvest separately for the fall/winter months (October 1 – May 10) and the spring/summer months (May 11 – September 30) because of differences in the nature of the harvest (Table 2). Seasonal harvests were added together to generate the annual harvest estimate. Since most harvest data were reported as the number of fish harvested, I estimated the total biomass removed by multiplying by 2 kg, the average weight of a lake whitefish harvested in 1819 by the trading post (Hudson Bay CompanyA,PAM,B.115/e/1,fo.3d as cited in McCullough and Maccagno 1991:101). The expected harvests of each user group from 1800 to 1911 were combined to generate a time series of fish harvest data (Table 3).

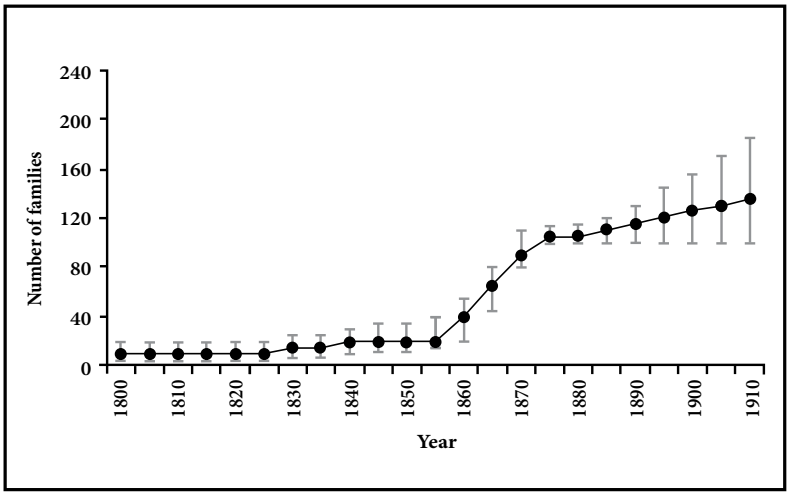

FIGURE 2. Number of families living in the Lac la Biche area for every fifth year between 1800 and 1910, including minimum and maximum estimates.

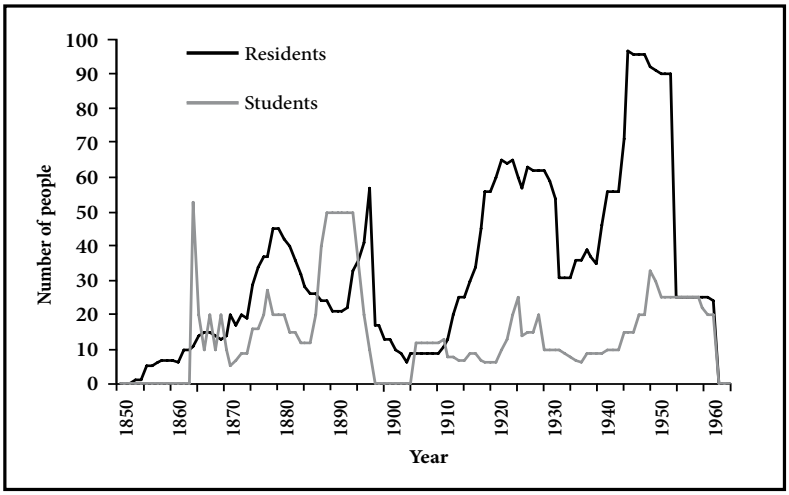

FIGURE 3. Number of residents (men, women, and boarders) and students residing at the Lac la Biche Mission from the arrival of the first priest in 1853 to the closing of the residential school in 1962.

Estimating subsistence harvest required information on the number of fish required to support a family as well as the number of families settled around and presumably relying on the lake. To generate a times series of the number of families in the area, I used references from fur trade and mission reports for the years between 1800 and 1869 (Champagne 1992; McCullough and Maccagno 1991; Tyrrell 1916), trading post census data from 1872 for the 1870s (Hardisty Papers, Glenbow-Alberta Institute, Calgary, as cited in McCullough and Maccagno

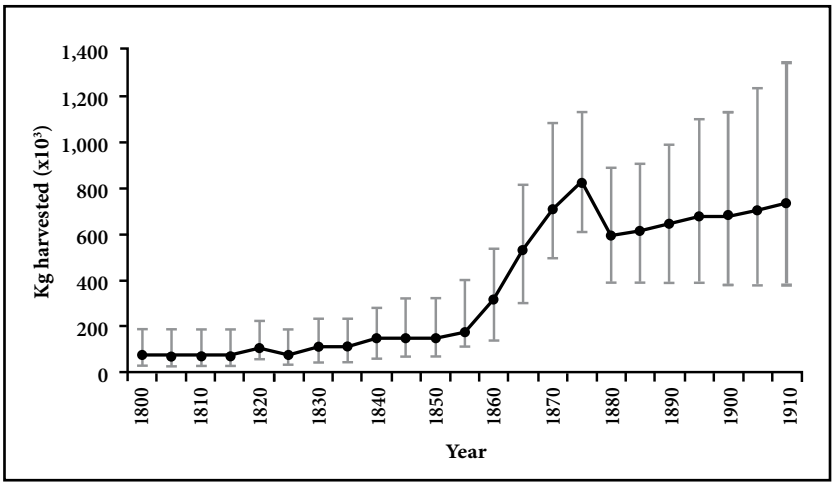

FIGURE 4. Total lake whitefish (*Coregonus clupeaformis*) harvest (kg•10³) by the Lac la Biche settlement (subsistence, fur trade and Mission) for every fifth year between 1800 and 1911, including minimum and maximum estimates.

1991:136), field notes of the land surveyer P.R.A. Belanger for the late 1880s (Belanger 1889 as cited by McCullough and Maccagno 1991:163), and federal census data for the years 1901 and 1911 (Library and Archives Canada 1901,1911) (Figure 2). Estimates of the number of Mission residents and the number of school children, used in calculating summer fish consumption, were derived from Champagne (1992) (Figure 3).

Reductions in fish harvest after the collapse of lake whitefish were rationalized, where necessary, based on anecdotal reports describing declines in the supply of fish. For instance, McCullough and Maccagno (1991:141) describe how the failure of the fall fishery for lake whitefish in 1878 occurred in response to "…heavy fishing pressure brought on by increased population densities" and on December 9, 1882 the *Edmonton Bulletin* reported "…that the supply of fish is giving out." (McCullough and Maccagno 1991:150). In 1884, it was reported that the increasing scarcity of lake whitefish was the "…result of the taking of fish during their spawning season…" and that "If some steps [were] not taken to do away with this custom the result [would] be the extermination of the white fish…" (Dominion of Canada 1884:137). Similar reports documenting reductions in the fish supply occurred throughout the remainder of the 19th century (Champagne 1992:241,251; Department of Marine and Fisheries 1895; Dominion of Canada 1887:94) and were used to justify reduced harvest estimates during this period.

An initial harvest estimate of 77,000 kg (range 32,000 to 188,000 kg) for 1800 represents light harvest by nomadic peoples, specifically aboriginals and 'freemen' associated with the fur trade (Figure 4). Following the establishment of permanent trading posts in 1817, there was a slight increase but relative stability of the harvest. A rapid rise in fish harvest after 1855 reflects the development of the Oblate Mission and an influx of people into the area. Rapid settlement resulted in harvests of 824,000 kg (range 609,000 to 1,131,000 kg) in 1875 (Figure 4), shortly before the reported collapse of the lake whitefish population. Partial recovery was reported to have occurred following the introduction of fishing regulations in the late 1800s, with harvests increasing to 725,000 kg (range 379,000 to 1,343,000 kg) in 1910 (Figure 4), just prior to the initiation of the commercial fishing industry.

The minimum estimates—of 111,000 individual lake whitefish consumed in the winter (226,000 kg) and an average of 76,000 consumed in the summer (176,000 kg) by the entire settlement post-collapse (1878-1912)—closely resemble the estimates reported in Belanger (1890:42) of 113,000 lake whitefish harvested during the fall spawning season of 1888, 108,000 harvested in the fall of 1887 and 500 to 1,000 fish harvested daily by the settlement each day during the summer. The similarity between this independent

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reporting of total fish harvest and the estimated fish harvest generated from this analysis supports the reported time series data.

Potential maximum harvests of greater than one million kg (~45 kg•ha^{-1}) annually seem absurd given the predicted productivity of Alberta lakes for lake whitefish (5.62 kg•ha^{-1}•yr^{-1}) (Chris Davis, Alberta Sustainable Resource Development, Lac la Biche, Alberta, personal communication, 18 July 2011). However, a 2011 mark-recapture study on Pigeon Lake, Alberta, found lake whitefish densities of 75 adult fish•ha^{-1} (average fish weight = 1.77 kg) (J. Cooper and V. Buchwald, Alberta Sustainable Resource Development, Red Deer, Alberta, personal communication, 17 January 2011). If similar densities were possible for Lac la Biche, given the average reported weight of historically harvested lake whitefish of 2 kg, in the 1800s the lake would have had a standing biomass of 3.4 million kg (153 kg•ha^{-1}). Even at a conservative density of 50 lake whitefish•ha^{-1}, Lac la Biche might have supported 2.27 million kg (102 kg•ha^{-1}). Given that the anecdotal estimates tend to support such a large potential harvest, and that current research suggests that the biomass of lake whitefish required to support such high harvests is achievable for Alberta lakes, these estimates appear reasonable.

Given the feasibility of the historic harvest estimates, combined with the frequency and abundance of reports of significantly reduced lake whitefish populations after their collapse in 1878, I would suggest that overharvest indeed occurred at Lac la Biche prior to the initiation of a formal commercial fishery. This overharvest was most likely the result of increasing settlement associated with the westward expansion of the fur trade and the establishment of the Roman Catholic Mission. Though landscape changes would also have occurred as farming was introduced to the area, a paleolimnological assessment suggests the effects of land conversion in the lake's catchment became apparent early in the 20th century (Schindler et al. 2008), two decades or more after the reported lake whitefish collapse.

CONTEMPORARY LAKE WHITEFISH HARVEST

To investigate the hypothesis that the historic overharvest of lake whitefish significantly impacted their future harvest potential, I investigated the magnitude and dynamics of the contemporary harvest regime. Commercial harvesting of lake whitefish from Lac la Biche was first recognized in 1912. Prior to this time, harvests by the fur traders, missionaries, and local Native Americans, Metis, and freemen were considered subsistence fisheries since their main purpose was to provide rations for people and animals. Few data were available for the years prior to 1940 when provincial monitoring of the fishery began so, for the years between 1912 and 1947, mission-related harvest was calculated as the average of the harvest estimates of 1900 to 1911. I made the assumption that mission harvest was consistent during this period based on claims from 1927 that "…big budgets were avoided by relying on fish" (Champagne 1992:292) and that the children residing at the Mission were tired of eating fish (Champagne 1991: 292). The fishery was closed in 1948 in response to a major winterkill in 1946 and cisco die-off in 1947. From 1949 to the closure of the Mission in 1962, harvest was estimated at half of the 1947 harvest.

Between 1912 and 1927, subsistence harvest was conservatively estimated at 250,000 kg based on annual reports of "Limitations of Commercial Catches…" published in the Canada Gazette (www.collectionscanada.gc.ca) between 1922 and 1927 of 375,000 lbs (170,000 kg) and 500,000 lbs (226,800 kg). That these limits were regularly exceeded is suggested by the comment in Chipeniuk (1975:21) that "All in all, the average yearly harvest of whitefish and pickeral would hardly have been less than 500,000 lb., and may well have reached 1,000,000 lb. [453,600 kg]." The vast majority of these fish would have been lake whitefish because they were the target species of the fishery. When the subsistence estimate is combined with mission and commercial harvests the total is close to the middle of the estimated range reported above. Between 1928 and 1947, I assumed

that subsistence harvest was equivalent to reported commercial harvests based on reports of increased local consumption during this period (Lac la Biche Heritage Society 1975:31), and the claim that "for this market another kind of businessman began to tap the fish resources of the lake, the farmer who would fill his wagon box [with fish]…and then go peddling" (Lac la Biche Heritage Society 1975:31). No harvest was reported for 1948 due to a lake closure, and between 1949 and 1986, I gradually increased subsistence harvest from 1,000 kg to 25,000 kg. Between 1987 and 2009, I gradually decreased harvest from 25,000 kg to 10,000 kg. I chose 1986 as the start of declining subsistence harvest to reflect a fairly significant decline in reported commercial harvest after this year. Major assumptions were required for estimating subsistence harvest in the 1900s due to an almost complete lack of data for this time. However, subsistence harvest values could be doubled or completely removed from the analysis of contemporary harvest without affecting the interpretation of a large shift in the magnitude of estimated historic harvest relative to contemporary harvest.

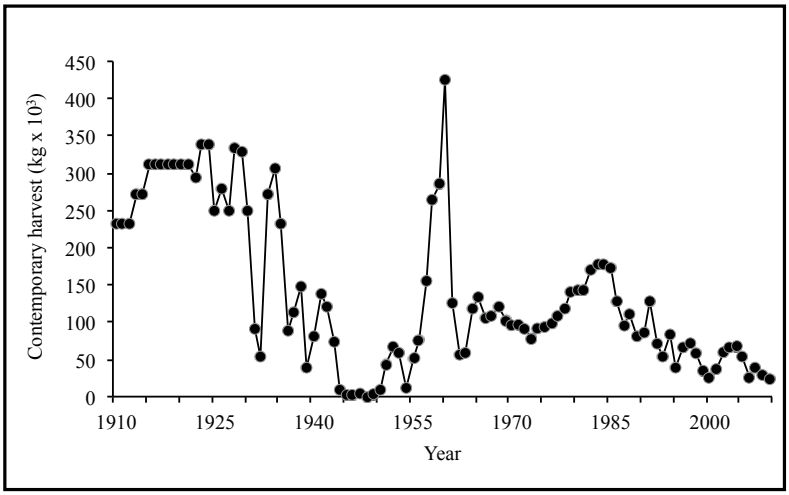

FIGURE 5. Annual total (subsistence and commercial) lake whitefsh (*Coregonus clupeaformis*) harvest (kg•10³) at Lac la Biche from 1910 to 2009.

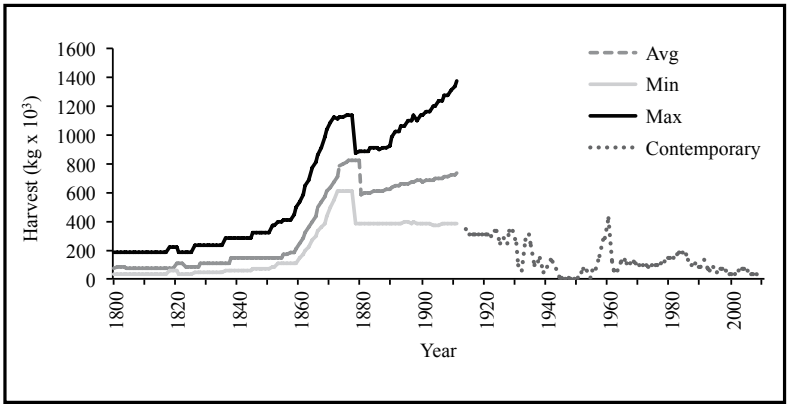

FIGURE 6. Minimum, average, and maximum historic (1800-1911) lake whitefish (*Coregonus clupeaformis*) harvest (kg•10³) time series relative to the contemporary (1912-2009) harvest time series.

No commercial harvest data were available for 1912 to 1922 so an estimate of 40,000 kg was used. This harvest value was chosen based on the first reported commercial harvest estimate of 42,900 kg in 1922. Commercial harvest data for 1922 to 1941 represent values published as part of the Fisheries Statistics of Canada (Dominion Bureau of Statistics for relevant years). For the years between 1942 and 1946, I reported the average of the provincially-reported commercial harvest data (Scott 1976) and the Fisheries Statistics of Canada data. Lake whitefish data from 1947 to 2009 represent provincially documented commercial harvests (Scott 1976).

Contemporary lake whitefish harvests officially peaked in 1960 at 424,000 kg (Figure 5). Near the start of the fishery, however, the distinction between commercial and subsistence harvests was probably not discrete and, if this is the case, early lake whitefish harvests could be considerably higher than estimated if local Metis, Cree and Native Americans were either peddling locally

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or marketing the fish elsewhere. Regardless of the details, the rush to participate in the commercial fishery had a negative impact on the lake as evidenced in the comments by Chipeniuk (1975:20) that "By the 'twenties the bloom was off and many of the fish plants formerly based on Lac La Biche moved to Lake Athabasca." Indications of a decline in the quality of the lake whitefish fishery all occurred prior to the peak estimate for contemporary harvests in 1960, suggesting that the potential of the lake whitefish population had been impacted prior to the onset of commercial harvest.

COMPARISON OF HISTORIC AND CONTEMPORARY LAKE WHITEFISH HARVEST

To determine if historic overharvest is responsible for the observed trends in contemporary harvest requires an understanding of the how the fishery has evolved in response to changes in the human population over the last two centuries. To examine this relationship, I first combined the historic harvest times series' representing minimum, average, and maximum harvests with that of contemporary harvest to examine the continuity of the of the data between the two periods (Figure 6). This combined harvest history for lake whitefish at Lac la Biche indicates that the minimum peak historic harvest in 1875 (609,000 kg) could have been as much as four times higher than the average of the contemporary harvest estimates (157,000 kg), whereas the average (811,000 kg) and maximum (1,131,000 kg) historic harvest estimates were more than five and seven times greater than the contemporary average, respectively. If estimates of contemporary subsistence harvest were removed due to high uncertainty in the magnitude of the values, the minimum peak historic harvest would have been seven times higher than the average contemporary harvest (88,000 kg). Based on this assessment, I chose to graph the minimum fish harvest data estimates and population data together for the period between 1800 and 2009 (Figure 7).

When lake whitefish harvest was assessed on a per capita basis, annual fish harvest increased from approximately 550 kg in the early 1800s to 1,000 kg in the 1870s. Following the lake whitefish collapse in 1878, annual harvest gradually decreased from 700 kg to 200 kg per person. In the 1940s, annual harvests decreased dramatically, fluctuating from less than 5 kg to 26 kg per person. From qualitative references describing the period after the lake whitefish collapse, it was assumed that total harvests decreased but fishing effort significantly increased to maintain harvest requirements given the reduced lake whitefish population size. However, it has been shown for the historic lake whitefish fishery in the Great Lakes that maintenance of high catches despite reductions in the size of the fish population resulted from increased effort and improved technology (Wells and McLain 1973). It is also likely that the shortage of lake whitefish was compensated for by harvesting larger proportions of other species, especially northern pike which was relied on by the mission in years when lake whitefish were not abundant (Champagne 1992:51). After the collapse and during what was thought to be the recovery period for lake whitefish in the late 19th century and early 20th century, harvests were still considerably higher than those reported during the period of contemporary commercial harvest and significant variability in harvest success was commonly reported.

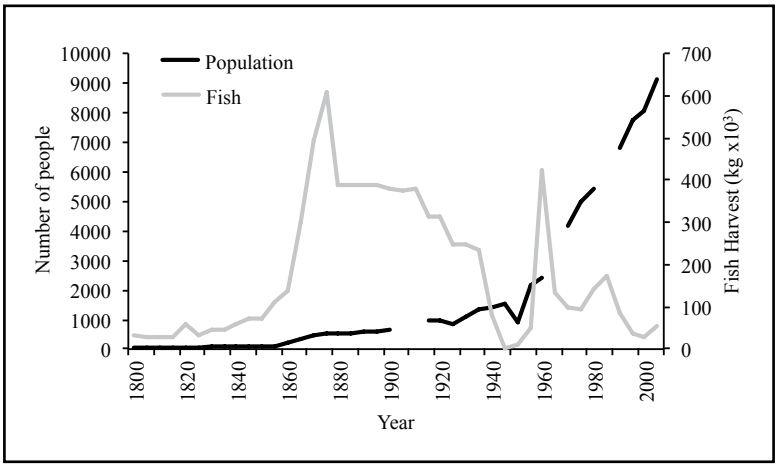

FIGURE 7. Time series of minimum estimates for lake whitefish (*Coregonus clupeaformis*) harvest (kg•10³) relative to the population of the Lac la Biche area from 1800 to 2009.

That historic overharvest of lake whitefish caused a reduction in the harvest potential of contemporary fisheries can be inferred from the trend data; however, the paucity of anecdotal or quantitative data for the critical period between the lake whitefish collapse (1878) and the first data reports from the commercial fishery (1920) make it difficult to draw strong conclusions about the cause of the decreased harvest. With no estimates of lake whitefish abundance available for any point during the contemporary or historic periods, I was unable to determine if trends in biomass of fish harvested represent a reasonable proxy for the harvestable population size. While harvest trend data are generally the most widely available indicator of changes in fish population size, they are strongly influenced by the efforts of the fishers. Fisher effort is motivated by many factors not considered in this study including weather, fish price, market demand, and fisheries quotas.

A plausible alternate explanation for the observed contemporary harvest trend is that intense overharvest through the mid- and late- 1800s decreased lake whitefish population resilience, as evidenced both by the increased likelihood that stochastic events negatively affected the fishery and by the increasing variability in harvest. Following the lake whitefish population collapse there was a noticeable increase in anecdotal references to stochastic weather events (Dominion of Canada 1887:94; McCullough and Maccagno 1991:150), droughts (Champagne 1992:251; Dominion of Canada 1886:131) and summer/winter kills of fish (Chipeniuk 1975:22) which were expected to have impacted survival or recruitment of the lake whitefish population (Dominion of Canada 1886:131). During the same time, there was evidence of increasing variability in lake whitefish harvest (Champagne 1992:240-241, 251; Department of Marine and Fisheries 1895, 1896; Dominion of Canada 1887:94). These types of fluctuations in state variables can be indicators of decreasing resilience (van Nes and Scheffer 2007). If perturbations caused by increasing harvest pressure, or landscape changes from the growing human population, decreased the resilience of the lake whitefish population, then a stochastic disturbance such as drought, could have caused such a regime shift to occur. If this shift resulted in the occurrence of a low-production lake whitefish system, this could explain why commercial harvests appear consistently low throughout the 20th century.

The failure of Lac la Biche lake whitefish population to recover over the last 50 years could also be the result of ecosystem changes acting synergistically with changes in lake whitefish productivity, leading to an ecosystem scale regime shift rather than a population level shift. It is plausible that large removals of lake whitefish freed up resources that then become available for use by other fish species occupying similar ecological niches (certain life stages of walleye, yellow perch, and cisco). If lake whitefish were outcompeted by newly dominant competitors this could explain their lack of recovery in the contemporary system as energy was diverted to other species. The overharvest of dominant fish predators such as pike and walleye in the 1950s allowed forage fish populations, mostly cisco and yellow perch, to increase dramatically in the latter half of the 20th century (McGregor 2013). Increased predation by forage fish on lake whitefish eggs and fry has not been documented but, like smelt and white perch in Lake Ontario (Christie 1973 as cited in Casselman et al. 1996), high predation could be keeping the population depressed. Biological changes to predator-prey relationships and energy flow could also have been supported by bottom-up changes in the abiotic conditions of the lake. For instance, cultural eutrophication has affected the lake since about the 1950s (Schindler et al. 2008) which could have negatively affected lake whitefish productivity (Casselman et al. 1996) or positively influenced the productivity of lake whitefish competitors or predators. In addition, a known historic spawning area was lost in 1968 when a causeway connecting the mainland to a nearshore island was created on top of the spawning habitat.

It is impossible to determine if the consistently low lake whitefish production over the last 100 years is the result of a loss of resilience at the population level,

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ecosystem level changes preventing potential production from being realized, or from factors unrelated to either. For example, the apparent consistency of contemporary harvest might also be the result of introduced harvest quotas (though they were poorly enforced) (Champagne 1992:240-241,251), underreporting of contemporary harvest (there are many reports that quotas were regularly exceeded) (Chipeniuk 1975:21), overestimation of historic subsistence harvest, or changes in harvest effort over time as the demand for lake whitefish changed (for examples see Lac la Biche Heritage Society 1975:30,31; McCullough and Maccagno 1991:185,189).

CONCLUSIONS

By assessing changes in historic (1800-1911) subsistence harvest demands, I have demonstrated that increasing settlement initiated by the westward expansion of the fur trade led to the overharvest of lake whitefish at Lac la Biche. By comparing harvest estimates for the historic and contemporary periods (1912-2009), I suggest that historic harvest pressure affected commercial harvest potential by decreasing the resilience of the lake whitefish population through changes in life history strategy and productivity, making it more susceptible to stochastic and other disturbances. Variable harvests, an increase in reports on the impacts of stochastic events on the lake whitefish population and a clear drop in the realized harvests support this conclusion. However, changes in abiotic and biotic conditions of the lake's ecosystem could also be preventing lake whitefish recovery by negatively affecting recruitment and productivity, or by causing an ecosystem scale regime shift.

Assessments of historic conditions can rely heavily on interpretation of how disparate pieces of information fit together into a comprehensive story. Interpretation error could also conceivably account for some of the observed difference between historic and contemporary lake whitefish production, but it is not likely to account for the largest proportion since minimum harvest estimates were used in the comparison of harvest between eras.

The conclusions drawn in this study represent the most complete, geographically-targeted history for a large lake ecosystem outside the Great Lakes that was found in an extensive literature review. Until better historic evaluations are assembled, these conclusions provide important insight for guiding fisheries management. Estimates of historic fish populations that are so large as to "seem unbelievable based on modern observations alone" (Jackson et al. 2001) can be easily disregarded by contemporary fisheries managers, potentially resulting in ecological and economic consequences. By providing an estimate that quantifies the historic magnitude of the lake whitefish population in Lac la Biche and speculating on why these levels are not currently achievable, this research provides an estimate of lake whitefish production potential and lost potential resulting from ecosystem change. The conclusions from this study highlight the significance of understanding the historical context in which fisheries issues developed, and in doing so help counteract the effects of the shifting baseline syndrome when setting management goals.

Andrea M. McGregor, *Department of Renewable Resources, University of Alberta,* amm15@ualberta.ca

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