Summary of 2000-2014 Fall Walleye Index Netting (FWIN) on Namakan Lake, Ontario and Assessment of Walleye and Northern Pike Population Status

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SUMMARY

Fall Walleye Index Netting (FWIN) were conducted in 2000, 2004, 2005 and 2014 on Namakan Lake, located approximately 70 km southeast of Fort Frances, Ontario. The lake is situated on the international border between NW Ontario and Minnesota. A diversity of fish species were captured in gill nets, and detailed biological data relating to walleye and northern pike were obtained.

Walleye populations showed some improvement in age structure in the 2004 and 2005 surveys but by 2014, populations were similar to those observed in 2000. Based on the 2014 assessment, the walleye population in Namakan Lake is on the edge of being classed as stressed based on the biomass of walleye in the lake. The mortality estimate also suggests it is being harvested above the upper limit of safe levels. The 2014 Fisheries Management Plan for Fisheries Management Zone 5 which includes Namakan Lake indicate that walleye >=45 cm (18") should make up more than 25% of the catch to meet objectives to protect and maintain spawning stock. Surveys between 2000 and 2014 indicate that Namakan Lake walleye population did not meet that objective in any year with % walleye >= 45 cm ranging from 6-18% and is currently at 10% of catch.

It would appear that the overall harvest of walleye in Namakan remains high enough to result in negative impacts to the amount of walleye and the size and age structure of the population resulting in a moderate abundance of small sized walleye in the lake. While current populations may be sustainable at this level, they are not providing quality fishery opportunities or the social, economic and ecological benefits that may result from a population with higher biomass of walleye which included older, larger fish.

Northern pike results suggest an improving pike population in Namakan Lake based on the trends in catch, size and age indicators. In spite of a decline in growth rates in 2014, there are more and larger pike in Namakan Lake due to increased survival to older age classes and pike populations are much healthier in 2014 than in 2000. Namakan Lake pike populations are currently meeting applicable management objectives identified in the 2014 Fisheries Management Plan for Fisheries Management Zone 5; in 2014 northern pike >=70 cm (27.5") made up 23% of catch (objective is to be more than 15% of catch) and pike >= 90cm made up 9% of the catch (objective is to be more than 3% of catch).

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INTRODUCTION

Namakan Lake is located approximately 70 km southeast of Fort Frances, Ontario, and forms part of the Namakan Reservoir which also includes Sand Point, Kabetogama, Crane, and Little Vermillion Lakes (Figure 1). Water levels in the reservoir are regulated by the International Joint Commission (IJC) through the International Rainy Lake Board of Control (IRLBC). Two water control dams at Kettle and Squirrel Falls regulate water levels based on a "rule curve". The first order of regulation for Rainy Lake and the Namakan Reservoir was established in 1949, and supplementary orders were issued in 1957 and 1970. Dissatisfaction with the 1970 order led to changes in the rule curve which were put in place in January 2000. The new curve, involved a decrease in the over-winter draw down by approximately 1 m (3 ft) along with earlier spring refill and a gradual summer draw down. The new rule curve was intended to improve fish stocks that spawn in both spring (e.g. walleye, *Sander vitreus;* northern pike, *Esox lucius)* and fall (e.g. lake whitefish, *Coregonus clupeaformis*). Changes to water regulation will involve a monitoring strategy to evaluate long term impacts, in which the Fall Walleye Index Netting (FWIN) program was included (IRLBC, 1999; USGS, 2000).

Namakan Lake is located on the International border, with 51% (5,150 ha) of the 10,100 ha surface area in Ontario (MDNR and OMNR, 1998). The lake is located in the southern range of the boreal forest in North America, and is typical of Canadian Shield lakes with soft water and little submerged aquatic vegetation. Characteristics of the lake are summarized in Table 1. A diverse coolwater fish community is present in the reservoir, including 43 known species (Appendix 1). The Ontario waters have been previously

Table 1: Physical and chemical characteristics of Namakan Lake, Ontario.

Parameter	Namakan Lake
Surface Area (ha)	5,150
Littoral Zone (%)	20
Mean Depth (m)	13.6
Maximum Depth (m)	45.7
Mean Summer Secchi Depth (m)	2.6
Greatest Length (km)	31
Perimeter Shoreline (km)	235
Island Shoreline (km)	75
T.D.S. (mg/L)	44
M.E.I.	2.8
Alkalinity (mg/l)	14

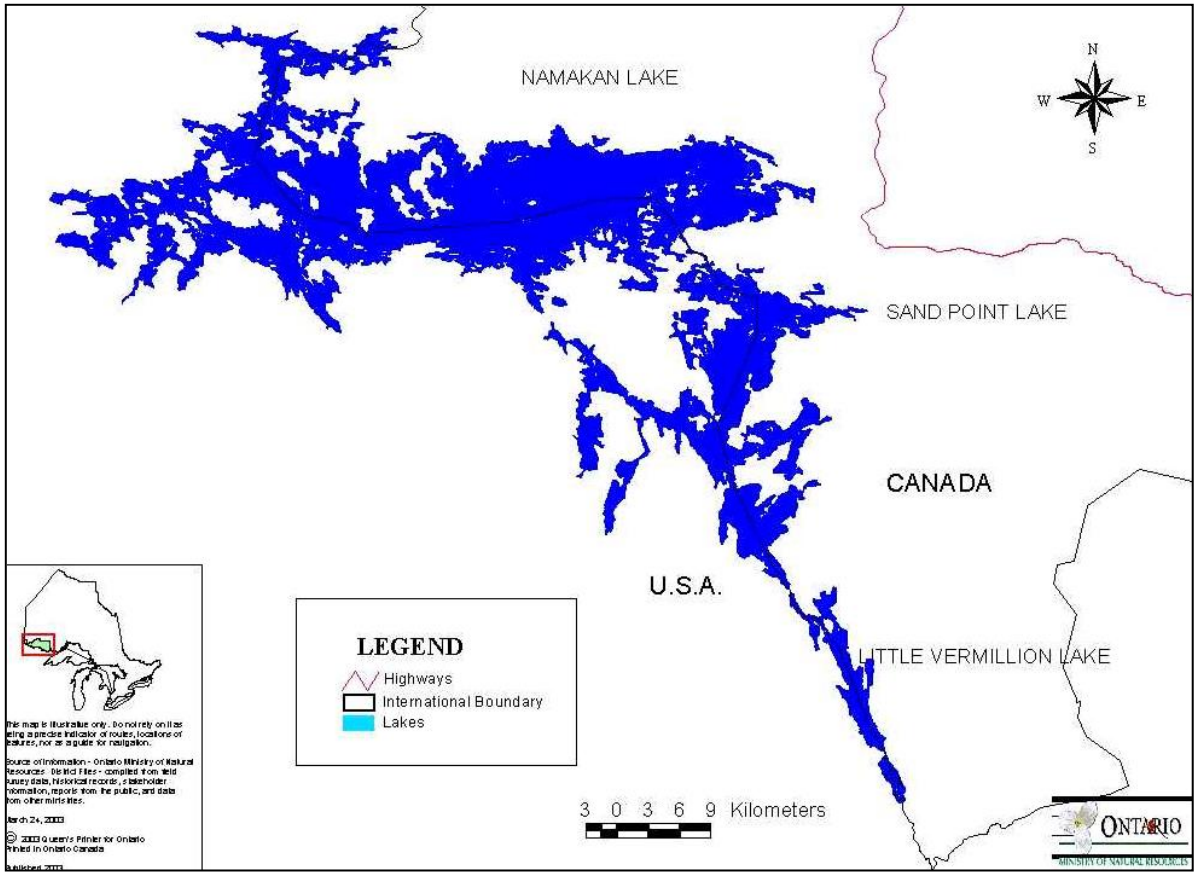

Figure 1: Location of the Namakan Reservoir; including Namakan, Sand Point, and Little Vermilion Lakes in Ontario.

assessed in 1994, however provincial FWIN standards were not utilized (Van den Broeck, 1995).

Development on the Ontario shoreline of Namakan Lake consists of a single recreational cottage site and a number of cottages on 37 patent properties. A Canada Customs/Immigration point of entry, a tourist lodge, a store, a boy scout camp and approximately 38 cottages are also located on the adjoining waters of Sand Point Lake, Ontario. Voyageurs National Park borders the Reservoir on the Minnesota side, where development is limited to 20 cabins and 35 campsites. There is an old logging camp on Namakan Lake and three privately developed tracts, in addition to 21 use and occupancy tracts and 7 campsites on Sand Point Lake (MDNR and OMNR, 1998).

Commercial fishing on Namakan Lake began in 1916-17, however the commercial walleye and northern pike fishery was eliminated in Minnesota waters in 1946. Currently, a single lake whitefish operator exists on the Minnesota side. Quotas existed in Ontario for lake whitefish, lake sturgeon (*Acipenser fulvescens)*, black crappie, walleye and northern pike from 1984 until the commercial fishery was eliminated in 2001.

Creel surveys indicated that the vast majority (99%) of fishing pressure was from non-resident anglers (Elder, 2001; Jackson, 1994). Nearly two-thirds (65%) of anglers on Namakan Lake were based out of Minnesota in 1998, with the remainder camping on Crown Land in Ontario (3%), guests at Ontario resorts (21%), or owners of cottages in Ontario (11%).

The majority of angler effort observed on Namakan Lake in 1998 was directed at walleye (85 %), with lesser effort directed at smallmouth bass (*Micropterus dolomieu*) (38 %) and northern pike (27 %). Overall, angling pressure on Ontario waters was 3.6 hours/ha (18,780 rod-hours) in 1998 (Elder, 2001). The lack of resident anglers has been attributed to the low quality of the walleye fishery relative to a number of more accessible lakes in the Fort Frances District. Angler catch rates were also low, averaging only 0.49 fish

caught/angler-hour with very few fish captured over 46 cm. Release rates were estimated at 47% in 1998.

Historically, walleye populations on Namakan Lake have fallen below desired levels, and have shown signs of over-exploitation stress since the early 1990s (MDNR and OMNR, 1998). Walleye abundance and fishing quality indicators appeared to be low, while angler exploitation was reported to be high.

Attempts to rehabilitate the Namakan Lake walleye fishery have included commercial fish buy-outs and angling regulation changes in both Ontario and Minnesota. In order to allow the walleye population to fully recover, the recommended target harvest level for Ontario waters was reduced to 3,500 kg/yr (0.70 kg/ha/yr), or 85% of the annual potential yield in 2004 (OMNR and MDNR, 2004). Previous target levels for Ontario were as high as 5,800 kg/yr (1.13 kg/ha/yr) (MDNR and OMNR, 1998). The potential yield of walleye is estimated at 4,100 kg/yr (0.80 kg/ha/yr), while annual harvests averaged only 2,900 kg/yr (0.56 kg/ha/yr) from 1997-2002, compared to previous levels of 5,200 kg/yr (1.0 kg/ha/yr) from 1990-1996. Since the closure of the commercial fishery in 2002, the only harvest from Ontario waters is from the angling fishery and is estimated at 1,150 kg/yr (0.22 kg/ha/yr).

In 1994, non-resident anglers were restricted to catch and release angling only for all species, unless staying overnight at an Ontario tourist establishment, houseboat, recreational fishing site, parcel of land or provincial park as described in the regulations. Pending a NAFTA trade challenge by the U.S., more general regulations were put in place across the border waters area in 2000 to limit harvest by all non-resident anglers. The daily catch limit for non-resident anglers of two walleye or sauger *(S. canadensis)* per day, with a possession limit of four (two for conservation licenses) was introduced. Walleye harvest had also been regulated since 1989 by a maximum size limit, whereby only one walleye greater than 50 cm (19.5”). This maximum size limit was changed in 1999 to one greater than 46 cm (18.1”), in conjunction with a number of fisheries regulation changes for the Northwest Region.

The recommended target harvest level for northern pike from Ontario waters was 2,700 kg/yr (0.52 kg/ha/yr), or 85% of the annual potential yield in 2004 to help population recovery and improve angling quality (OMNR and MDNR, 2004).). The potential yield of northern pike is estimated at 3,200 kg/yr (0.62 kg/ha/yr), while annual harvests averaged only 900 kg/yr (0.17 kg/ha/yr) from 1997-2002, a small portion of which was commercial harvest (100 kg/yr). After closure of the commercial fishery in 2002, total harvest from Ontario waters is estimated to be 600 kg/yr (0.11 kg/ha/yr).

Northern pike daily and possession limits were reduced in 1999 from six (three for conservation licences) to four (two for conservation licences) and the size limit was changed from only one greater than 70cm (27.5") to no fish between 70 cm to 90 cm (35") and only 1 over 90. In 2015, the size limit was changed to allowing zero fish larger than 75 cm (29.5").

In order to obtain more detailed biological information and to evaluate management strategies for Namakan Lake, Fall Walleye Index Netting (FWIN) was conducted in 2000, 2005 and 2014 consistent with the proposed fisheries assessment strategy (McLeod, 2002). Also, one additional FWIN survey was completed in Ontario waters in 2004 by Voyageur's National Park and USGS staff. In addition to providing information on the status of fish populations, the FWIN program also provides data for the evaluation and monitoring of water level changes initiated by the IRLBC (IRLBC, 1999; USGS, 2000) and contributes to long-term monitoring efforts of the Ontario-Minnesota Fisheries Committee (MDNR and OMNR, 1998).

METHODS

Standard FWIN gillnetting was conducted on Namakan Lake in early September following the Manual of Instructions: Fall Walleye Index Netting Surveys (Morgan, 2002). Gear consisted of standard OMNR FWIN gillnets constructed of clear monofilament, and made up of eight 7.6m panels with stretched mesh sizes of 25mm, 38mm, 51mm, 64mm, 76mm, 102mm, 127mm, and 152mm (made by *Les Industries Fipec Inc*., Quebec, catalog #FEX-03). Nets were set as close to perpendicular (90^{o}) from shore as each net site would allow.

Twenty-four (twenty five in 2000) net sites were randomly selected with minor adjustments to selected sites to meet the depth stratification requirements. Sampling intensity in each strata (shallow = 2-5 m, deep = 5-15 m) was determined by the relative amount of shallow versus deep areas of the lake with 40 % (10/24) of nets were in the shallow strata, and 60% (14/24) in the deep strata. Surface water temperatures were much warmer than the FWIN protocol (i.e. 10-15^{o}C) every year and surface averages ranged from 17.4 to 19.9°C (Table 1). The timing of the surveys was adjusted to coincide with previous index netting efforts on the Namakan Reservoir and on the South Arm of Rainy Lake by the MDNR, VNP and OMNR. Thermal stratification was present each year with the thermocline estimated to start just below 15m.

Table 1. Dates and conditions for. FWIN surveys conducted on Namakan Lake between 2000 and 2014.

	2000	2004	2005	2014
Survey dates	Sept. 6-14	Sept. 7-17	Sept. 8-15	Sept. 8-19
Average surface temperature (^{o}C)	17.4		19.9	17.8
Number of sets	25	24	24	24
Total fish mean cue (#/net)	23.0	58.0	25.0	23.7
Total fish mean cue (kg/net)	12.8	14.5	10.9	11.4
Total fish (***without perch***) mean cue (#/net)	19.8	23.5	21.8	19.5
Total fish (***without perch***) mean cue (kg/net)	12.4	14.0	10.8	11.2

All walleye, northern pike, smallmouth bass and lake sturgeon were measured for fork and total length and weighed. These species were also biologically sampled for sex and maturity by comparing gonad development (Duffy et al. 1999) (excluding sturgeon), and aging structures were taken (otiliths for walleye >30 cm; scales for walleye <30 cm; cleithra and scales for pike; 4th dorsal spine and scales for smallmouth bass; and large pectoral fin ray for sturgeon). All lake sturgeon were live released and not sampled for sex and maturity. All aging structures were assessed by the OMNR Northwest Regional Aging Facility in Dryden, Ontario. All other fish species were measured for length and weighed, but no aging structures were taken. Data were compiled and analyzed using FISHNET2 (Lester and Korver, 1996).

RESULTS

A total of 16 species were captured in during the surveys of Namakan Lake (Table 2). Walleye were generally the most abundant species in the FWIN catch representing between 21 - 45% of the annual catch by number (Table 2). In 2004, yellow perch (*Perca flavescens*) were the most abundant species at 34 fish/net and 59 % of the total catch although in all other years, average catch ranged from 3.2 – 4.2 fish/net (13-18% of fish caught). Rock bass (*Ambloplites rupestris*) averaged 1.4 - 4.0 fish/net and represented 10-16 % of the total number of fish caught except in 2004 when they only accounted for 2%. Northern pike catches ranged from 1.2 - 1.8 fish/net and 3 - 8% of the catch.

With the exception of 2004, when a very high catch of yellow perch accounted for more than half the fish caught, total catch of fish has remained consistent. Excluding perch, total fish catch has averaged between 19.5 and 23.5 fish/net (10.8 – 14.0 kg/net) with the highest catch occurring in 2004 (Table 1).

Table 2: Summary of catch data from Fall Walleye Index Netting (FWIN) in Namakan Lake 2000-2014.

Species	CUE Arithmetic				% of catch			
	2000	**2004**	**2005**	**2014**	**2000**	**2004**	**2005**	**2014**
Walleye	7.6	11.9	11.3	**8.8**	33%	21%	45%	37%
Northern Pike	1.2	1.6	1.3	**1.8**	5%	3%	5%	8%
Smallmouth Bass	1.5	1.2	0.9	**0.8**	6%	2%	4%	3%
Lake Whitefish	0.0	0.8	0.2	**0.4**	0%	1%	1%	2%
Cisco (Lake Herring)	0.4	1.9	0.1	**1.0**	2%	3%	0%	4%
White Sucker	1.3	1.8	1.3	**1.6**	6%	3%	5%	7%
Shorthead Redhorse Sucker	0.0	0.0	0.1	**0.2**	0%	0%	1%	1%
Silver Redhorse Sucker	1.2	0.4	0.3	**0.4**	5%	1%	1%	2%
Sauger	1.8	2.2	2.1	**2.0**	8%	4%	9%	8%
Yellow Perch	3.2	34.4	3.2	**4.2**	14%	59%	13%	18%
Rock Bass	3.0	1.4	4.0	**2.3**	13%	2%	16%	10%
Pumpkinseed	0.0	0.0	0.0	**0.1**	0%	0%	0%	1%
Black Crappie	0.3	0.1	0.1	**0.0**	1%	0%	1%	0%
Mooneye	0.2	0.1	0.1	**0.0**	1%	0%	0%	0%
Bullhead	0.9	0.1	0.0	**0.0**	4%	0%	0%	0%
Lake Sturgeon	0.3	0.0	0.1	**0.0**	1%	0%	1%	0%
Total	***23.0***	***58.0***	***25.0***	**23.7**				

WALLEYE

The FWIN catch per unit effort (CUE) of walleye increased from an arithmetic mean of 7.6 walleye/net in 2000, to 12.0 and 11.3 walleye/net in 2004/2005 and then declined to 8.8 by 2014 (Figure 2). None of these changes were statistically significant at $p<0.05$. Relative standard errors for walleye CUE ranged from 13% to 21% for the four surveys.

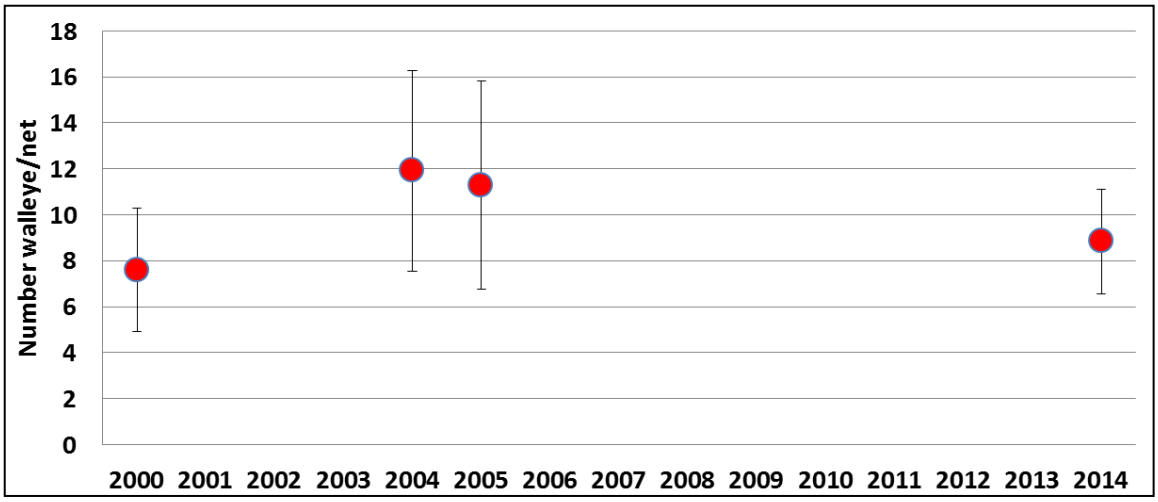

Figure 2. Average number of walleye caught/net for FWIN surveys of the Ontario waters of Namakan Lake between 2000 and 2014 (error bars indicate +/- 95% C.I.)

Changes in walleye catch by weight reflected changes in the number with the average adult biomass (estimated by the average weight of walleye larger than 35cm) increasing between 2000 and 2004 but then declining to previous levels by 2014. (Figure 3).

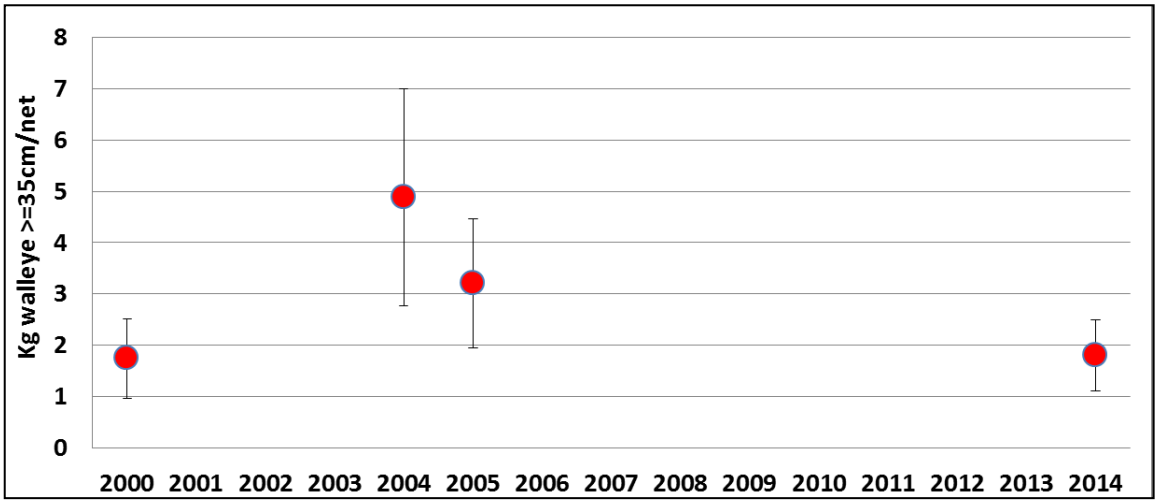

Figure 3. Average kg of walleye larger than 35cm TL caught/net for FWIN surveys of the Ontario waters of Namakan Lake between 2000 and 2014. (error bars indicate +/- 95% C.I.)

Comparisons with regional data sets have typically been done using geometric means (Morgan et al. 2002). The geometric mean CUE for all walleye ranged from 5.4 to 7.8 walleye/net from Namakan which was below the regional median value of 9.8

walleye/net but within the 25th-75th quartile range of 5.1 - 15.5 walleye/net. For walleye less than 30 cm, the geometric mean catch was below the regional 25th-75th quartile range in 2000 and 2004 but within the range in 2005 and 2014 (Figure 4). However, for larger walleye (total length >= 45cm), the geometric mean catch was well below the regional quartile for all years (Figure 5). There was an increase in catch of large walleye between 2000 and 2004 but by 2014, it had declined back to 2000 levels.

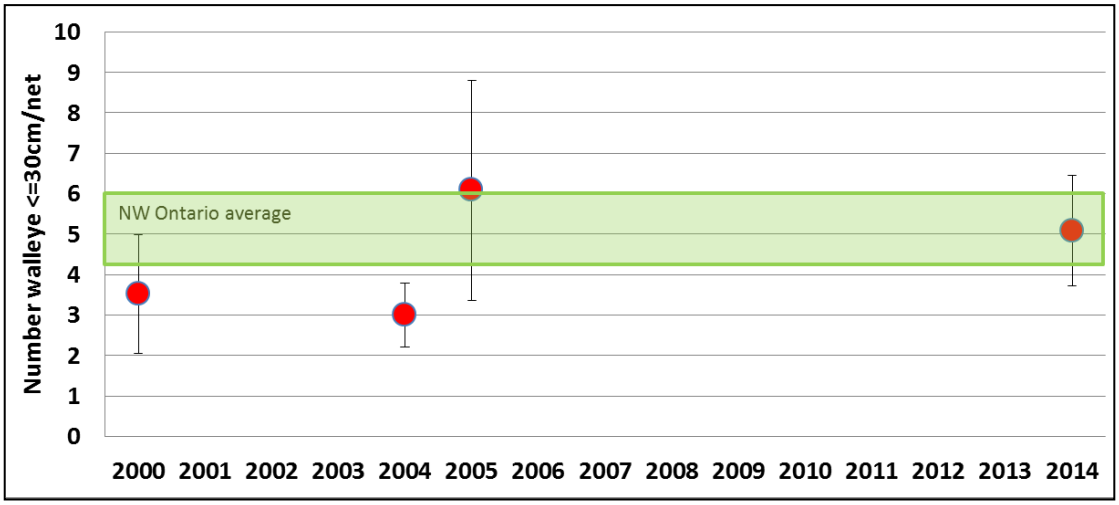

Figure 4. Geometric mean number of walleye smaller than 30cm TL caught/net during FWIN surveys of the Ontario waters of Namakan Lake between 2000 and 2014. (error bars indicate +/- 95% C.I.). Green box indicates northwest Ontario 25th-75th quartile range for comparison.

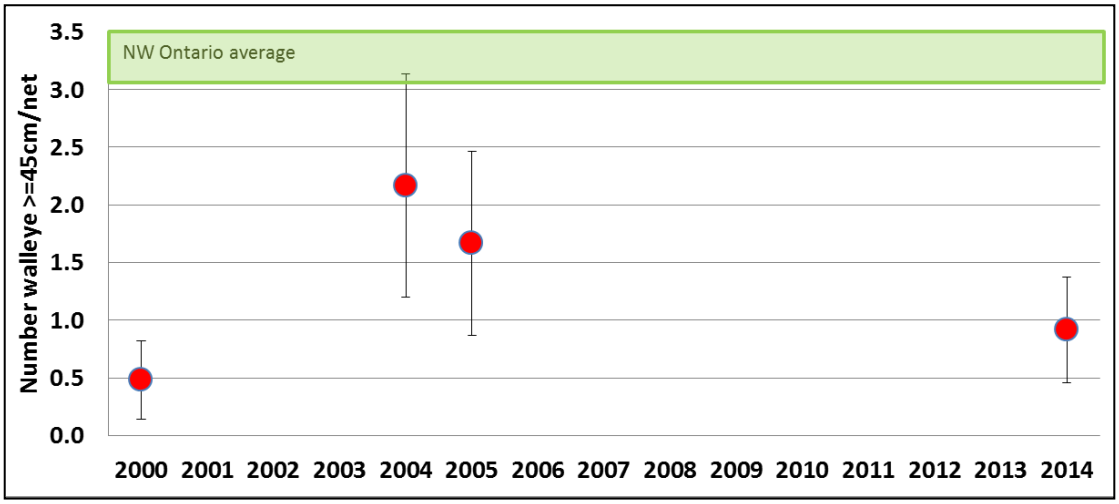

Figure 5. Geometric mean number of walleye larger than 45cm TL caught/net during FWIN surveys of the Ontario waters of Namakan Lake between 2000 and 2014. (error bars indicate +/- 95% C.I.). Green box indicates northwest Ontario 25th-75th quartile range for comparison.

Table 3: Summary of walleye biological data from Fall Walleye Index Netting (FWIN) in Namakan Lake 2000-2014.

	2000	2004	2005	2014
n	190	287	271	212
mean TL (cm)	31.8	35.6	31.2	30.0
Fish Quality Index	25	41	29	21
Mean weight	354	508	375	298
Mean age	3.4	4.5	3.7	3.8
# age classes	10	11	12	14
# age classes>10 years	1	1	2	3

The size distribution of walleye caught from Namakan was generally dominated by smaller fish with walleye less than 30cm making up about 50% of the catch (except for 2004) and those greater than 45cm making up approximately 10% of the catch (Figure 6, Figure 7). The 2014 Fisheries Management Plan for Fisheries Management Zone 5 which includes Namakan Lake indicate that walleye >=45 cm (18") should make up more than 25% of the catch to meet walleye management objectives to protect and maintain spawning stock. Surveys between 2000 and 2014 indicate that Namakan Lake walleye population did not meet that objective in any year.

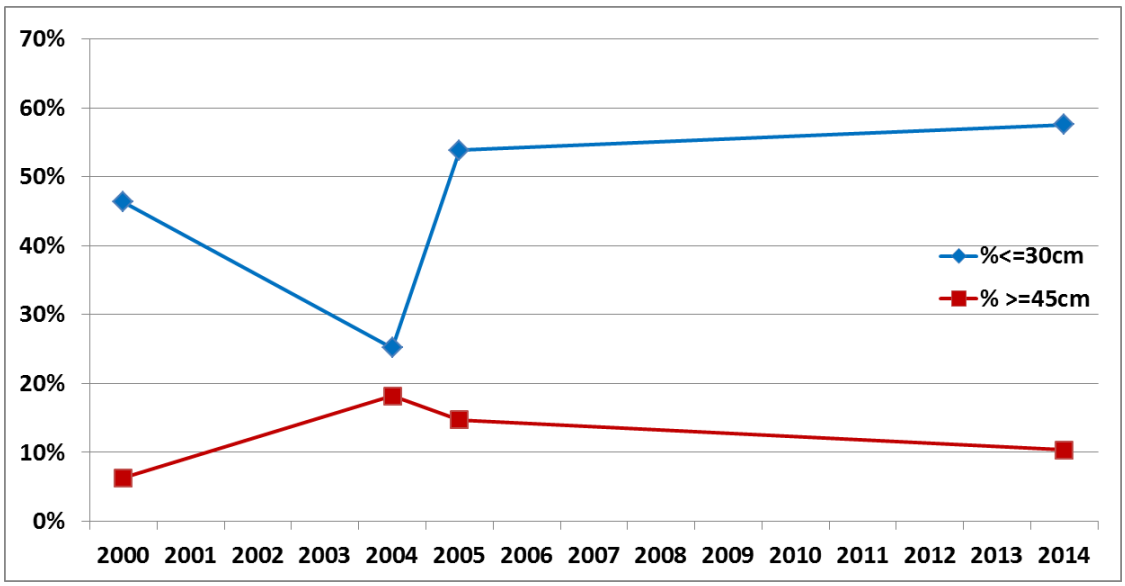

Figure 6. Proportion of walleye sampled which were smaller than 30cm and larger than 45 cm during FWIN surveys of the Ontario waters of Namakan Lake between 2000 and 2014.

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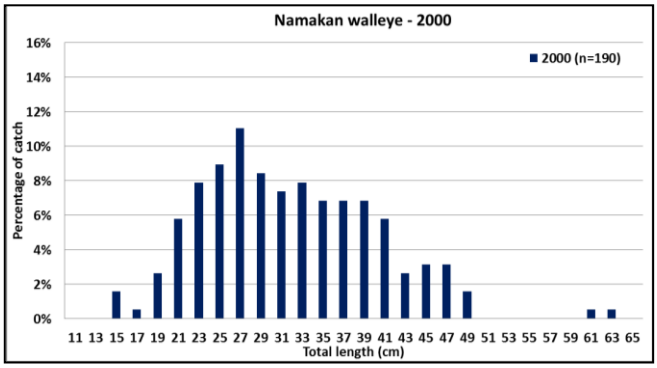

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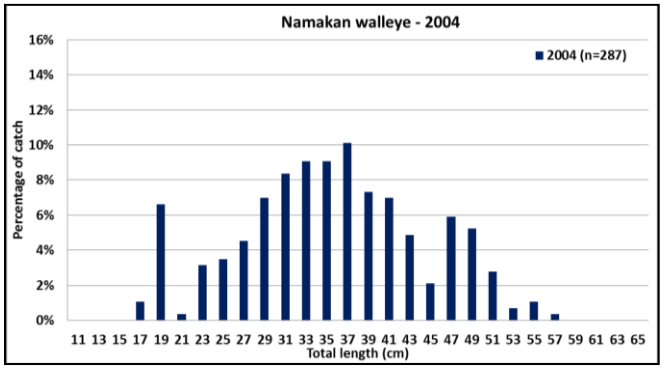

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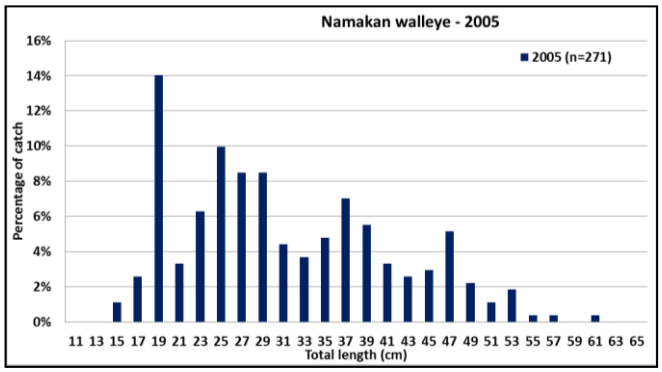

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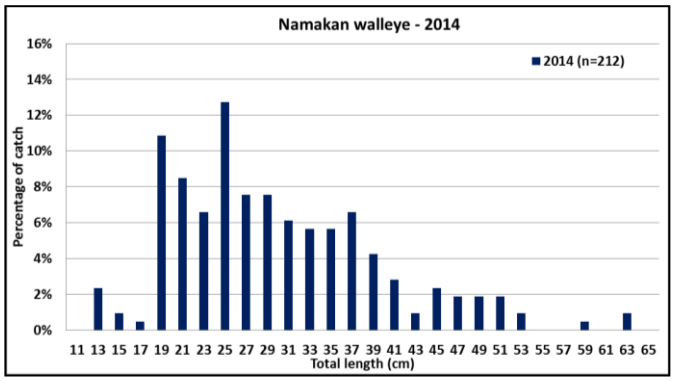

Figure 7. Length distribution of walleye sampled during FWIN surveys of the Ontario waters of Namakan Lake between 2000 and 2014.

Age distribution reflected the size distribution with the walleye population being dominated by younger fish for most years surveyed between 2000 and 2014. With the exception of 2004, walleye age 4 or less made up 75% or more of the fish caught (Figure 8). The percentage of walleye age 8 and older was very low in 2000 at only 3% but had increased to 13% in 2014.

Age distribution show the variability in year class and the low representation of ages older than 8 in the population (Figure 9). Generally, 1996, 1998, 2001, 2003, 2004, 2006 and 2011 appeared to be above average year classes.

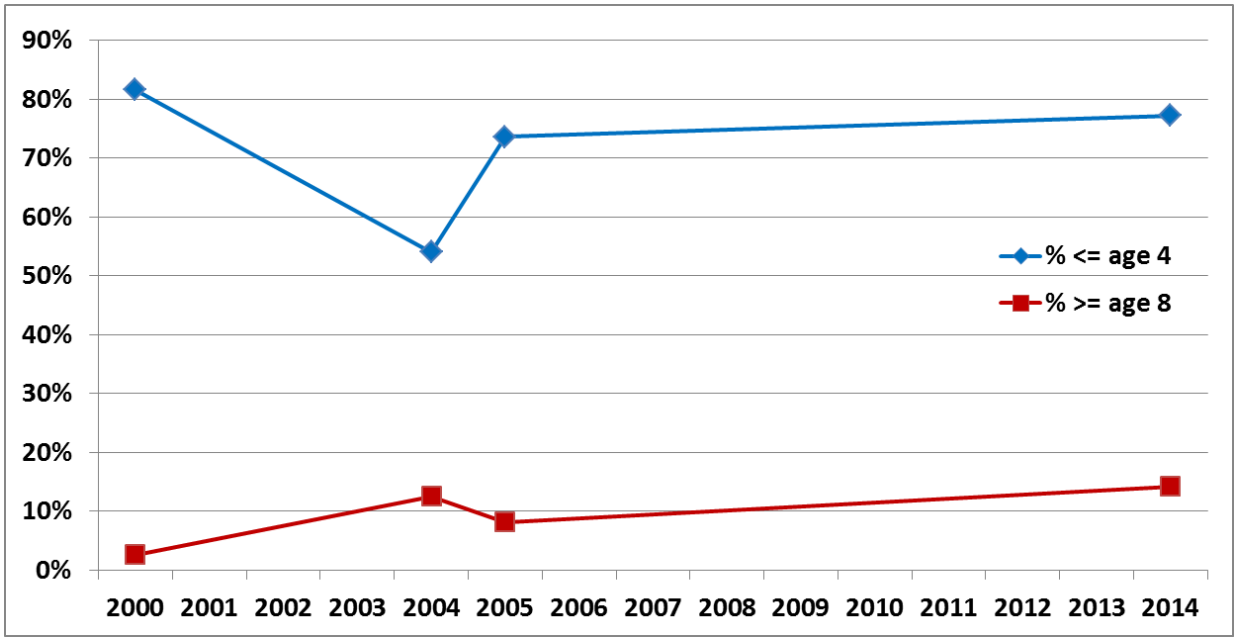

Figure 8. Proportion of walleye sampled which were age 4 and younger and age 5 and older during FWIN surveys of the Ontario waters of Namakan Lake between 2000 and 2014.

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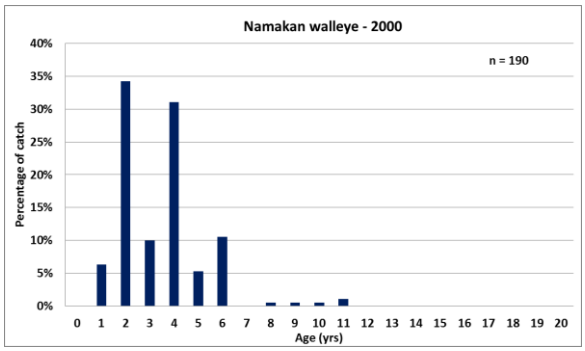

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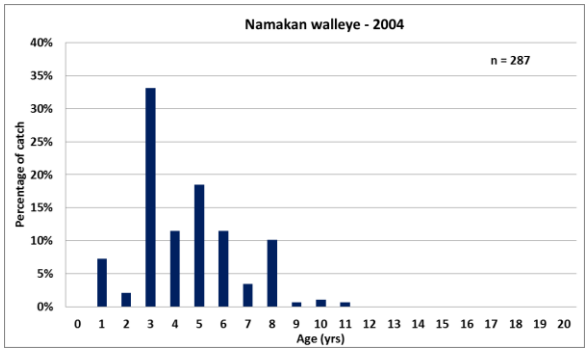

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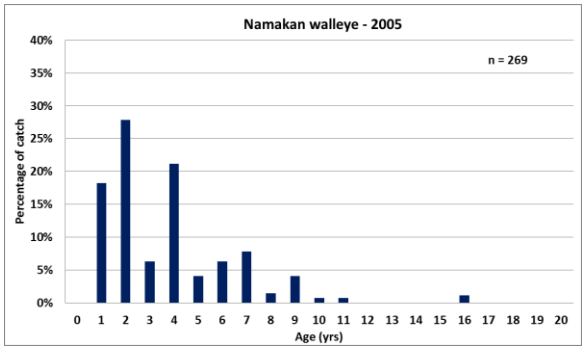

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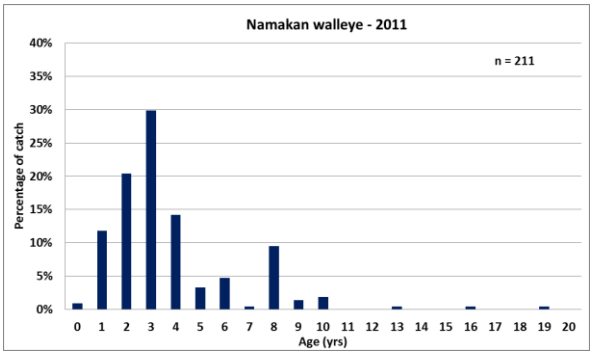
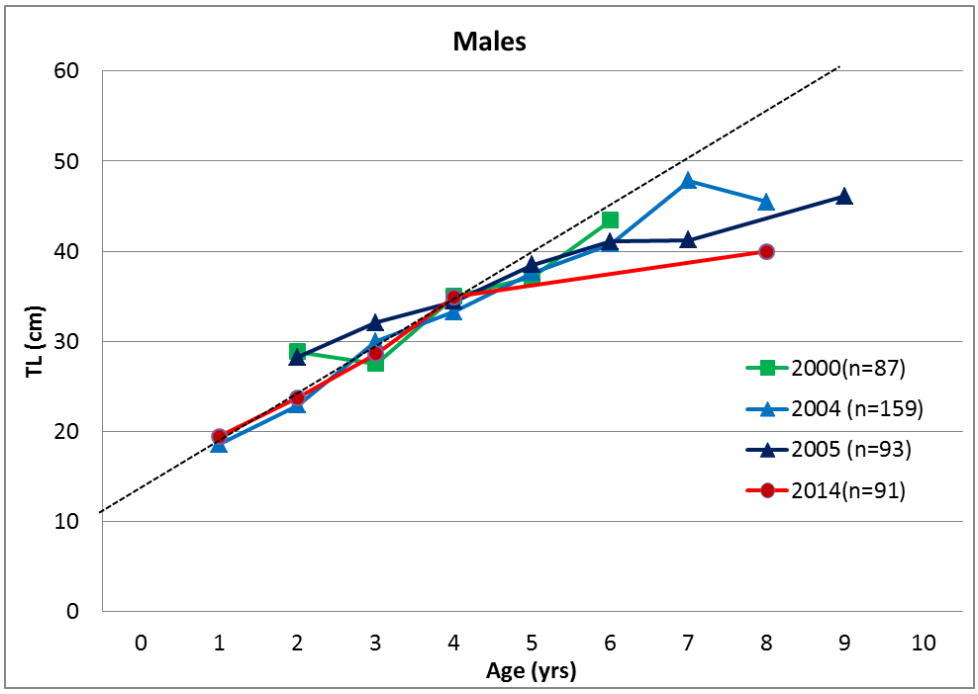


Figure 9. Age distribution of walleye sampled during FWIN surveys of the Ontario waters of Namakan Lake between 2000 and 2014.

The biphasic growth model (Lester et al. 2004) suggests that before maturity, growth should be linear and similar for both sexes with growth rates slowing after maturity when fish begin to put more energy into gonad development. Observed length at age for Namakan walleye support this model with similar growth rates for both sexes up to age four (35cm) of approximately 70 mm/year (Figure 10). For males, growth begins to slow by age 5 suggesting that maturity occurs around 35 cm and maximum observed size was less than 50cm (Figure 10a). For females, growth slowed around age 6-7 (40-45cm) (Figure 10b) and maximum size observed of a female was 63cm. There was little apparent change in length at age for walleye between 2000 and 2014.

Size at maturity for Namakan suggests that males walleye begin maturing around 33 cm and most are mature by 37 cm with a 50% maturity occurring around 35 cm (Figure 11a). Females mature later with 50% maturity occurring around 41 to 43 cm and most females mature by 45 cm (Figure 11b). There was no apparent trend of size at maturity changing between 2000 and 2014.

a)



b)

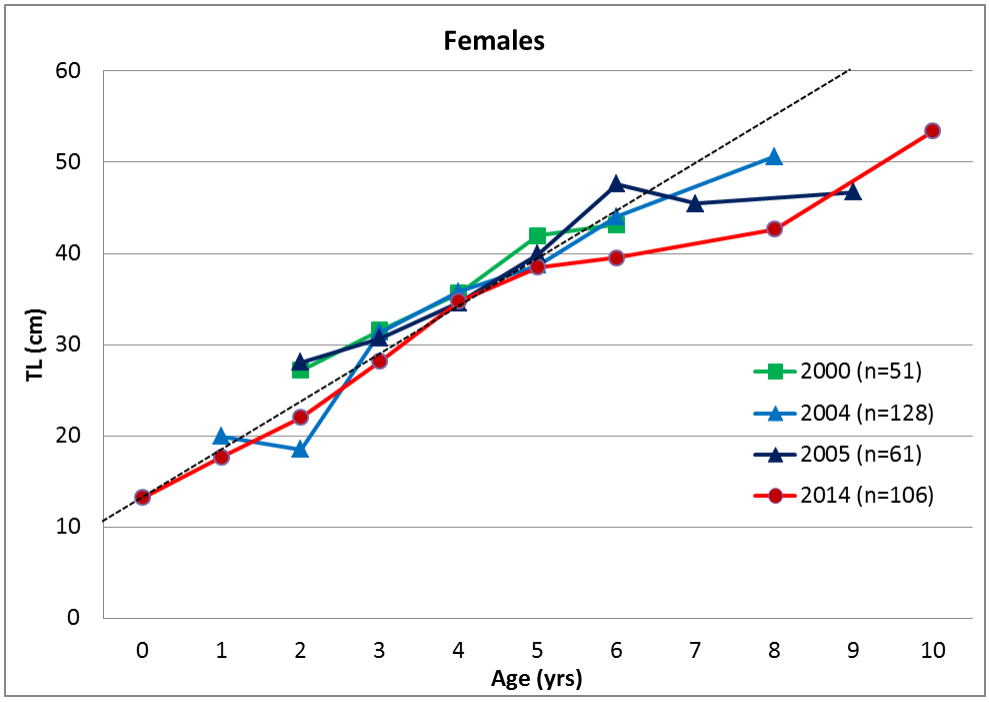
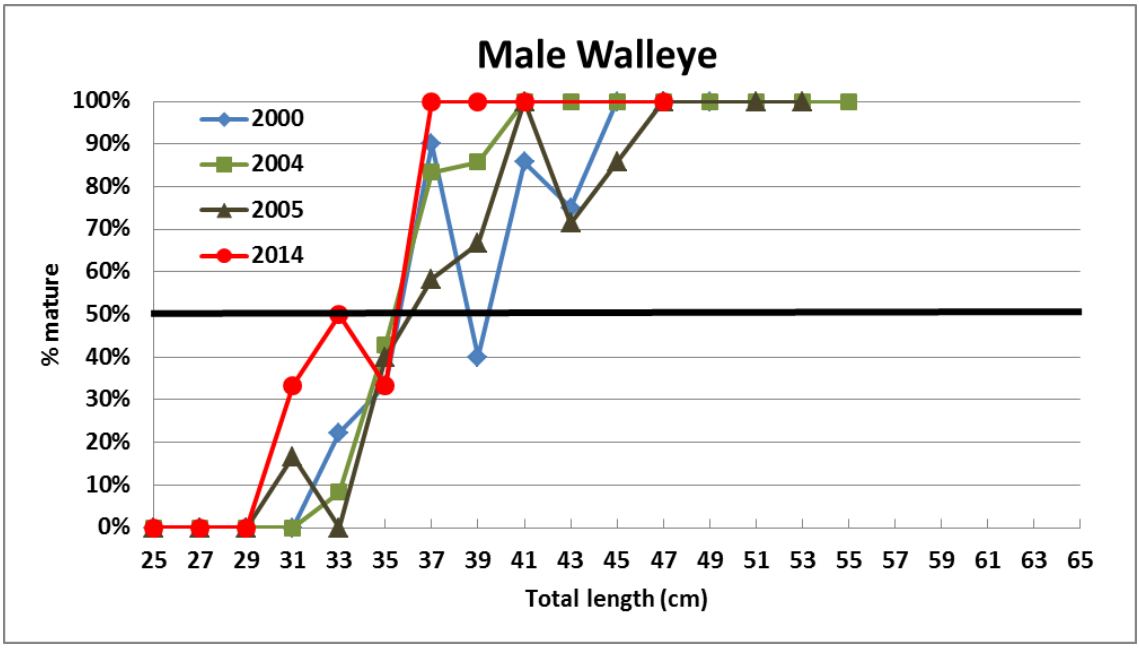


Figure 10. Observed length at age for a) male and b) female walleye sampled during FWIN surveys of the Ontario waters of Namakan Lake between 2000 and 2014.

a)



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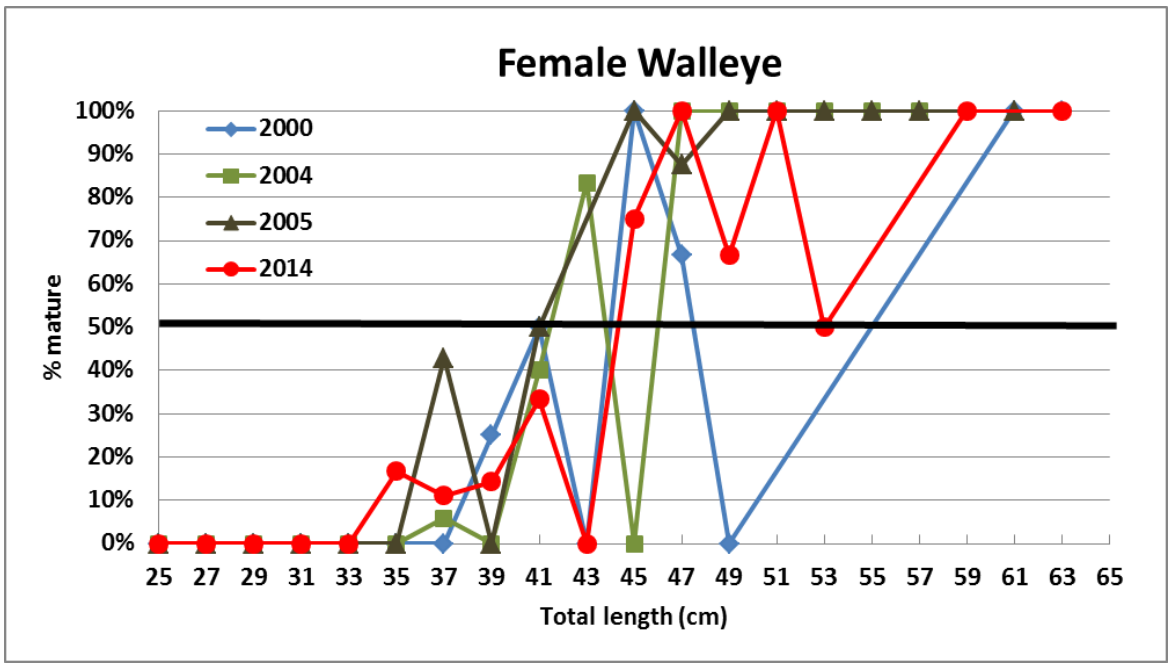


Figure 11. Maturity by length for a) male and b) female walleye sampled during FWIN surveys of the Ontario waters of Namakan Lake between 2000 and 2014.

Population status was assessed by comparing the biomass and mortality of walleye estimated from the FWIN surveys to biological reference points calculated for Namakan Lake. The biomass of walleye in the lake, or observed biomass, is estimated from the weight of walleye larger than 35 cm caught in netting surveys and is compared to the biomass of walleye expected in an unfished population, or maximum biomass, which is estimated from the physical and chemical characteristics of the waterbody including lake area, depth, water clarity and temperature (Lester et al. 2004). Maximum sustainable yield is expected when the observed biomass is half the maximum biomass. The biomass indicator is reported as a percentage of the biomass of an unfished population; percentages greater than 50 indicate maximum sustainable yields are likely not exceeded. Estimated biomass which are less than 25% of maximum biomass suggest that the fishery is at a high risk of being unsustainable, particularly if mortality estimates are also high (Hilborn 2010).

The mortality indicator compares observed total mortality (death rate due to fishing and natural causes) to estimated values of natural mortality only (Lester et al. 2014). Total instantaneous mortality (Z) is determined from the age distribution of walleye caught in netting surveys while natural mortality (M) is estimated from known relationships between climate, fish survival and maturity. It is suggested that maximum sustainable yield is achieved when total mortality approaches twice that of natural mortality (Lester et al. 2014, Zhou et al. 2012). This however assumes that that initial harvest of walleye is close to size at maturity and that as initial size of harvest decreases, safe limits of mortality also decrease. The current standard practice in Ontario is to estimate the total instantaneous mortality for walleye older than age at 35 cm because that is typically the minimum size when walleye are fully vulnerable to angling. However, in Namakan Lake, past surveys have found the majority of walleye harvested are smaller than 35 cm and significant harvest of walleye begins at approximately 30 cm (Figure 12). Because of this, mortality estimates have been calculated for walleye older than age at 30 cm for Namakan Lake walleye and the

upper safe limit has been set at 1.75 times natural mortality (or natural mortality + 0.75 x natural mortality). The mortality indicator is reported as the ratio of total mortality to natural mortality; values less than 1.75 represent safe rates of total mortality and low risk of overexploiting the fish stock.
Comparison of these two indicators is a valuable method of assessing the status of fisheries. Ideally, populations are maintained with biomass above 50% of the maximum biomass and mortality is less than 1.75 times the natural mortality estimate. FWIN surveys of Namakan walleye between 2000 and 2014 suggest this condition has rarely occurred.

Population assessments in both 2000 and 2014 indicate that walleye biomass is depressed with both years below biomass at MSY at about 25% of maximum biomass and mortality estimates were above twice the natural mortality estimate and exceeding the safe levels (Figure 13). The impact of the strong 1998, 2001 and 2003 year classes were evident in the higher biomass estimates in 2004 and then the lower mortality estimate of 2005. However, by 2014, biomass estimates were very similar to that observed in 2000 although the increase in older fish (see Figure 8) was reflected in lower mortality rates.

The walleye objectives in 2014 Fisheries Management Plan for Fisheries Management Zone 5, which includes Namakan Lake, indicates that lakes with populations less than 25% of unfished biomass are considered stressed. Based on the 2014 assessment, the walleye population in Namakan Lake is on the edge of being classed as stressed. The mortality estimate also suggests it is being harvested above the upper limit of safe levels.

It would appear that, although harvest levels in Ontario waters of Namakan have declined over the past three decades with changes in non-resident angling regulations and removal of the commercial fishery, overall harvest of walleye in Namakan remains high enough to result in negative impacts to the amount of walleye and the size and age structure of the population resulting in a moderate abundance of small sized walleye in the lake. While current populations may be sustainable at this level, they are not providing quality fishery

opportunities or the social, economic and ecological benefits that may result from a population with higher biomass which includes older, larger fish.

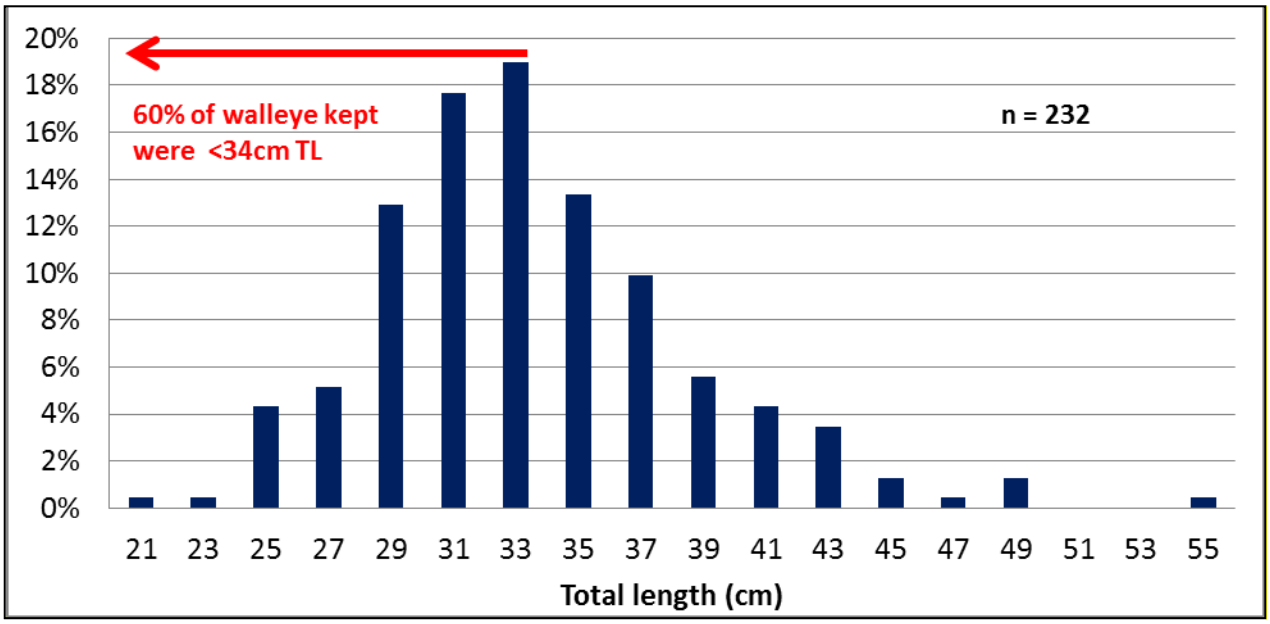


Figure 12. Size distribution of walleye harvested by anglers from Namakan Lake – 1998.

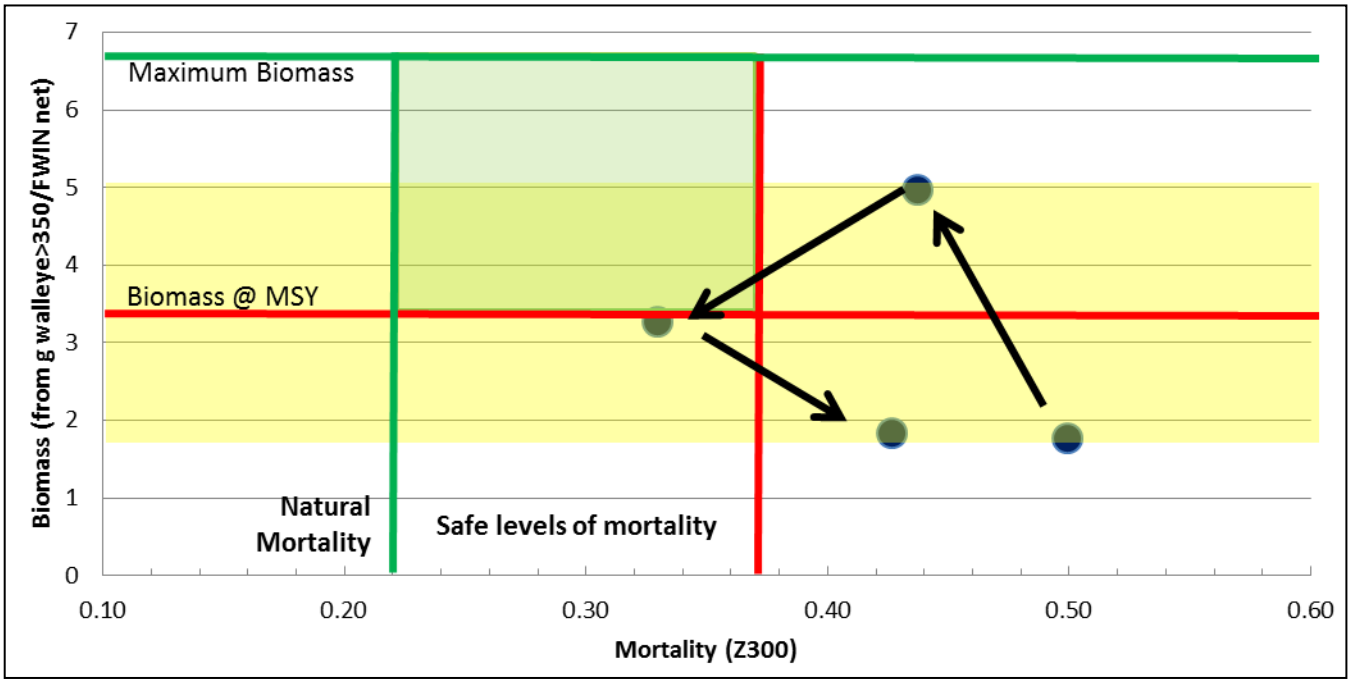


Figure 13. Biomass and mortality indicators for walleye based on FWIN surveys of the Ontario waters of Namakan Lake for 2000, 2004, 2005 and 2014 compared to biological reference points for the lake. The black arrows indicate the progression from the 2000 to the 2014 survey.

NORTHERN PIKE

Table 4: Summary of northern pike biological data from Fall Walleye Index Netting (FWIN) in Namakan Lake 2000-2014.

	2000	2004	2005	2014
n	31	39	31	44
mean TL	60.3	63.9	64.8	61.2
Fish Quality Index	87	108	121	102
Mean weight	1445	1961	1891	1743
Mean age	2.9	3.4	4	5.1
# age classes	5	8	8	12

The general trend has been for a slight increase in pike catches in Namakan although none of the trends are statistically significant. Overall catches increased from an average catch of 1.2 pike/net in 2000 to 1.8 pike/net in 2014 (Figure 14). Both the weight of pike/net (Figure 15) and the number of large pike (>=70 cm) (Figure 16) showed a similar increase.

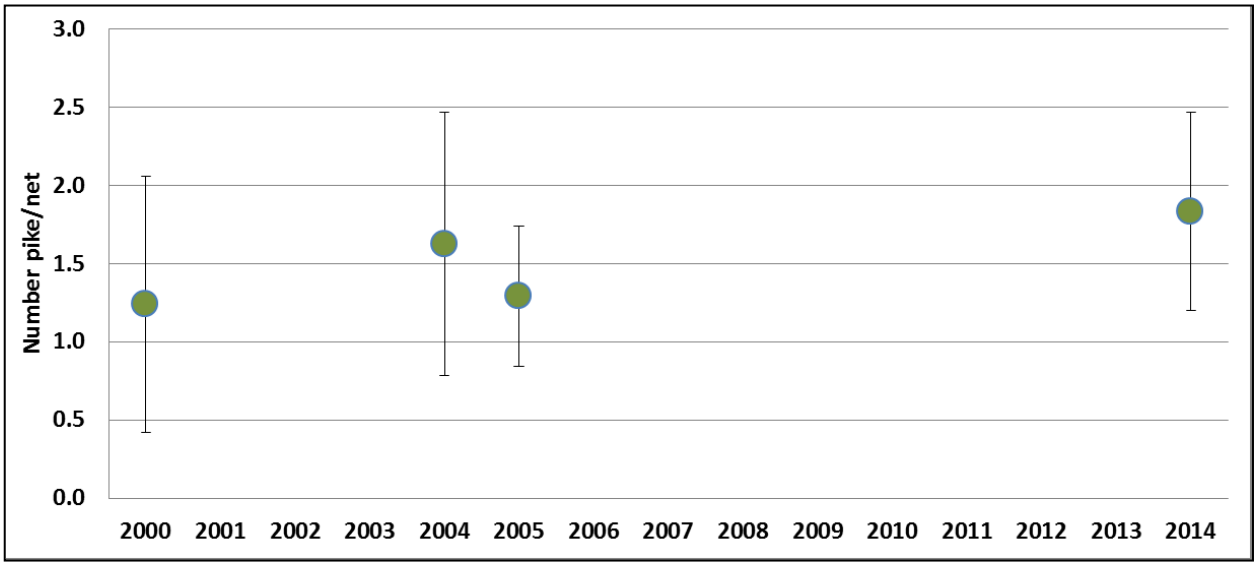


Figure 14. Average number of northern pike caught/net for FWIN surveys of the Ontario waters of Namakan Lake between 2000 and 2014 (error bars indicate +/- 95% C.I.)

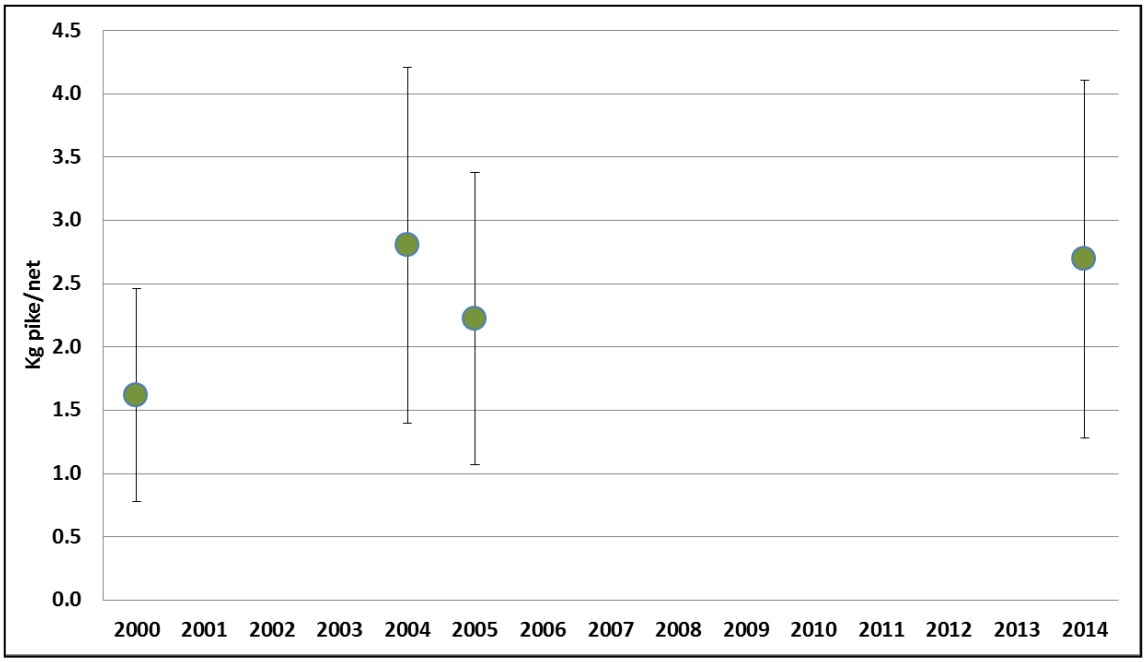


Figure 15. Average weight of northern pike larger than 55cm caught/net for FWIN surveys of the Ontario waters of Namakan Lake between 2000 and 2014 (error bars indicate +/- 95% C.I.)

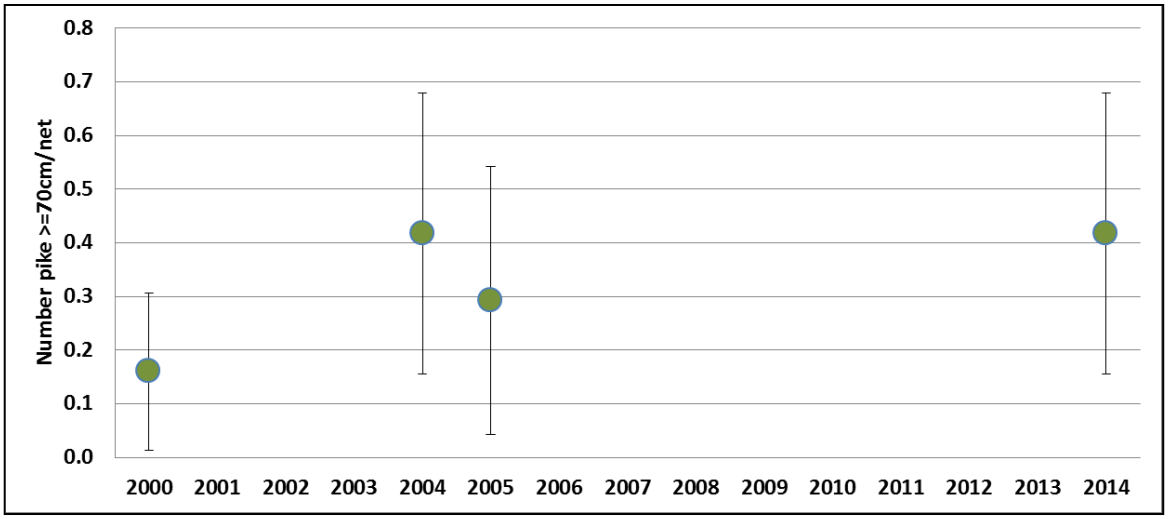


Figure 16. Average number of northern pike larger than 70 cm caught/net for FWIN surveys of the Ontario waters of Namakan Lake between 2000 and 2014 (error bars indicate +/- 95% C.I.)

There has been an increase in the proportion of larger pike in the catch since 2000 as well with the proportion of pike large than both 70 cm and 90 cm being higher in 2014 than in 2000 (Figure 17). Size distribution of pike catches indicate very few pike larger than 70 cm in 2000 but by 2004 there was a noticeable increase in larger fish that remained in 2005 and 2014 surveys (Figure 18). The 2014 size distribution shows a much wider range of fish caught relative to the 2000 sample.

The 2014 Fisheries Management Plan for Fisheries Management Zone 5 which includes Namakan Lake indicate that northern pike >=70 cm (27.5") should make up more than 15% of the catch to meet pike management objectives to protect and maintain spawning stock and pike >= 90cm (35") should be more than 3% to meet trophy angling objectives. Surveys between 2000 and 2014 indicate that Namakan Lake pike population has been meeting both objectives since 2004.

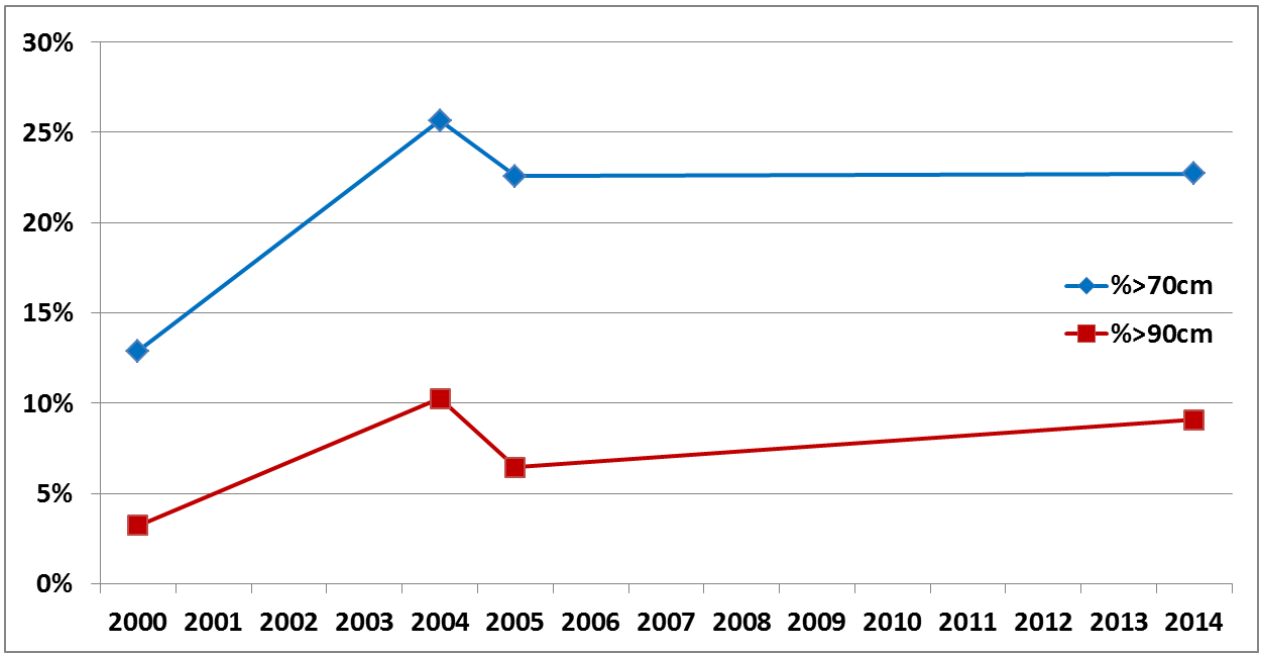
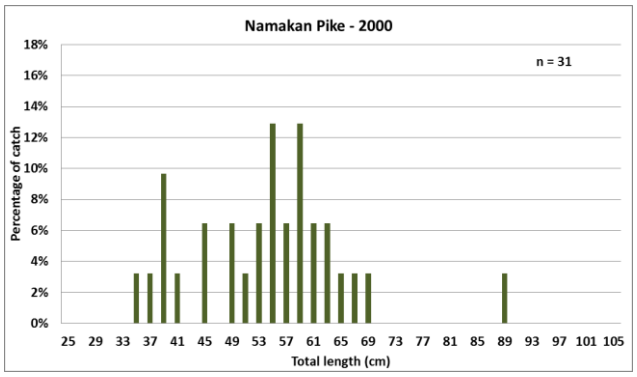


Figure 17. Proportion of northern pike sampled which were larger than 70cm and 90 cm during FWIN surveys of the Ontario waters of Namakan Lake between 2000 and 2014

a)



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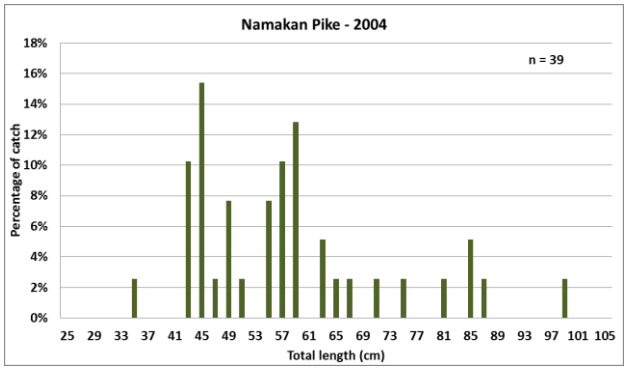
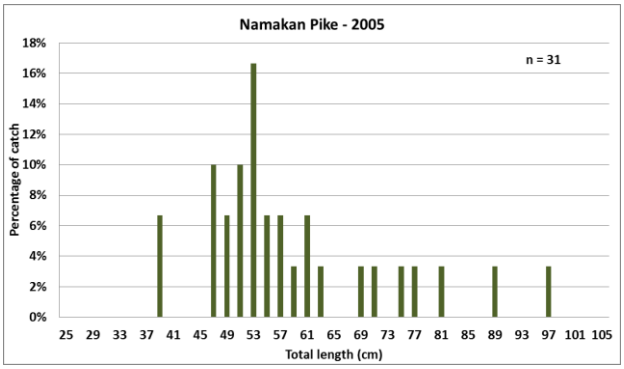


c)



d)

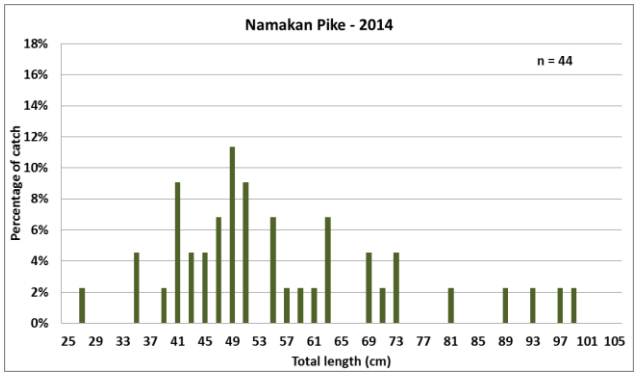


Figure 18. Length distribution of northern pike sampled during FWIN surveys of the Ontario waters of Namakan Lake between 2000 and 2014.

Similar to changes in size distribution, there was an increase in both the average age and the number of age classes of pike sampled between 2000 and 2014 (Figure 19). Age distribution show steady increase in number of ages represented with no pike older than age 5 being caught in 2000 and by 2014, pike up to age 14 were represented in the catch (Figure 20).

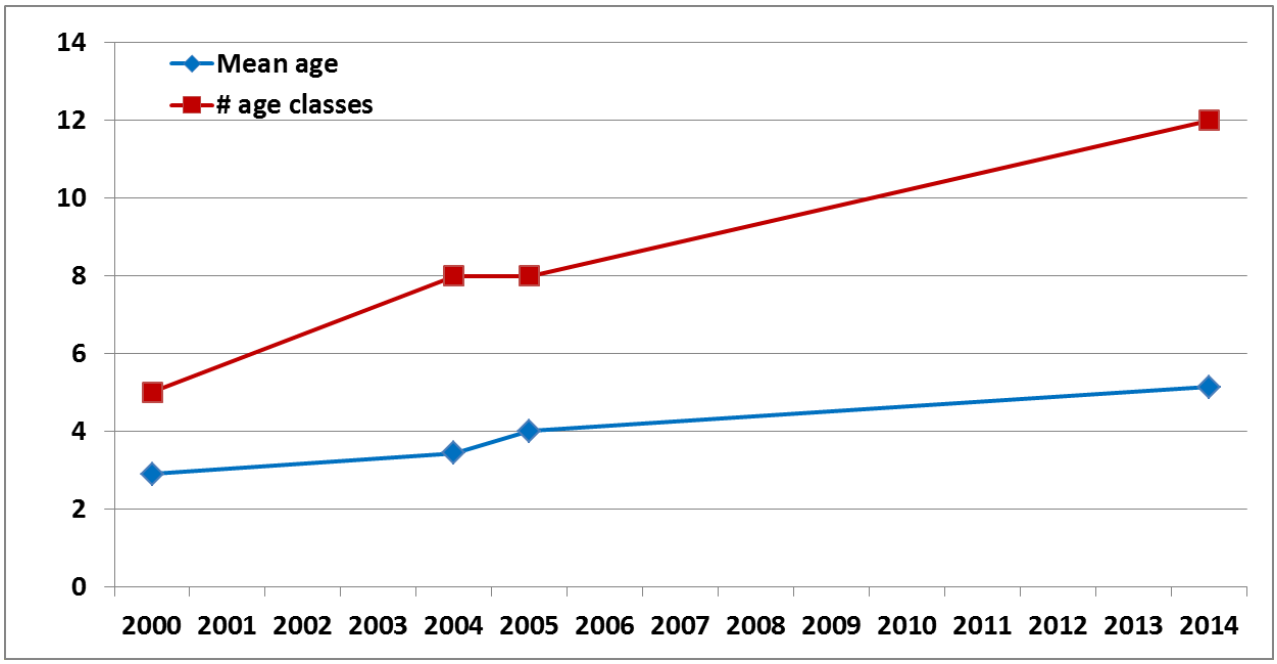
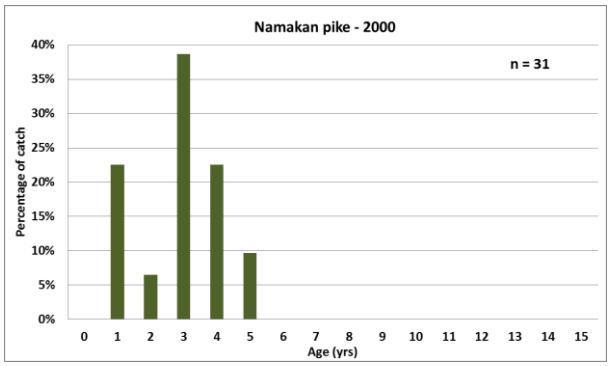


Figure 19. The mean age and number of age classes of northern pike sampled during FWIN surveys of the Ontario waters of Namakan Lake between 2000 and 2014

a)



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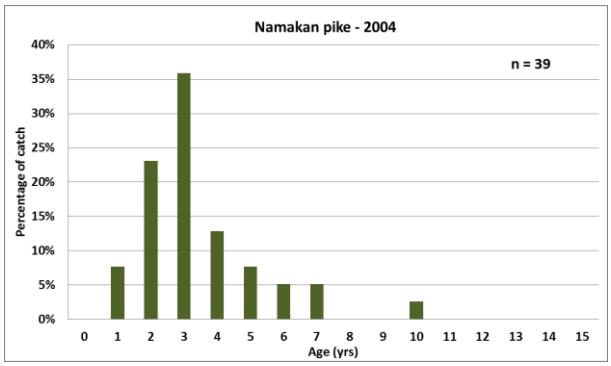

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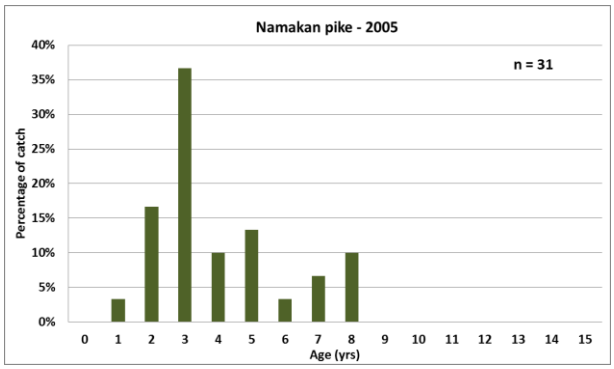

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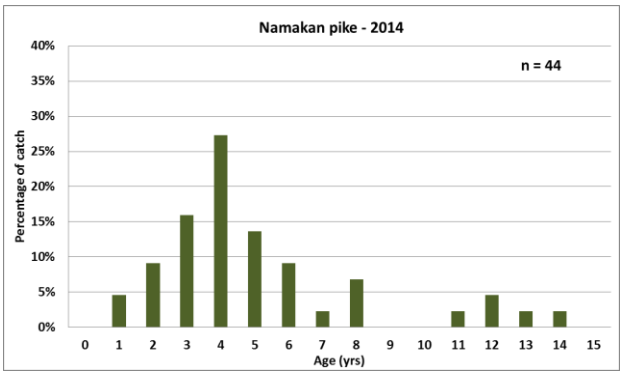

Figure 20. Age distribution of northern pike sampled during FWIN surveys of the Ontario waters of Namakan Lake between 2000 and 2014.

The observed length at age for pike was very similar for the years 2000, 2004 and 2005 however by 2014, pike appeared to be growing at a much slower rate with observed lengths being about 10 cm/year less for ages 1-8 years (Figure 21).

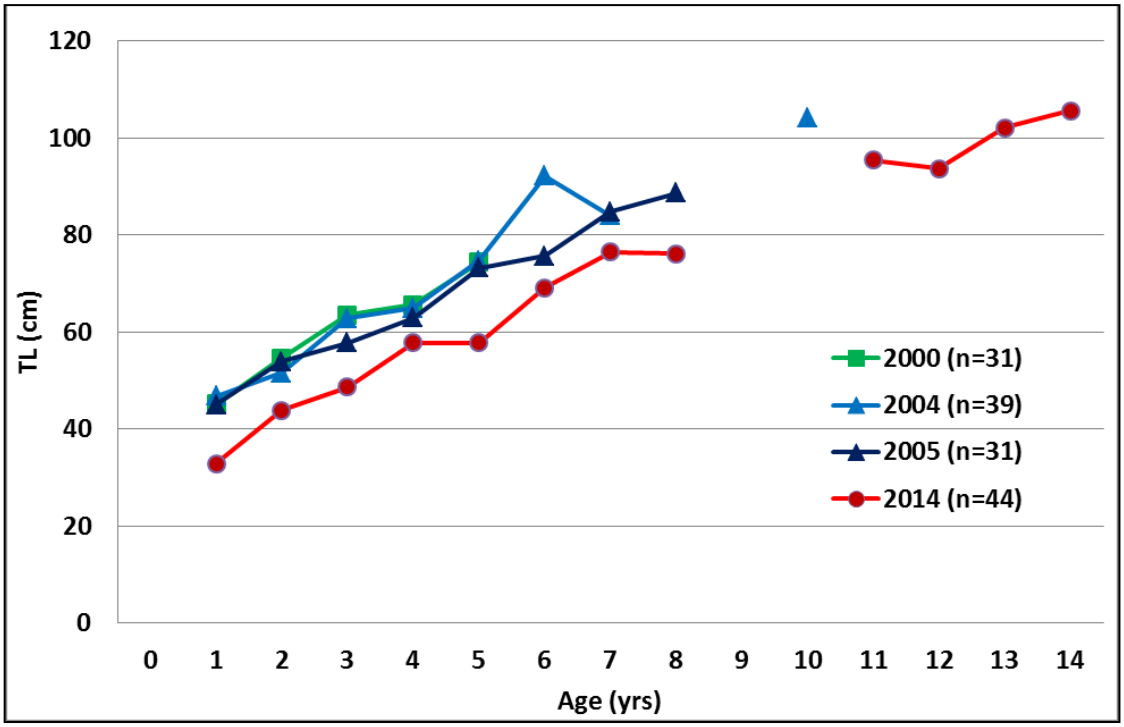

Figure 21. Observed length at age of northern pike sampled during FWIN surveys of the Ontario waters of Namakan Lake between 2000 and 2014.

Population status was assessed by comparing the mortality rate of northern pike estimated from the FWIN surveys to biological reference points calculated for Namakan Lake (unlike walleye, a biological reference point for northern pike biomass has not yet been developed). The mortality indicator compares observed total mortality (death rate due to fishing and natural causes) to estimated value of natural mortality. Total instantaneous mortality estimates have been calculated for fish older than age at 55cm for Namakan Lake pike.caught in netting surveys (Z550) while natural mortality (M) is estimated from known relationships between climate, growth and lake area.. The mortality indicator is reported as the ratio of total mortality to natural mortality; values less than 2 represent safe rates of total mortality and low risk

of overexploiting the fish stock. (Lester et al. 2014, Zhou et al. 2012). This would suggest that Namakan Lake pike population was being over-exploited in the early to mid-2000's but currents levels of harvest are within the acceptable range.

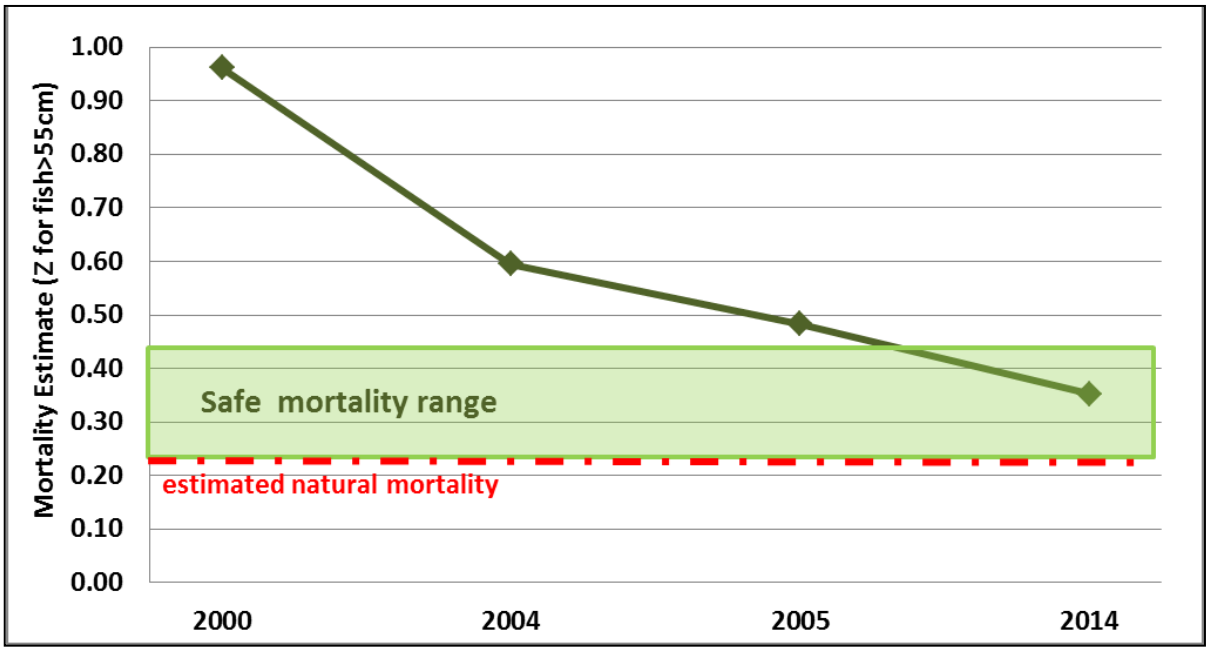

Figure 22. Total instantaneous mortality estimates (Robson-Chapman calculation) for northern pike older than age at 55cm sampled during FWIN surveys of the Ontario waters of Namakan Lake between 2000 and 2014.

All pike indicators including catch, size and age suggest an improving pike population in Namakan Lake. In spite of a decline in growth rates, there are more and larger pike in Namakan Lake due to increased survival to older age classes and pike populations are much healthier in 2014 than in 2000.

There have been two significant management changes that have occurred over the past couple of decades that may account for these differences. The first is a change in northern pike angling regulations in Ontario. Pike angling regulations have changed from a limit of 6/day with no size restrictions in the 80's to a limit of 6/day with only 1>70 cm during the 90's to a limit of 4/day with none between 70-90cm and only 1>90cm since 2000. This increasing restriction on harvest of larger pike has shown to improve the size and age distribution in other pike populations in northwest Ontario (Jackson 2012). The

elimination of the commercial fish harvest in 2002 may have had an additional role in harvest reduction as well although the commercial harvest was relatively small compared to sport fish harvest (less than 10% of the total estimated harvest between 1997 and 2001).

The other management action that may have impacted pike productivity was the change to water level management in Namakan as a result of a change to the IJC rules curves in 2000 (IRLBC, 1999; USGS, 2000). These changes were expected to result in increased and more consistent production of northern pike as a result of improved spawning conditions and an increase in the exploitable population of northern pike resulting from improved productivity of the littoral zone (Kallemyn et al. 2003).

CONCLUSIONS

WALLEYE

- Based on the 2014 assessment, the walleye population in Namakan Lake is on the edge of being classed as stressed based on the biomass of walleye in the lake. The mortality estimate also suggests it is being harvested above the upper limit of safe levels.
- The 2014 Fisheries Management Plan for Fisheries Management Zone 5 which includes Namakan Lake indicate that walleye >=45 cm (18") should make up more than 25% of the catch to meet objectives to protect and maintain spawning stock. Surveys between 2000 and 2014 indicate that Namakan Lake walleye population did not meet that objective in any year with percentage walleye >= 45 cm ranging from 6-18% and is currently at 10% of catch.
- It would appear that, although harvest levels in Ontario waters of Namakan have declined over the past three decades with changes in non-resident angling regulations and removal of the commercial fishery, overall harvest of walleye in Namakan remains high enough to result in negative impacts to the amount of walleye and the size and age structure of the population resulting in a moderate abundance of small sized, young aged walleye in the lake with limited survival to older age clasess. While current populations may be sustainable at this level, they are not providing quality

fishery opportunities or the social, economic and ecological benefits that may result from a population with higher biomass which included older, larger fish.

NORTHERN PIKE

- All pike indicators including catch, size and age suggest an improving pike population in Namakan Lake. In spite of a decline in growth rates, there are more and larger pike in Namakan Lake due to increased survival to older age classes and pike populations are much healthier in 2014 than in 2000.
- Namakan Lake pike populations are currently meeting applicable management objectives identified in the 2014 Fisheries Management Plan for Fisheries Management Zone 5 which includes Namakan Lake including that northern pike >=70 cm (27.5") should make up more than 15% of the catch to meet pike management objectives to protect and maintain spawning stock and pike >= 90cm (35") should be more than 3% to meet trophy angling objectives. Results from the 2014 FWIN survey indicates the percentage of pike >=70 cm is 23% and percentage of pike >= 90cm is 9%.

REFERENCES

Duffy, M., J. McNulty, and T. Mosindy. 1999. Identification of sex, maturity, and gonad condition of walleye (*Stizostedion vitreum vitreum*). NWST Field Guide FG-05. Lake of the Woods Fisheries Assessment Unit, Ontario Ministry of Natural Resources. Kenora, Ontario. 33 p.

Elder, D. 2001. Creel Survey of Namakan Lake and Sand Point Lake, Ontario. 1998. Ontario Ministry of Natural Resources Fort Frances District Report Series # 48. 51 p.

Gabelhouse, D.W. 1984. A length-categorization system to assess fish stocks. N. Am. J. Fish. Mgmt. 4: 273-285.

Hilborn, R. 2010. Pretty Good Yield and exploited fishes. Mar. Pol. 34:193-196

IRLBC. 1999. Review of the IJC Order for Rainy and Namakan Lakes. International Rainy Lake Board of Control. Final Report. 11 p.

Jackson, B.W. 2012 Pike

Jackson, B.W. 1994. 1993 Creel survey of Namakan Lake, Sand Point Lake, and Lac La Croix. Ontario Ministry of Natural Resources – Atikokan Office Report. 53 p.

Lester, N.P., and R.M. Korver. 1996. FISHNET 2.0 analyses of index fishing and creel surveys. Part B. Fish statistics. Ontario Ministry of Natural Resources, Maple, Ontario. 23 p.

Lester, N.P., B.J. Shuter, R.S. Kushneriuk and T.R. Marshall. 2000. Life History Variation in Ontario Walleye Populations: Implications for safe rates of fishing. Fish and Wildlife Branch, Ontario Ministry of Natural Resources. Peterborough, ON. 38 p.

Lester, N. P., B. J. Shuter, and P. A. Abrams. 2004. Interpreting the von Bertalanffy model of somatic growth in fishes: the cost of reproduction. Proceedings of the Royal Society of London B 271:1625–1631.

Lester NP, Shuter BJ, Venturelli P, Nadeau D. 2014. Life-history plasticity and sustainable exploitation: a theory of growth compensation applied to walleye management. Ecol. Appl. **24**: 38-54

Malette, M.D. and G.E. Morgan. 2005. Provincial Summary of Northern Pike Life History Characteristics Based on Ontario's Fall Walleye Index Netting (FWIN) Program 1993 to 2002. Cooperative Freshwater Ecology Unit. Dept. Biology. Laurentian University. 138 p.

M[c]Leod, D.T. 2002. A fisheries assessment strategy for Rainy Lake and the Namakan Reservoir (Ontario). Ontario Ministry of Natural Resources. Fort Frances District Report Series No. 49. 35 p.

Morgan, G.E. 2002. Manual of Instructions - Fall Walleye Index Netting (FWIN). Percid Community Synthesis, Diagnostics and Sampling Standards Working Group. Ontario Ministry of Natural Resources. 34 p.

Morgan, G.E., M.D. Malette, R.S. Kushneriuk, and S.E. Mann. 2002. Regional summaries of walleye life history characteristics based on Ontario's Fall Walleye Index Netting (FWIN) program 1993 to 2001. Fish and Wildlife Branch, Ontario Ministry of Natural Resources. Peterborough, ON. 189 p.

OMNR. 1990. A proposal for management of recreational fishing quality in the Northwestern region. Report of the Northwestern Region Technical Subcommittee on Recreational Fishing Quality. Ontario Ministry of Natural Resources. 61 p.

OMNR and MDNR. 2004. Minnesota-Ontario Boundary Waters Fisheries Atlas for Lake of the Woods, Rainy River, Rainy Lake, Namakan Lake, Sand Point Lake. Ontario Ministry of Natural Resources and Minnesota Department of Natural Resources. 95 p.

U.S.G.S. 2000. Proceedings of the Rainy Lake – Namakan Reservoir Ecological Monitoring Workshop. U.S. Geological Survey, Washington, D.C. 60 p.

APPENDICES

Appendix I: Fish Species Present in the Namakan Reservoir

Common Name	*Scientific Name*	MNR Species Code
Silver Lamprey	*Ichthymyzon unicuspis*	013
Lake Sturgeon	*Acipenser fulvescens*	031
Lake Whitefish	*Coregonus clupeaformis*	091
Cisco (Lake Herring)	*Coregonus artedii*	093
Rainbow Smelt	*Osmerus mordax*	121
Northern pike	*Esox lucius*	131
Mooneye	*Hiodon tergisus*	152
White Sucker	*Catostomus commersoni*	163
Silver Redhorse Sucker	*Moxostoma anisurum*	168
Shorthead Redhorse Sucker	*Moxostoma macrolepidotum*	171
Northern Redbelly Dace	*Phoxinus eos*	182
Finescale Dace	*Phoxinus neogaeus*	183
Golden Shiner	*Notemigonus crysoleucas*	194
Emerald Shiner	*Notropis atherinoides*	196
Common Shiner	*Notropis cornutus*	198
Blackchin Shiner	*Notropis heterodon*	199
Blacknose Shiner	*Notropis herolepis*	200
Spottail Shiner	*Notropis hudsonius*	201
Mimic Shiner	*Notropis volucellus*	206
Bluntnose Minnow	*Pimephales notatus*	208
Fathead Minnow	*Pimephales promelas*	209
Blacknose Dace	*Rhinichthys atratulus*	210
Longnose Dace	*Rhinichthys cataractae*	211
Black Bullhead	*Ictalurus melas*	231
Brown Bullhead	*Ictalurus nebulosus*	233
Tadpole Madtom	*Noturus gyrinus*	236
Burbot	*Lota lota*	271
Brook Stickleback	*Culaea inconstans*	281
Trout-Perch	*Percopsis omiscomaycus*	291
Rock Bass	*Amboloplites rupestris*	311
Pumpkinseed	*Lepomis macrochirus*	313
Bluegill	*Lepomis macrochirus*	314
Smallmouth Bass	*Micropterus dolomieui*	316
Largemouth Bass	*Micropterus salmoides*	317
Black Crappie	*Pomoxis nigromaculatus*	319
Yellow Perch	*Perca flavescens*	331
Sauger	*Sander canadensis*	332
Walleye (Yellow Pickerel)	*Sander vitreus*	334
Iowa Darter	*Etheostoma exile*	338
Johnny Darter	*Etheostoma nirgrum*	341
Logperch	*Percina caprodes*	442
Mottled Sculpin	*Cottus bairdi*	381

***Total Species:* 43**

Appendix II: Number of fish by species captured from FWIN surveys of Namakan Reservoir – 2000-2014

Species	CUE (average #/net)			
	2000	**2004**	**2005**	**2014**
Walleye	190	287	271	212
Northern Pike	31	39	31	44
Smallmouth Bass	37	28	21	19
Lake Whitefish	0	19	5	9
Cisco (Lake Herring)	11	45	2	24
White Sucker	32	44	30	39
Shorthead Redhorse Sucker	0	1	3	4
Silver Redhorse Sucker	30	9	6	10
Sauger	46	52	51	47
Yellow Perch	80	826	76	101
Rock Bass	75	34	95	54
Pumpkinseed	0	0	0	3
Black Crappie	7	3	3	1
Mooneye	6	2	2	0
Bullhead	22	2	0	0
Lake Sturgeon	8	1	3	1
Silver lamprey (attached to other fish)	?	?	?	3
Total	575	1392	599	568
Number of sets	25	24	24	24

Appendix IIIa: Total length frequency distribution of walleye captured in FWIN gill net sets on Namakan Lake, 2000-2014.

Total length (cm)	2000	2004	2005	2014
5	0	0	0	0
7	0	0	0	0
9	0	0	0	0
11	0	0	0	0
13	0	0	0	5
15	3	0	3	2
17	1	3	7	1
19	5	19	38	23
21	11	1	9	18
23	15	9	17	14
25	17	10	27	27
27	21	13	23	16
29	16	20	23	16
31	14	24	12	13
33	15	26	10	12
35	13	26	13	12
37	13	29	19	14
39	13	21	15	9
41	11	20	9	6
43	5	14	7	2
45	6	6	8	5
47	6	17	14	4
49	3	15	6	4
51	0	8	3	4
53	0	2	5	2
55	0	3	1	0
57	0	1	1	0
59	0	0	0	1
61	1	0	1	0
63	1	0	0	2
65	0	0	0	0
Total	**190**	**287**	**271**	**212**
Mean	31.8	35.6	31.2	30

Appendix IIIb: Total length frequency distribution of northern pike captured in FWIN gill net sets on Namakan Lake, 2000-2014.

Total length (cm)	2000	2004	2005	2014
25	0	0	0	1
27	0	0	0	0
29	0	0	0	0
31	0	0	0	0
33	0	0	0	1
35	0	0	0	0
37	0	0	0	0
39	0	0	0	0
41	1	1	0	2
43	1	0	0	0
45	3	0	2	1
47	1	0	0	4
49	0	4	0	2
51	2	6	0	2
53	0	1	3	3
55	2	3	2	5
57	1	1	3	4
59	2	0	5	0
61	4	3	2	3
63	2	4	2	1
65	4	5	1	1
67	2	0	2	1
69	2	2	1	3
71	1	1	0	0
73	1	1	0	0
75	1	0	1	2
77	0	1	1	1
79	0	0	0	2
81	0	1	1	0
83	0	0	1	0
85	0	0	0	0
87	0	1	1	1
89	0	0	0	0
91	0	2	0	0
93	0	1	0	0
95	1	0	1	1
97	0	0	0	0
99	0	0	0	1
101	0	0	0	0
103	0	0	1	1
105	0	1	0	1
Total	31	39	31	44
Mean	60.3	63.9	64.8	61.2

Appendix IVa: Age distribution and average length at age of walleye captured in FWIN gill net sets on Namakan Lake, 2000-2014.

	2000		2004		2005		2014		*combined*
Age	**n**	**Mean TL**	**n**	**Mean TL**	**n**	**Mean TL**	**n**	**Mean TL**	***Ave. TL***
0							2	13.3	*13.3*
1	12	18.4	21	19.1	49	18.9	25	18.5	*18.7*
2	65	26.1	6	22.2	75	25.3	43	22.7	*24.1*
3	19	29.0	95	30.7	17	29.7	63	28.3	*29.4*
4	59	34.7	33	34.3	57	34.0	30	34.5	*34.4*
5	10	40.0	53	38.1	11	38.2	7	37.8	*38.5*
6	20	43.3	33	41.7	17	44.2	10	39.3	*42.1*
7			10	46.9	21	42.6	1	35.5	*41.6*
8	1	45.9	29	48.5	4	47.1	20	42.0	*45.9*
9	1	60.3	2	51.7	11	44.2	3	50.0	*51.5*
10	1	49.7	3	53.3	2	53.1	4	50.7	*51.7*
11	2	54.8	2	51.3	2	50.0			*52.0*
12									
13							1	53.5	*53.5*
14									
15									
16					3	53.7	1	63.0	*58.4*
17									
18									
19							1	62.3	*62.3*
20									
Total	**190**		**287**		**269**		**211**		
Ave. Age	**3.4**		**4.5**		**3.7**		**3.8**		

Appendix IVa: Age distribution and average length at age of northern pike captured in FWIN gill net sets on Namakan Lake, 2000-2014.

	2000		2004		2005		2014	
Age	**n**	**Mean TL**	**n**	**Mean TL**	**n**	**Mean TL**	**n**	**Mean TL**
0								
1	7	45.2	3	46.8	1	45.0	2	32.9
2	2	54.6	9	51.6	5	53.9	4	43.9
3	12	63.5	14	62.8	11	57.8	7	48.6
4	7	65.6	5	65.0	4	62.9	12	57.8
5	3	74.4	3	74.8	4	73.3	6	57.9
6			2	92.3	1	75.7	4	69.1
7			2	84.0	2	84.9	1	76.5
8					3	88.6	3	76.2
9								
10			1	104.2				
11							1	95.5
12							2	93.8
13							1	102.1
14							1	105.6
15								
Total	**31**		**39**		**31**		**44**	
Ave. Age	**2.9**		**3.4**		**4.0**		**5.1**	

Appendix Va: Biological Performance Indicators for walleye captured in FWIN surveys of Namakan Lake, 2000-2014.

Indicator	2000	2004	2005	2014	Reference	
Arithmetic Mean CUE (#/net)	7.6	11.9	11.3	8.8	NW region mean catch - 14.1 (Std. Dev – 8.3)	NW Region FWIN data
Arithmetic Mean CUE (#>450 mm/net)	0.48	2.2	1.7	0.9	NW region mean catch - 3.1 (Std. Dev – 3.0)	NW Region FWIN data
Biomass ($B_{350\ observed}/_{expected}$)	0.26	0.73	0.48	0.27	>0.5	Biological Reference Point
Mortality Indicator ($Z_{350\ observed}/_{natural\ mortality}$)	3.7	2.0	2.0	1.7	<2	Biological Reference Point (Lester et al. 2014)
# Age Classes (n>1)	7	11	12	10		Lakes classed as healthy typically >=11 (Morgan et al, 2003)
Maximum Age $(years)_{observed}$	11	11	16	19	>=16	Supportive (Morgan et al, 2002)
Shannon Diversity Index	0.55	0.56	0.83	0.85	>0.66	Morgan et al (2002); also MDNR (>0.70)
Fish Quality Index	25	41	29	21	trend (25-100 quantity, >100 trophy)	Supportive (NW Region Fishing Quality, 1990)
Age @ 50% Maturity (female)					trend	Supportive, also MDNR
TLEN @ 50% maturity (female)					trend	Supportive, also MDNR
TLEN @ age 3 (adjusted to GDD at age 0)					trend	Tentative, supportive, also MDNR

Appendix Vb: Biological Performance Indicators for northern pike captured in FWIN surveys of Namakan Lake, 2000-2014.

Indicator	2000	2004	2005	2014	Reference	
Arithmetic Mean CUE (#/net)	1.24	1.63	1.29	1.80	Provincial geometric mean catch - 2.2 (0.9 – 3.0 quartiles)	Morgan and Malette (2005)
Arithmetic Mean CUE (#>700 mm/net)	0.16	0.42	0.29	0.42	Trend only	NW Region
Biomass ($B_{550\ observed}$)	1.62	2.81	2.22	2.70	Trend only at this time	Biological Reference Point
Mortality Indicator ($Z_{550\ observed}/_{natural\ mortality}$)	4.4	2.7	2.2	1.6	<2	Biological Reference Point (Lester et al. 2014)
Mean Total Length (mm)	603	639	648	612	Provincial mean - 581mm	Supportive (Morgan and Malette, 2005)
Mean Weight (g)	1445	1961	1891	1743	Provincial mean – 1470g	Supportive (Morgan and Malette, 2005)