Status of Lake Nipissing Northern Pike and Associated Fisheries 1967 to 2018

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Table of Contents

List of Tables

List of Figures

Appendices

Executive Summary

This project aimed to improve our understanding and management of the Lake Nipissing Northern Pike (*Esox lucius* (Linnaeus, 1758)) population, by extending the baseline scientific information. The status of Northern Pike in Lake Nipissing was assessed using a combination of fishery-dependent (i.e., recreational winter and open water angling surveys, and commercial harvest data) and fishery-independent data (i.e., trap net and fall Walleye index netting surveys). The biological performance indicators (from both the fishery-dependent and fishery-independent) data that were considered were total length-at-age 3 (mm) and the population age structure (for estimating adult mortality – $Z_{\geq Age\ 3}$).

The Northern Pike population experienced relatively high levels of biomass through the 1990s. Subsequent declines in fishery metrics demonstrates a rapid and substantial decrease in harvestable biomass, reflective of unsustainable levels of exploitation. Changes in growth rate (i.e., total length-at-age 3) appeared to be negatively density-dependent. Recreational fishing effort during the open water period tracked the exploitable biomass. Efforts to reduce the harvest of Northern Pike should be focussed on angler harvest during the winter and open water periods.

The combination of fishery-independent estimates of mortality ($Z_{\geq Age\ 3}$) and patterns in size (total length-at-age 3) from the annual fall Walleye index netting program provide the most compelling source of information to assess Lake Nipissing's Northern Pike status.

Résumé

Ce projet visait à améliorer notre compréhension et notre gestion de la population de grands brochets du lac Nipissing (*Esox lucius* (Linnaeus, 1758)) en élargissant les informations scientifiques de base. La situation du grand brochet dans le lac Nipissing a été évaluée à l'aide d'une combinaison de données dépendant de la pêche (c.-à-d. Relevés récréatifs de pêche hivernale et en eau libre et de données sur les prises commerciales) et indépendantes de la pêcherie (c.-à-d. Relevés de netting de filet pêchant et de doré jaune à l'automne). Les indicateurs de performance biologique (des données dépendantes de la pêche et indépendantes de la pêche) ont été pris en compte: longueur totale à l'âge de 3 ans (mm) et structure d'âge de la population (pour l'estimation de la mortalité adulte - $Z_{\geq Age\ 3}$).

La population de grands brochets a connu une biomasse relativement élevée au cours des années 1990. Les déclins ultérieurs des paramètres de pêche révèlent une diminution rapide et substantielle de la biomasse exploitable, reflétant des niveaux d'exploitation non durables. Les changements du taux de croissance (c'est-à-dire la longueur totale à l'âge 3) semblaient dépendre négativement de la densité. L'effort de pêche récréative en eau libre a permis de suivre la biomasse exploitable. Les efforts visant à réduire la capture de grand brochet devraient être axés sur la pêche à la ligne en hiver et en eau libre.

La combinaison d'estimations indépendantes de la pêche de la mortalité ($Z_{\geq Age\ 3}$) et des schémas de taille (longueur totale à l'âge de 3 ans) du programme annuel de compensation du doré jaune à l'automne constitue la source d'informations la plus convaincante pour évaluer le statut du grand brochet du lac Nipissing.

Status of Lake Nipissing Northern Pike and Associated Fisheries 1967 to 2018.

1 – Introduction

Northern Pike (*Esox lucius* (Linnaeus, 1758)) is a common top-predator in freshwater systems all over the Northern Hemisphere. For many years, Northern Pike has been a popular target for recreational anglers. However Northern Pike management is often a lower priority in comparison to more intensively managed species such as Walleye (*Sander vitreus* (Mitchill, 1818)). In many freshwater ecosystems, recreational fishing has even replaced commercial fisheries and this fishing pressure can have negative impacts on Northern Pike populations. Detailed knowledge about Northern Pike ecology, including life history characteristics, is important to inform proper fisheries management decisions.

This review was undertaken by the Ontario Ministry of Natural Resources and Forestry (OMNRF) to contribute an unbiased source of Northern Pike information that has been synthesized from existing fishery-dependent and fishery-independent data on Lake Nipissing. Better information about the impacts of harvesting could contribute to management aimed at restoring or enhancing Northern Pike populations. As well evaluations of the effectiveness of regulations designed to improve Northern Pike sizes depend on our understanding of their life history characteristics. This review will lead to more confident assessments of the stock and ensure the long-term sustainability of Lake Nipissing's Northern Pike resource.

This report provides an assessment of the status of Northern Pike in Lake Nipissing. Consequently, this report (1) analyses fishery-dependent (e.g., catch, harvest, and effort) and fishery-independent (e.g., growth and mortality) data from 1967 to 2018; (2) assesses the status of the resource; and (3) identifies future monitoring needs.

2 – Methods[1]

2.1 Study Area — Lake Nipissing (46° 16' 54", 80° 0' 0") is Ontario's seventh largest inland lake (87325 ha) located in north-central Ontario approximately 350 km north of the city of Toronto between the Ottawa River and Georgian Bay. The Lake Nipissing watershed (≈13,100 km^2) is largely forested or rural and lies on Precambrian bedrock that is overlain in many areas by sand and clay deposits that is drained by 12 major rivers (Neary and Clark 1992). Four of these rivers drain almost three-quarters of the total watershed area (Sturgeon River 37%, Amateewakea River 13%, South River 11%, and Veuve River 10%). The lake is situated at a mean elevation of 196m above sea level. The productivity of this water body is classified as mesotrophic (2003-04 total phosphorus 17.5 $\mu \bullet L^{-1}$) and is slightly basic (2003-04 pH 7.1) as a consequence of the surrounding the surficial geology and watershed characteristics (Clark et al. 2010). The lake is shallow (average depth of 4.5m) with a maximum depth of 52m close to the French River which is Lake Nipissing's only outflow. Water levels are regulated by dams located on the French River (annual winter drawdown ≈1.2m) and water replacement time is less than one year (≈0.70 years).

1. The methods section of this report is slightly modified from the Morgan (2013) Lake Nipissing data review 1967 to 2011 report.

Two communities (North Bay, population ≈54,000; West Nipissing, population ≈14,000) use Lake Nipissing for recreation. Dokis First Nation (population ≈200) and Nipissing First Nation (NFN) (population ≈1,400) are situated on the shoreline of Lake Nipissing. Both First Nations rely on the lake for subsistence fishing, while NFN also has a court-recognized treaty right to commercially fish the lake. There are also over 125 tourist establishments on Lake Nipissing (located mainly on the eastern and southern shores, and Northwest Bay) that depend primarily on the fisheries resources for their livelihood.

Lake Nipissing supports a diverse fish community (42 species) dominated by Walleye, Yellow Perch (*Perca flavescens* (Mitchill, 1814)), Northern Pike, and White Sucker (*Catostomus commersoni* (Lacepède, 1803)) with a significant Coregonid component (Cisco, *Coregonus artedi* (Lesueur, 1818)) and Lake Whitefish, *Coregonus clupeaformis* (Mitchill, 1818). Other culturally significant species include Muskellunge (*Esox masquinongy* (Mitchill, 1824)), Smallmouth Bass (*Mircopterus dolomieu* (Lacepède, 1802)), Largemouth Bass (*Micropterus salmoides*, (Lacepède, 1802)), and Lake Sturgeon (*Acipenser fulvescens* (Rafinesque, 1817)).

2.2 Data for Fish Stock Assessments — Two sources of data were used in this fish stock assessment: fishery-dependent and fishery-independent.

•Fishery-dependent data were collected directly from the recreational (i.e., winter and open water angling) and commercial (i.e., open water gill net) fisheries. These data include: 1) fishing effort, 2) total number caught and amount (number and kilograms) of fish harvested, and 3) biological information (i.e., length and calcified tissues collected for age interpretation) from sampling the harvested fish.

•Fishery-independent data were collected from on-water surveys, where Ontario Ministry of Natural Resources and Forestry (OMNRF) and partner organizations gathered data on fish stock abundance, biology, and their ecosystem. Data ideally came from statistically-designed surveys that sampled fish at a variety of locations throughout the lake. Most surveys were conducted annually and collected data on all ecosystem components using standardized sampling methods. The frequency of this data allowed the relative index of abundance, information on fish growth rates, and mortality trends to be shown over time.

2.2.1 Fishery-dependent Data — Roving angler surveys were used to collect information on recreational fishing effort, catch rates, harvest levels, and types of users. Lake Nipissing has been divided into 17 sampling sectors based primarily on historical fishing pressure distribution (Jorgensen 1986). The major advantage of the present survey design (both winter and open water) has been its highly precise estimates of catch and effort for the three most exploited species; Walleye, Northern Pike, and Yellow Perch (Rowe and Seyler 2000).

2.2.1.1 Winter Creel — Winter angler surveys commenced on the opening day of the fishing season and were terminated at the end of the fishing season or earlier if the ice conditions deteriorated and it was unsafe to use snowmobiles on the lake. During the winter angler survey 13 sectors (Figure 1; Callander

Bay – E1, 2880 ha , Manitou Islands – E2, 11719 ha, South Bay – E3, 3438 ha, North Bay shoreline – E6, 5060 ha, South Shore – E5, 7019 ha, Deepwater Point – E7, 652 ha, Iron Island – W1, 8813 ha, Goose Islands – W2, 10941 ha, Hardwood Islands – W3, 3904 ha, French River to Cross Point – W4, 3362 ha, Cache Bay to the mouth of the Sturgeon River – W5, 6682 ha, West Bay – W7, 4285 ha, and West Arm – W9, 1974 ha) were sampled and angling parties were interviewed while counts were made of the number of commercial ice huts, personal ice huts, and angler groups fishing on the ice. The fishing day varied in length over the winter season (08:00 to 17:00 in January and 09:00 to 18:00 in February and March). Two, three or, more rarely, four sectors were sampled each sampling day so that each sector was sampled a minimum of 4 times (2 work days (Monday to Friday) and 2 non-work days (Saturday, Sunday or statutory holiday)) over the fishing season[2]. A sub-sample of angling parties, which was proportional to the time available to cover a sampling sector, was interviewed by survey crews during each survey day. The total number of angler-hours fished per party, species preference, the number of fish caught and harvested, residency of the anglers and their visitor type (e.g., permanent resident or resort guest, use of guide services, etc.) were recorded. All fish kept by ice anglers were tallied and sub-sampled for total length measurements (minimum sampling target of 100 Walleye and Yellow Perch each month; all other species sampled as encountered over the winter season). Northern Pike harvested by anglers during the 2014 to 2018 winter creel surveys were also sampled for ageing structures (scales) for later age interpretation.

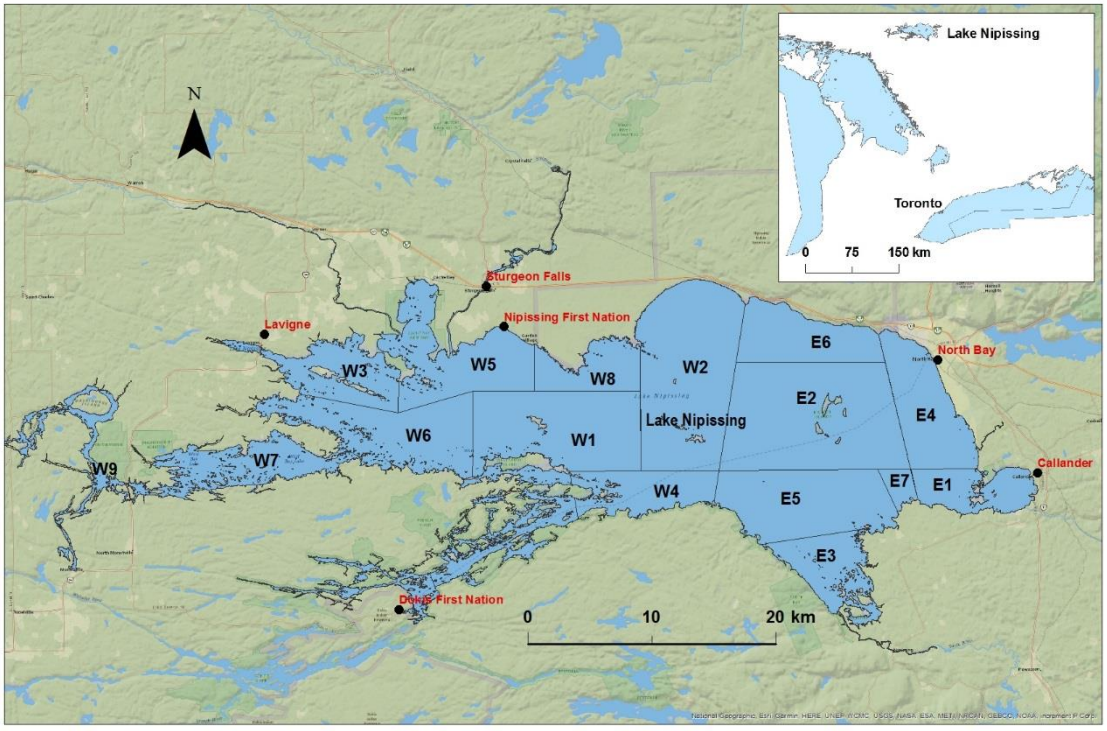

Figure 1. Lake Nipissing winter creel survey sampling sectors.

2. The 1996 winter angler survey was terminated early due to the Ontario Public Service Employees Union strike so the estimates of effort, catch, and harvest were expanded to represent the entire fishing season.

2.2.1.2 Open Water (Spring-Summer) Creel — Open water angler surveys commenced on the opening day of the season and ended on the Friday after Labour Day (early September) (Note: Due to budget constraints in 1992 the open water angler survey was only conducted in July and August and the 1993 open water angler survey only covered a portion of the lake, therefore only partial estimates of effort, catch, and harvest were available for these years). Fourteen sectors (Figure 2; Callander Bay – E1, 2880 ha , Manitou Islands – E2, 11719 ha, South Bay – E3, 3428 ha, North Bay shoreline – E4, 5060 ha, South Shore – E5, 7671 ha, Northeast shoreline – E6, 4305 ha, Iron Island – W1, 8813 ha, Goose Islands – W2, 10941 ha, Hardwood Islands – W3, 3904 ha, French River to Cross Point – W4, 3362 ha, Cache Bay to the mouth of the Sturgeon River – W5, 6682 ha, Middle West Bay – W6, 6718 ha, West Bay – W7, 4285 ha, and Northwest shoreline – W8, 2792 ha) were sampled. Three sectors were sampled each sampling day. The fishing day was stratified into an AM period (08:30 to 14:30 in May and June, and 09:30 to 15:30 from July to September) and PM period (14:30 to 20:30 in May and June, and 15:30 to 21:30 from July to September). Each sector was sampled a minimum of 8 times (2 time periods (AM and PM), 2 work days (Monday to Friday), and 2 non-work days (Saturday, Sunday or statutory holiday)) over the fishing season. A circuit was made of the sector and an activity count of the number of boats actively engaged in fishing was conducted. A sub-sample of angling parties, which was proportional to the time available to cover a sampling sector, was interviewed by survey crews during each survey day. The total number of angler-hours fished per party, species preference, the number of fish caught and harvested, residency of the anglers and their visitor type (e.g., permanent resident or resort guest, use of guide services, etc.) were recorded. All fish kept by boat anglers were tallied and sub-sampled for total length measurements (minimum sampling target of the first 75 Walleye, Yellow Perch, and Northern Pike encountered in each month). Additionally, scales were collected from Northern Pike harvested by anglers during the open water seasons of 1967, 1968, 1972 to 1989, 1991, 1994, 1997, and 2015 to 2018 for age interpretation.

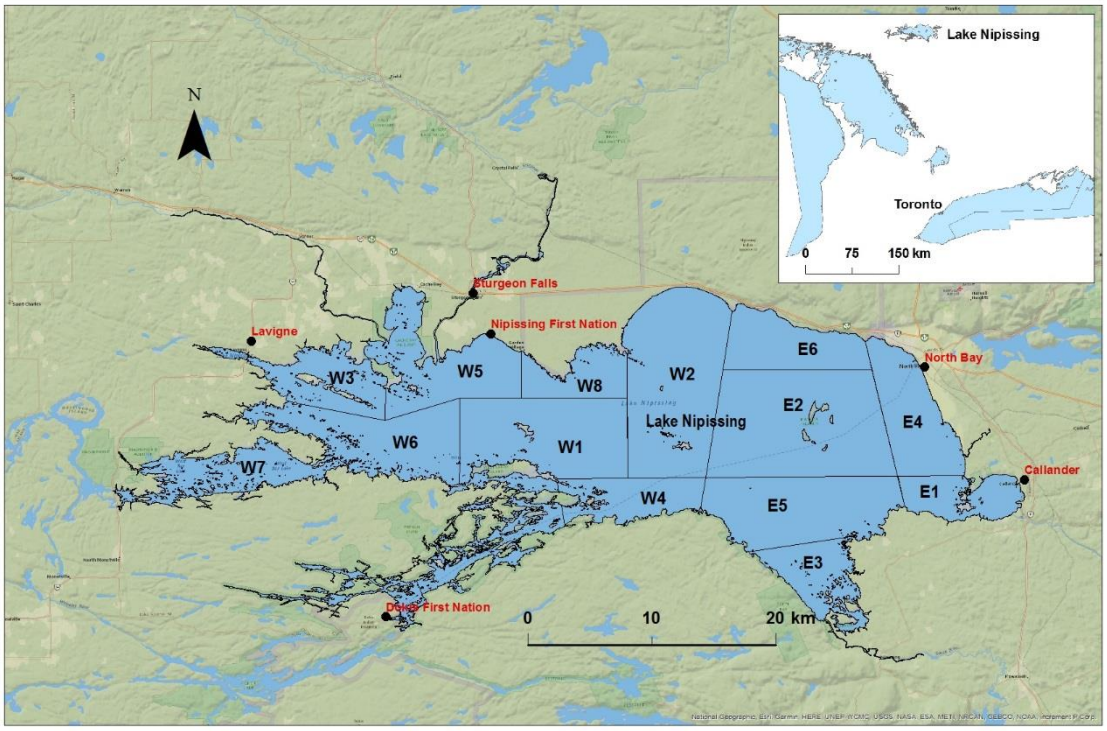

Figure 2. Lake Nipissing open water creel survey sampling sectors.

2.2.1.3 Commercial Gill Netting— Nipissing First Nation (NFN) began reporting their commercial Northern Pike harvests in 1995. Prior to 1995 there is no recorded information on the nature or extent of this fishery. Commercial Northern Pike harvests from 1995 to 1998 were estimated from voluntary information provided by commercial fishers to Anishinabek/Ontario Fisheries Resource Centre (A/OFRC) technicians who interviewed the fishers at community docks or at their residences (McLeod 1999). It was estimated that 90% of NFN commercial fishers reported their harvests during this program (Rowe and Seyler 2000).

From 2014 to 2018 a total of 198 Northern Pike (56 samples in 2014, 12 samples in 2015, 66 samples in 2016, 19 samples on 2017, and 45 samples in 2018) were measured from a sub-sample of the commercial harvests by NFN natural resources staff for fork and total length to the nearest mm, weighed to the nearest 1 g using electronic balance, and had scales samples (5 to 10 scales) removed from above the lateral line and below the dorsal fin for later age interpretation (Mann 2004).

2.2.2 ***Fishery-independent Data*** — Index netting surveys were used to collected information on Northern Pike abundance, length, weight, sex and maturity, and obtain structures for later age interpretation. Historical netting surveys were conducted in the summer while contemporary surveys occurred during the spring or fall seasons.

2.2.2.1 ***Summer Index Trap Netting*** — During the first three weeks of June, trap netting was conducted at five fixed sites (Site 2 – 46° 14' 12", 79° 56' 15", Site 3 – 46° 19' 08", 79° 52' 30", Site 4 – 46° 14' 31", 79° 52' 30", Site 10 – 46° 15' 07", 79° 53' 10", and Site 17 – 46° 17' 45", 79° 59' 32") in the west end of Lake Nipissing by the Lake Nipissing Fisheries Assessment Unit, Ontario Ministry of Natural Resources (OMNR) from 1976 until 1994 (the unit was closed in 1996). The trap nets were lifted daily, Monday through Friday and all fish were identified to species and enumerated. Northern Pike (and other selected fish species) were measured for fork and total length (mm), weighed to the nearest 5 g using spring scales, and scales were collected for age interpretation in 1977 to 1985, 1988, 1989, 1991, 1993, and 1994. All data collected by the Lake Nipissing Fisheries Assessment Unit are archived with the OMNRF in the Aquatic Data Repository Project (these include summer index trap netting projects, and winter and open water angler surveys).

2.2.2.2 ***Ice Out Trap Netting (IOTN)*** — Ice out trap netting was identified as the recommended technique of Northern Pike and Muskellunge ("*Esocids*") during the Lake Nipissing assessment plan workshops held jointly by the A/OFRC and the OMNR. Subsequently, A/OFRC and OMNR co-authored a ten-year assessment plan for Lake Nipissing (2000-2009) which included ice out trap netting as an assessment technique worthy of evaluation to see if it could provide the data required to determine stock status and make appropriate management decisions (Rowe and Seyler 2000). Ice out trap netting projects (targeting Northern Pike and Muskellunge) were conducted in partnership by OMNRF, NFN, and A/OFRC. Different areas of Lake Nipissing known to contain appropriate *Esocid* nearshore habitat were sampled in each sample year — 1999 (Callander and South Bay), 2000 (South Bay), 2001 (South Bay), 2007 (Northwest Shore), 2013 (Callander Bay), 2014 (Callander Bay), and 2016 (South Bay).

Esocids were collected with trap nets in mid- to late April during ice-out and spawning in each lake. The sampling program commenced as soon as the ice had receded from the shore of Lake Nipissing (nets first set on April 19th in 1999, April 14th in 2000, April 25th in 2001, April 16th in 2007, April 30th in 2013, May 6th in 2014, and May 2nd in 2016).

From 1999 to 2007, two standard six-foot spring-haul trap nets were set along the shoreline each day at pre-determined sites in specific areas of the lake. Each selected site was fished for two consecutive nights (but sampled daily), after which time they were moved to another pre-selected location. No attempt was made to randomize trap-net effort; rather, effort was directed at sampling the greatest number of fish possible with a minimum target sample size of 25 trap net sets. Nets were placed in suitable spawning habitat that is not uniformly distributed and some spatial clumping of net locations occurred.

From 2013 to 2016, the method was changed to follow the standardized OMNR End of Spring Trap Netting (ESTN) protocol (Skinner and Ball 2004). Net set locations were randomized, the nets were allowed to soak for 24 hours, and then subsequently moved the following day.

Trap net effort varied between years, ranging from 28 to 58 sets·year^{-1}, effort differing with the duration of the spawning season. The fieldwork was terminated in early to mid- May (last nets were lifted on May 6th in 1999, May 5th in 2000, May 18th in 2007, May 17th in 2013, May 27th in 2014, and May 12th in 2016).

Standard trap nets have 64mm black, polypropylene mesh on the leader and top and bottom of house and heart; and 44mm mesh on the rest of the head nets (Stirling 1999; Skinner and Ball 2004). They have rectangular frames (3.45m long, 1.83m wide, and 1.83m high), one throat (sometimes referred to as the tunnel) 25cm in diameter, and a 45.7m long by 1.83m high lead that extended onto the shore. The trap nets were left to fish for approximately 24 hours (acceptable daily sampling duration of ±4 hrs) after which time they were lifted and the fish were sampled.

Fish sampling included counts of all species captured with detailed biological data collected for Northern Pike and other sport fish species. Northern Pike were measured for fork and total length to the nearest mm, weighed to the nearest 5 g using spring scales, externally sexed (Note: Fish not extruding milt or eggs were assumed to be pre-spawning females or immature because age 1 and older males typically had milt throughout the trapping periods), and had scales samples (5 to 10 scales) removed from above the lateral line and below the dorsal fin (Mann 2004).

2.2.2.3 Fall Walleye Index Netting (FWIN) — The annual Walleye population assessment begins in the autumn when water surface temperatures have cooled to 15^{o}C (and stops when water temperatures decrease to <10^{o}C) using a standard index netting method (Morgan 2002). Benthic multimesh monofilament gill nets (60.8m long by 1.8m deep) are set perpendicular to shore at haphazardly selected locations for 24 hours (the number of nets set in Lake Nipissing varied from 42 to 107 nets•year^{-1} between 1998 and 2018). Each net has eight panels (7.6m long by 1.8m deep) with sequentially increasing mesh sizes (25, 38, 51, 64, 76, 102, 127, and 152mm (stretched mesh)). Sets alternate with the large and small mesh ends of the net set closest to shore.

From 1998 to 2003 sampling was both stratified by depth (“shallow” 2-5m and “deep” 5-15m) and area (creel sectors) resulting in annually varying proportions of shallow and deep sets (but good spatial coverage). Beginning in 2004 the minimum lake wide sampling effort target was set at 42 nets with depth stratification determined from lake bathymetry (by assigning one-third of sampling effort to the shallow stratum and two-thirds of sampling effort to the deep stratum) and to further guarantee spatial coverage there were a minimum of 3-4 sets in the West Arm sector, 3 sets in West Bay sector (shallow depth stratum), 3 sets in the Callander Bay sector, 4 sets in the South Bay sector, 4 sets in the French River sector. Finally, in 2007 the minimum lake wide sampling effort was increased to 48 nets to be set over a two-week period (based on an analysis of sample size requirements for precision and statistical power using data collected from 1998 to 2006).

All fishes captured were identified to species, enumerated, and measured for fork and/or total length to the nearest millimetre. All Northern Pike individuals were measured for fork and total length, weighed to the nearest gram using an electronic balance, and examined internally to determine sex and state of gonad maturation. Age structures were collected for later age interpretation (Note: A fish assigned age x years in the fall had completed x+1 growing-seasons). Scales samples (5 to 10 scales) were collected from above the lateral line and below the dorsal fin (after wiping away mucus and dirt), and cleithrum were removed, cleaned of all excess flesh, and allowed to dry for later age interpretation (Mann 2004).

3 Management History

3.1 ***Recreational Fishing Regulations*** — Few changes to the recreational Northern Pike fishing regulations on Lake Nipissing have occurred in the last half-century. From 1960 until 1973 the Northern Pike fishing season on Lake Nipissing opened on the second Saturday in May and closed on March 31st the next year. In 1974 the season opener was changed to the third Saturday in May and in 1975 the season opener was delayed a further week and opened on the fourth Saturday in May. From 1976 to 1986 the season opened on the Wednesday after the Victoria Day weekend (May) and closed on March 15th the next year. Beginning in 1987 the season was split to reflect the calendar year format of the fishing regulation summary; January 1st to March 15th and the Saturday preceding Victoria Day (May) until December 31st. In 1992 and 1993 the winter season was from December 26th to March 15th (the next year) and the open water season was from the Saturday preceding Victoria Day (May) until November 30th. The 1994 to 1998 season was January 1st to March 15th, the Saturday preceding Victoria Day (May) to November 30th, and December 25th to December 31st. In 1999 the winter and open water seasons were shortened by two weeks (January 1st to March 7th and the Saturday preceding Victoria Day (May) to October 15th.

There was no size limit for Northern Pike on Lake Nipissing from 1960 to 2007. However, following an OMNR management plan review of Lake Nipissing, a variable size limit was implemented for Northern Pike – an angler could catch-and-retain 6 fish less than 610mm (24.02 inches) OR 4 fish less than 610mm (24.02 inches) and not more than 2 fish greater than 610 mm (24 inches), of which not more than 1 can be greater than 860mm (33.89 inches) in 2008 (Roberts and Burns 2007).

From 1960 until 1998 there was a daily catch-and-possession limit of 6 fish. This was reduced to a daily catch-and-possession limit of 4 fish in 1999. For anglers with a conservation licence the daily catch-and-possession limit is 2 fish.

3.2 ***Nipissing First Nation Commercial Fishing Regulations*** — The commercial fishery is regulated under the NFN Fisheries Law (NFN 2019). This document describes:

- fishing areas,
- fishing season,
- species, size and quantities,
- reporting and assessment requirements,
- fishing gear specifications, and
- compliance and enforcement

Since 2007 the Chief and Council have been setting the annual quantity of fish that can be commercially harvested (with gill nets) and reserve the right to take management action, including closing of the fishery, if the Walleye fishery is seriously threatened. For Northern Pike the annual target has always been 4501 kg (9924 pounds).

4 Data Analyses

4.1 ***The Fisheries*** — Estimates of the number of Northern Pike caught and harvested, angler success (number•angler-hour^{-1}) as well as fishing effort (angler-hours) in the winter and open water recreational fisheries were generated using FISHNET (v2) (Lester and Korver 1996). Recreational (winter and open water) harvest by weight was estimated as the number harvested multiplied by the average weight (kg) of angled Northern Pike during each creel survey.

Gini coefficients (Smith 1990) were calculated from constructed Lorenz curves (Lorenz 1905) using winter and open water creel data for anglers fishing ≥3 hours. Lorenz curves are a plot of the cumulative percentages of anglers (x-axis) who caught (or harvested) from 0 to 6 Northern Pike versus the cumulative proportion of fish caught (or harvested) (y-axis). The closer the curve is to the 45^{o} reference line, the more equal the catch (or harvest) is distributed among anglers (i.e., 10% of fish are caught with 10% of effort, 20% of fish are caught with 20% of effort, and so on). The Gini coefficient is equal to two times the area between the Lorenz curve and the 45^{o} diagonal line of equality. A Gini coefficient of 0 indicates complete equality. A Gini coefficient of 1 indicates perfect inequality. The lower the Gini coefficient the more equitable the catch (or harvest).

Estimates of NFN commercial Northern Pike harvest by number from 1999 to 2018 were extrapolated from the average ratio of Northern Pike-to-Walleye (expressed as the number of Northern Pike•100 Walleye^{-1} compiled from the 2009 to 2018 daily catch forms submitted by commercial fishers to the NFN natural resources department) applied to the reported estimated number of Walleye harvested in each year (Nikki Commanda, NFN natural resources biologist, personal communication) (Table 1). Commercial harvest by weight was estimated as the number harvested multiplied by the average weight (1.527 kg) of Northern Pike sampled by NFN staff from 2014 to 2018.

Table 1. Number of Northern Pike•100 Walleye^{-1} harvested by Nipissing First Nation commercial fishers as reported on their daily catch forms 2009 to 2018.

Year	Number of Walleye Harvested	Number of Northern Pike Harvested	Pike•100 Walleye^{-1}
2009	53845	2470	5
2010	34223	2842	8
2011	20808	2507	12
2012	21104	1536	7
2013	15100	1484	10
2014	21263	1047	5
2015	11042	736	7
2016	11845	883	7
2017	13855	609	4
2018	20065	726	4
Average	22315	1484	7

Length and age frequency distributions for Northern Pike were calculated based on the fish sampled (during the creel surveys and from the commercial catch monitoring) and the harvest estimates.

4.2 Biological Attributes — Size-at-age 3 was established as a point of reference to describe variability in the temporal patterns in growth (most frequently caught age class of Northern Pike caught in the winter and open water angler sampling, commercial catch sampling, summer index trap netting, IOTN, and FWIN programs over the entire range of data available).

Northern Pike growth was characterized using the von Bertalanffy growth model. The parameters were calculated from the pooled 1998 to 2018 FWIN observations for males (n=722), females (n = 1072), and all fish (n = 1810) using the non-linear least squares estimation function in the R project (R Core Team 2013). The von Bertalanffy growth parameters are:

$$L_t = L_\infty\left(1 - e^{-k(t-t_o}\right)$$

Where L_t is the size (total length in mm) at age t, L_∞ is the maximum theoretical length (mm), k is the Brody growth coefficient (•year^{-1}), and t_0 is the year when length is zero.

Northern Pike condition (weight-at-length) was estimated from length-weight regressions (an ordinary least-squares regression model fitted to logarithmically transformed (base 10) length and weight data) (Guy and Brown 2007) using the pooled 1998 to 2018 FWIN observations for males (n=718) and females (n = 1065):

$$W = aL^B$$

Where W and L are weight and length respectively, a is the y-intercept, and B is the slope of the line.

Total adult (≥3 years old) Northern Pike mortality rate (designated as Z) estimates were based on the catch at age data from the winter and open water angler sampling, summer index trap netting, IOTN, and FWIN programs over the entire time series (i.e., each project) using the Robson and Chapman's maximum likelihood estimator (Guy and Brown 2007). Fishing mortality was estimated from Z and M (i.e., F = Z-M) and exploitation rate (designated as u) was calculated as u = FA•Z^{-1}, where A = 1-e^{-Z} (Ricker 1975). To isolate the effects of fishing (designated as F), natural mortality (designated as M) was estimated from a modification of the Lester et al. 2014 life history model (Cindy Chu, OMNRF, personal communication[2]) and the von Bertalanffy growth model parameters (Then et al. 2015). The exploitable Northern Pike stock biomass was reconstructed using the estimates of the combined (angling and commercial gill net fisheries) yield (kg) and exploitation rate (i.e., biomass = Yield•u^{-1}).

The non-parametric Mann-Kendall test was utilized to detect monotonic trends in the data series (Gilbert 1987). The null hypothesis, H_0, is that the data come from a population with independent realizations and are identically distributed. The alternative hypothesis, H_A, is that the data follow a monotonic trend. A monotonic upward (downward) trend means that the variable consistently increases (decreases) over time, but the trend may or may not be linear. In a monotonic relationship, the variables tend to move in the same relative direction, but not necessarily at a constant rate. LOESS (locally weighted smoothing), regression was used to plot trends that were statistically significant (Cleveland 1979). This local regression model creates a smooth line through a time plot or scatter plot to see relationships between variables and foresee trends.

2. $M = \frac{2h \times GDD5}{L_{mat}+h \times GDD5}$; where h = 0.045 cm•year^{-1}, L_{mat} = 50cm (length-at-50% maturity in Northern Pike), and GGD5 = growing degree-days ≥5C.

5 Results and Discussion

5.1 ***The Fisheries*** — Angling: Creel data confirmed that Walleye were the primary target species of the recreational and commercial fisheries in Lake Nipissing. Northern Pike were the third-most sought-after species by anglers in winter and the second-most sought-after species in the open water period (Figure 3 – Note: A summary of the creel data is provided in Appendix 1). Northern Pike were primarily an incidental bycatch in the NFN commercial gill net fishery.

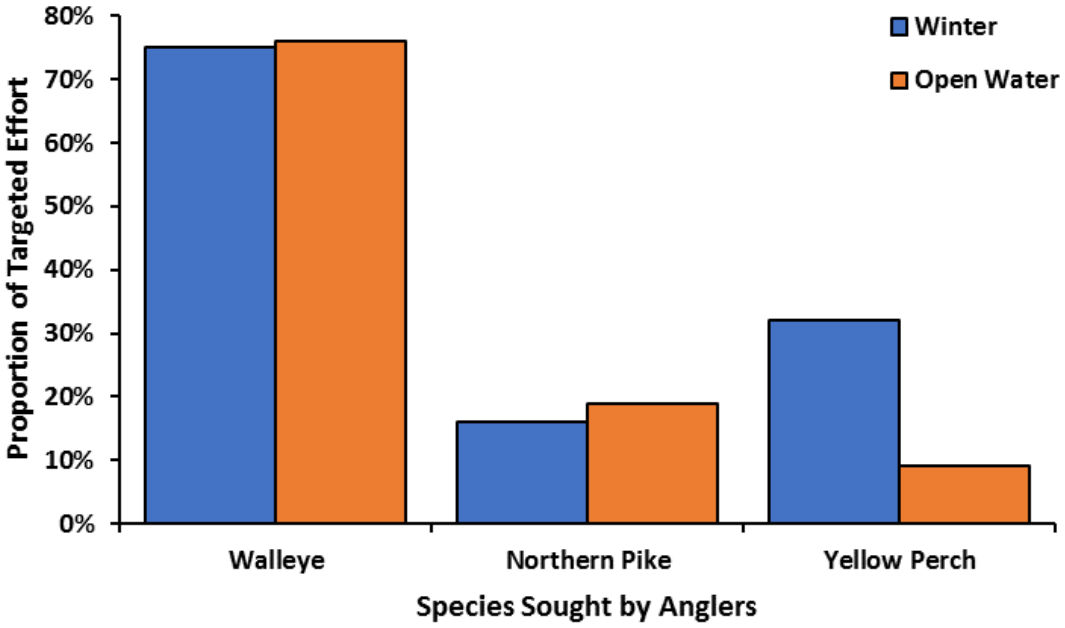

Figure 3. Proportion of fishing effort (angler-hours) targeting Walleye, Northern Pike, and Yellow Perch during the winter and open water creel surveys. Targeted angler effort is the amount of time in hours that an angler spends fishing for a specific species.

Winter fishing effort was relatively constant ($S = -16$, $p = 0.88$) over the time series (≈320000 hours) while open water fishing effort significantly declined ($S = -741$, $p < 0.001$) from 1970 until 2010 with a slightly increasing trend afterwards (Figure 4). More effort occurred during the open water period from 1970 to 1990 but since 2000 more fishing effort has occurred in the winter.

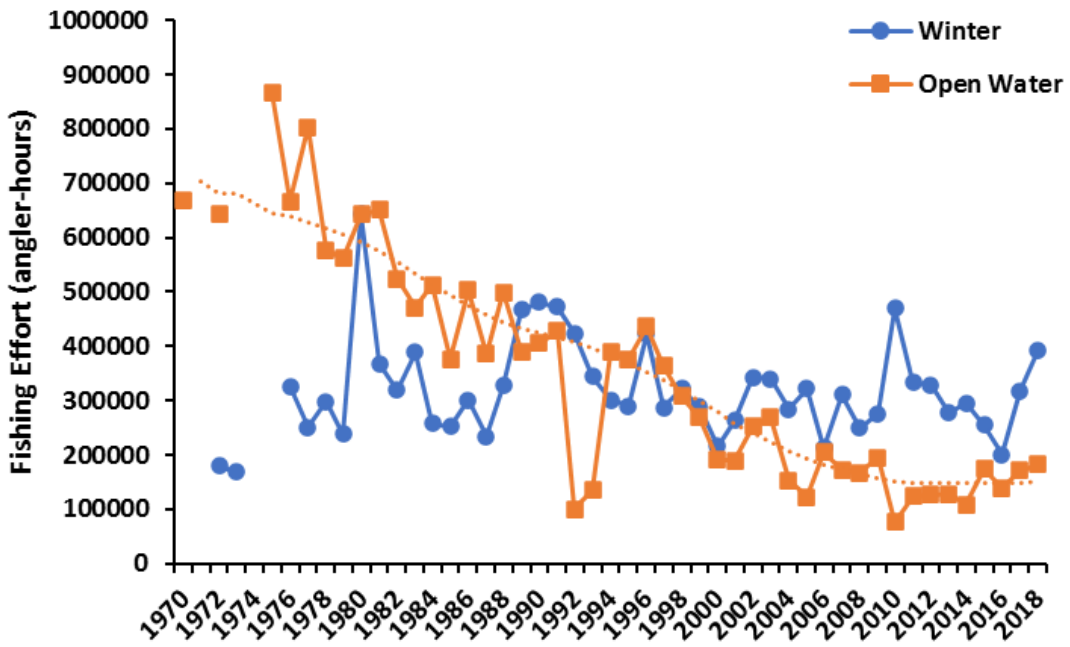

Figure 4. Estimated fishing effort (angler-hours) from the winter and open water creel surveys 1970 to 2018 (Significant trend line (LOESS regression) for open water fishing effort time series also plotted).

Reported winter and open water Northern Pike catches and harvests have significantly declined over the last 40 years (Figure 5: winter catch S = -220, $p < 0.001$; summer catch S = -279, $p < 0.001$; Figure 6: winter harvest S = -558, $p < 0.0001$; summer harvest S = -821, $p < 0.0001$. Reported Northern Pike catches were generally higher in the open water period than in the winter (≈10000 more Northern Pike caught in the open water period) but harvests between the winter and open water season were similar (Figures 5 and 6, respectively). Retention rates (i.e., % kept) significantly declined from 1970 to 2018 (winter: S = -316, $p < 0.0001$; open water: S = -285, $p < 0.0001$) but winter anglers kept a much larger proportion of the fish they caught compared to open water anglers (Figure 7). Open water anglers were twice as successful as winter anglers (0.34 Northern Pike caught•angler-hour^{-1} in the open water whereas winter catch rate was 0.17 Northern Pike caught•angler-hour^{-1}) even though winter anglers could fish with 2 lines (Figure 8). There was a weakly significant declining trend for winter angler success (S = -133, $p < 0.05$). The number of Northern Pike caught and harvested by anglers in winter and open water seasons were positively correlated to the amount of fishing effort (Table 2). However, the relationships were weaker for the winter season (i.e., r^2 much lower in winter; r^2 of 0.30 to 0.47, compared to open water season; r^2 of 0.70 and 0.80).

Table 2. Linear regression models of fishing effort-catch and fishing effort-harvest for winter and open water recreational fisheries for Northern Pike.

Winter Season

	Slope (β)		Intercept (α)		r^2	Sample Size
	Estimate	95% Confidence Limits	Estimate	95% confidence Limits		
Catch	0.091	0.054 to 0.128	-14301	-26521 to -2081	0.47	31
Harvests	0.066	0.035 to 0.069	-5352	-15625 to 4920	0.30	45

Open Water Season

	Slope (β)		Intercept (α)		r^2	Sample Size
	Estimate	95% Confidence Limits	Estimate	95% confidence Limits		
Catch	0.114	0.094 to 0.135	-3893	-9718 to 1933	0.80	34
Harvests	0.083	0.066 to 0.100	-11503	-18265 to -4740	0.70	46

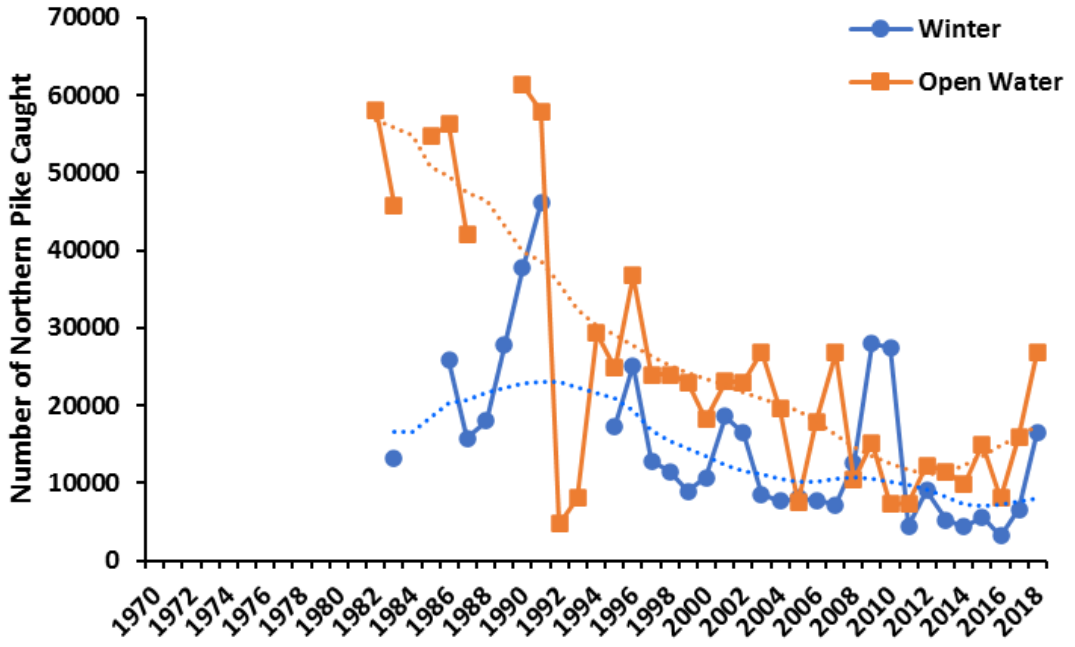

Figure 5. Estimated number of Northern Pike caught from the winter and open water creel surveys 1970 to 2018 (Significant trend lines (LOESS regression) for winter and open water catch time series also plotted).

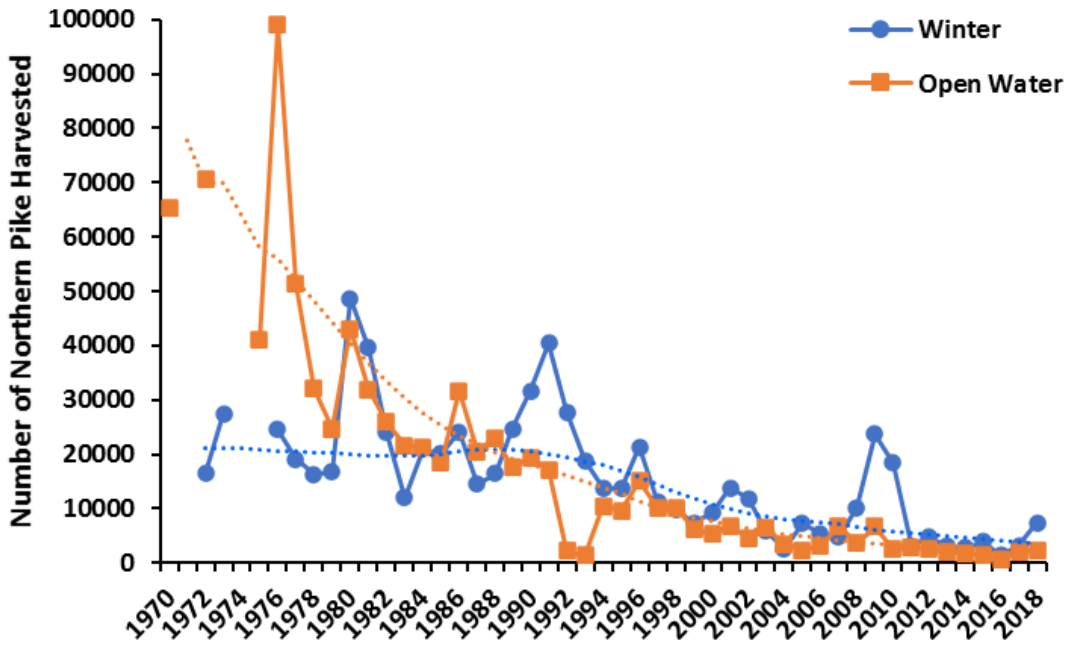

Figure 6. Estimated number of Northern Pike harvested from the winter and open water creel surveys 1970 to 2018 (Significant trend lines (LOESS regression) for winter and open water harvest time series also plotted).

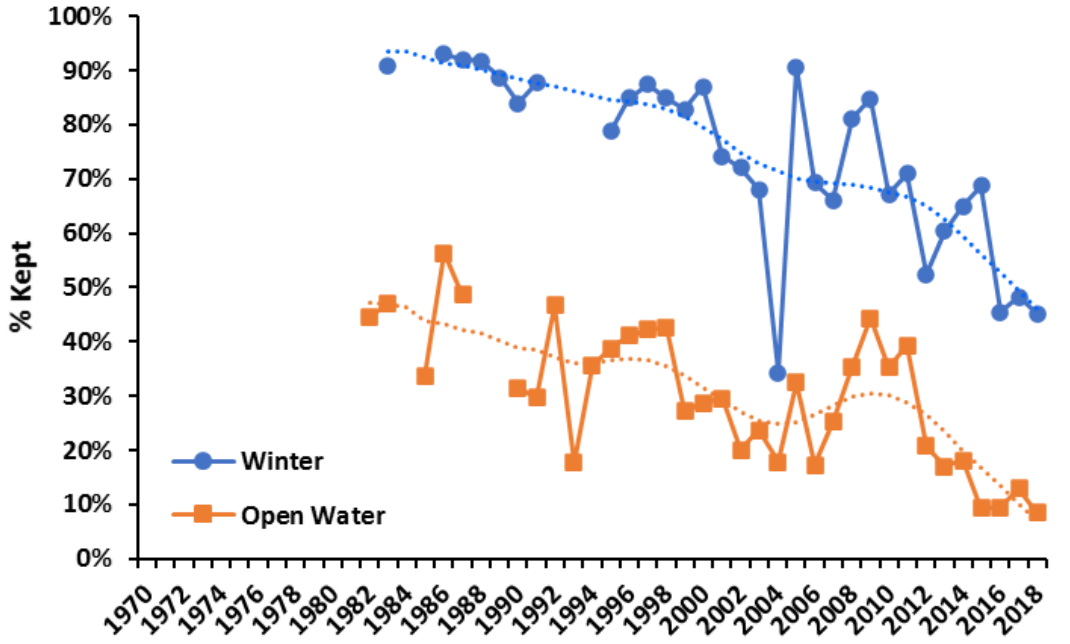

Figure 7. Proportion of Northern Pike kept from the winter and open water creel surveys 1970 to 2018 (Significant trend lines (LOESS regression) for winter and open water % kept time series also plotted).

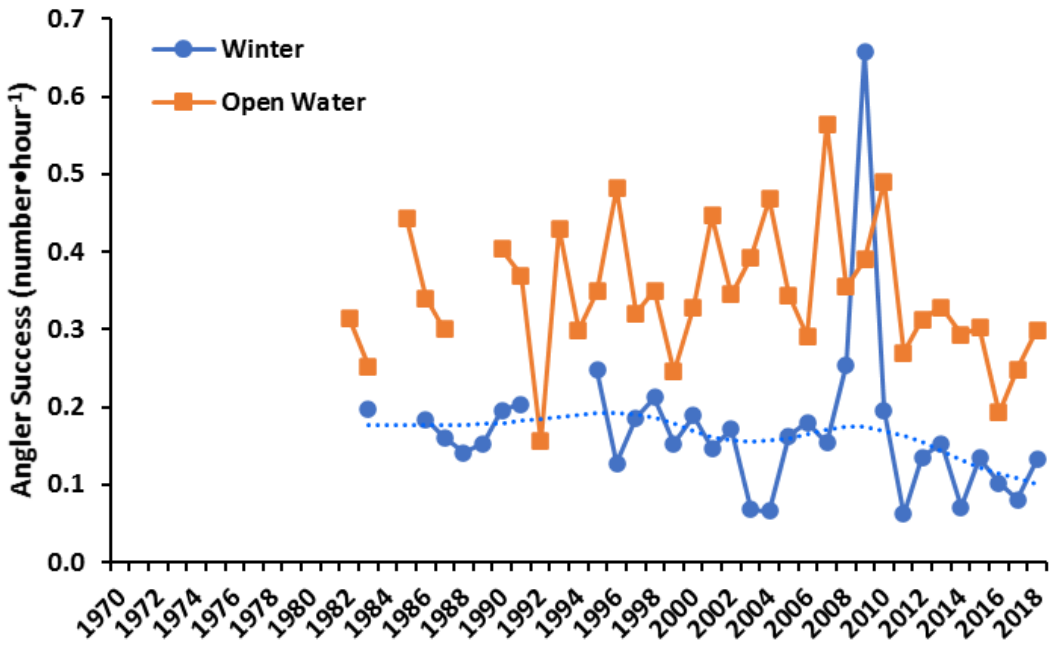

Figure 8. Angler success rate (number of Northern Pike caught•angler-hour^{-1}) from the winter and open water creel surveys 1970 to 2018 (Significant trend line (LOESS regression) for winter angler success time series also plotted).

Most anglers on Lake Nipissing caught at least one Northern Pike during their fishing trip (Figure 9 – left panels). Almost 90% of winter anglers caught one or more Northern Pike with the majority (74% of the anglers) catching one fish. In the open water season, more than 80% of the anglers caught one or more Northern Pike with most catching one or two fish (50% of the anglers caught one fish and 18% of the anglers caught two fish. The majority of the winter harvest (71%) was from anglers who kept one fish. One-quarter of the open water catch was by anglers catching three of more Northern Pike. Open water anglers who kept one or two fish accounted for 80% of the Northern Pike harvested.

The Gini coefficients (and associated Lorenz curves) generally indicated that the Northern Pike catch was distributed among more anglers than their harvest was in both the winter and open water periods (Figure 9). Also, the catch and harvest was more equitably distributed amongst winter anglers compared to open water anglers.

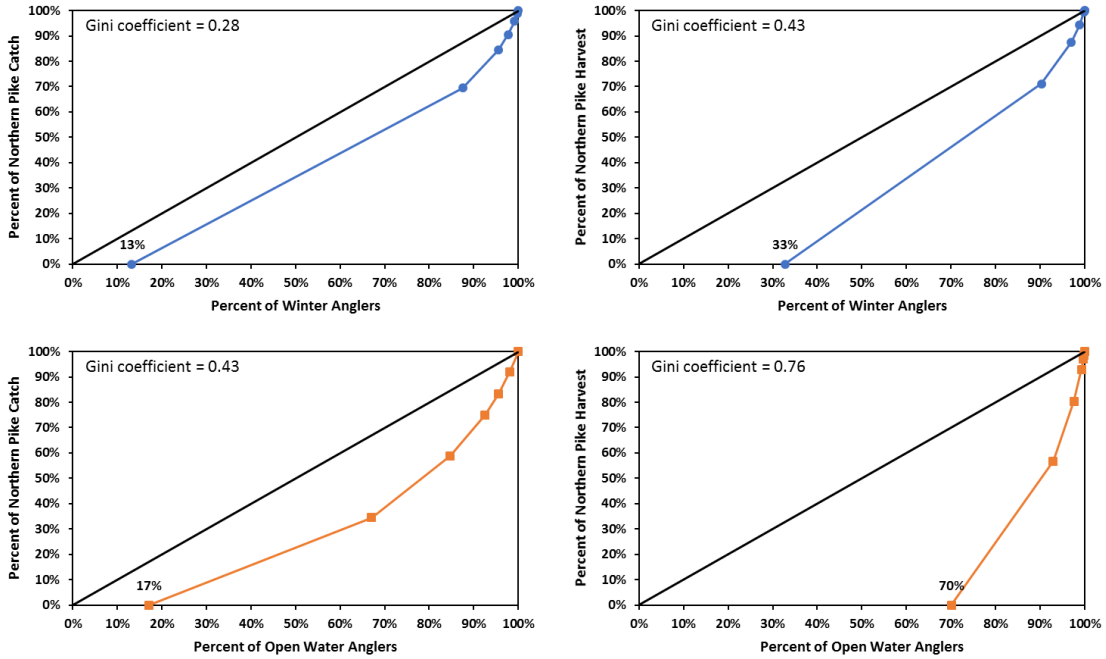

Figure 9. Lorenz curves and Gini coefficients for Northern Pike catch and harvest from anglers fishing ≥3 hours during winter (top panels) and open water (bottom panels) creel surveys 1998 to 2018 (pooled data; 1826 winter anglers and 924 open water anglers). The 45° line represents perfect equality of catch (a total of 1953 Northern Pike were caught in winter and 1339 Northern Pike were caught in open water) or harvest (a total of 1486 Northern Pike were harvested in winter and 382 Northern Pike were harvested in open water) amongst anglers (Gini coefficient = 0). Gini coefficients and the proportion of anglers who did not catch or harvest a Northern Pike are presented within the graphs.

The average size of Northern Pike harvested by anglers has significantly increased over the time series (Figure 10). The increase was marginally significant for the size of harvested Northern Pike in the winter ($S = 118$, $p < 0.05$) and highly significant for the size of harvested fish in the open water season ($S = 166$, $p < 0.0001$). There was little difference in the size of Northern Pike harvested by anglers in either the winter or open water season (Figure 11). Over the entire time series, the average size of harvested fish was ≈550mm long.

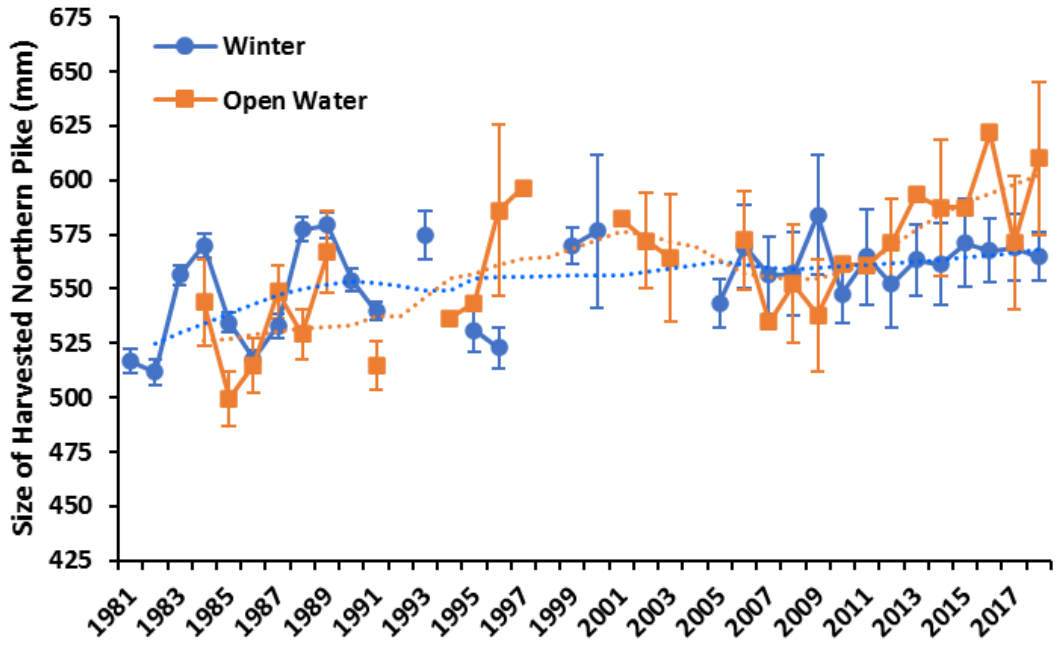

Figure 10. Average size (total length in mm) of harvested Northern Pike (with ±95% confidence limits displayed for samples sizes ≥30 fish) in the winter and open water creel surveys 1981 to 2018 (Significant trend lines (LOESS regression) for winter and open water average size time series also plotted).

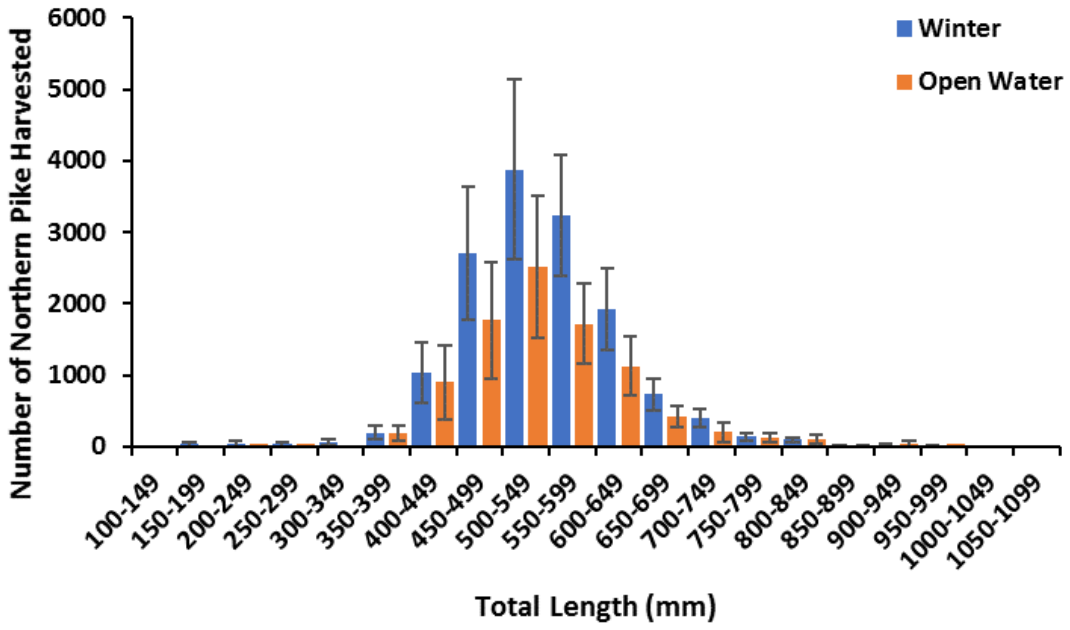

Figure 11. Size distribution (average ±95% confidence limits) of harvested Northern Pike from winter and open water creel surveys 1981 to 2018.

Over three-quarters of the Northern Pike harvested during the winter and open water periods were 2 to 4 years old (Figure 12). The average age of the harvested Northern Pike was 3.4 years old in the winter and 3.5 years old in the open water period.

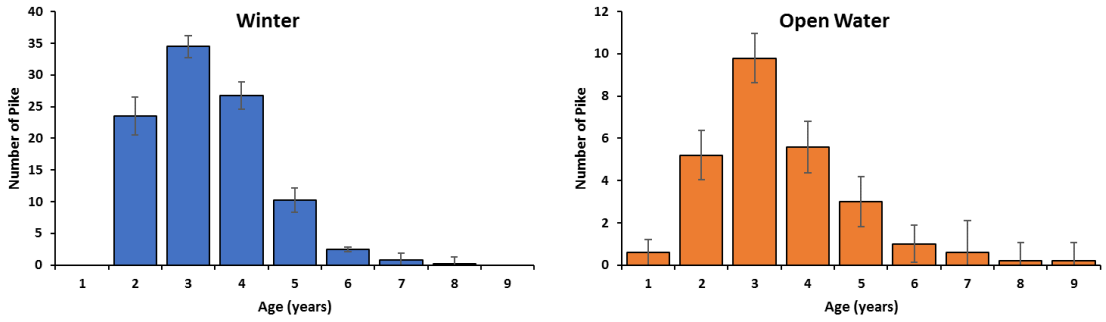

Figure 12. Age distributions (average ±95% confidence limits) of harvested Northern Pike from 2015 to 2018 winter creel surveys and 2014 to 2018 open water creel surveys

5.1 ***The Fisheries*** — Commercial: Between 1995 to 2018 the NFN commercial fishery harvest varied from 2000 to 8200 Northern Pike (Figure 13 – Note: A summary of the commercial harvest data is provided in Appendix 2). In most years the harvest was less than 4000 fish.

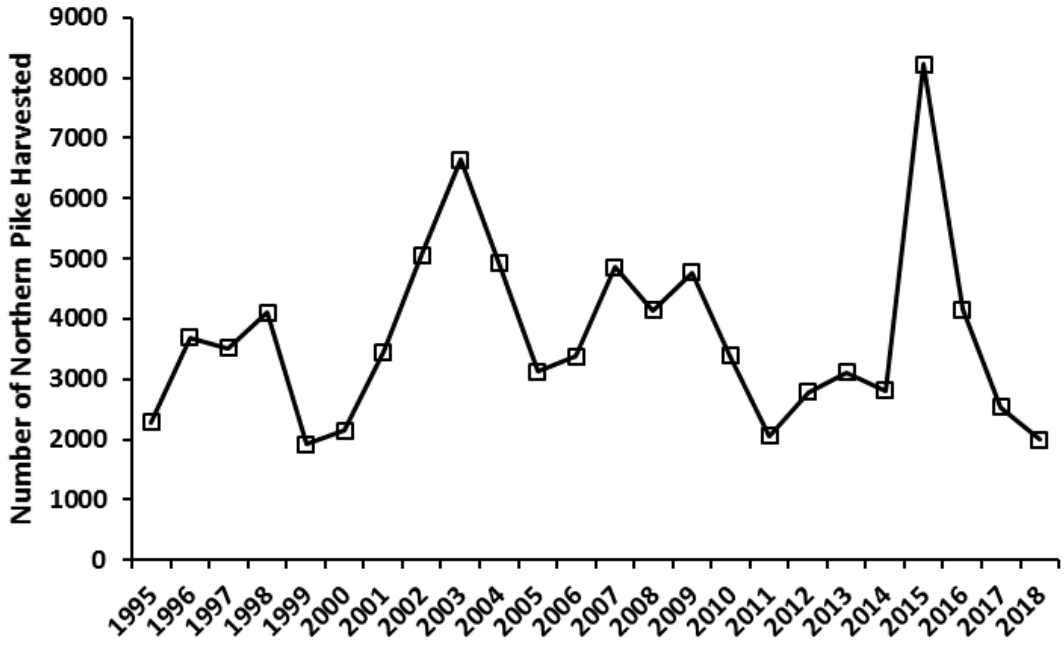

Figure 13. Estimated number of Northern Pike harvested by the Nipissing First Nation commercial fishery 1995 to 2018.

The average size of harvested Northern Pike in the NFN commercial fishery was ≈620mm and most fish were 3 or 4 years old (Figure 14). Using the harvest estimates from the fisheries, angling accounted for ≈75% of the number of Northern Pike removed annually from Lake Nipissing.

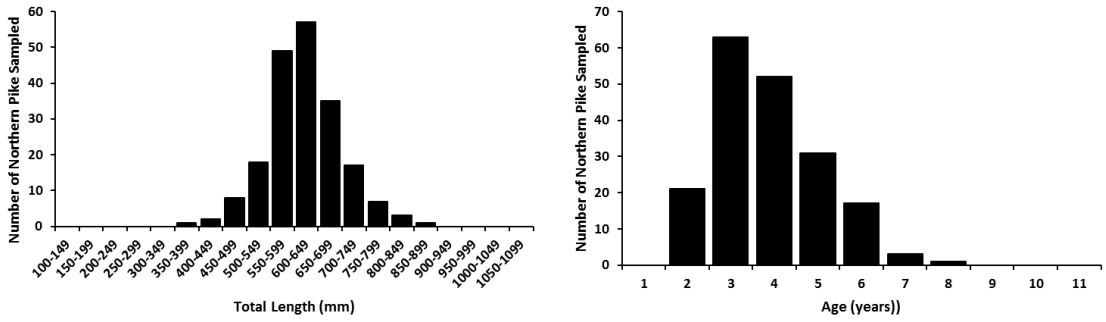

Figure 14. Size (left panel) and age (right panel) distribution of Northern Pike sampled during the 2014 to 2018 Nipissing First Nation commercial gill net fishery (pooled data)

5.2 *Biological Attributes* — The length of Northern Pike at age 3 has varied considerably over the last half-a-century (Figure 15 – Note: Appendix 3 summarizes the total length-at-age 3 data from the fishery-dependent and fishery-independent sampling programs. A summary of the total length across all ages is provided in Appendix 4). For example, the average age 3 Northern Pike measured in 2003 was 623 mm (95% confidence limits ±36.1 mm), nearly 300 mm longer than those in 1967 (337mm, 95% confidence limits ±34.5mm). The size-at-age 3 time series displayed a significant increasing trend (entire time series: $S = 446$, $p < 0001$ or excluding pre-1977 data points, $S = 369$, $p < 0.0001$).

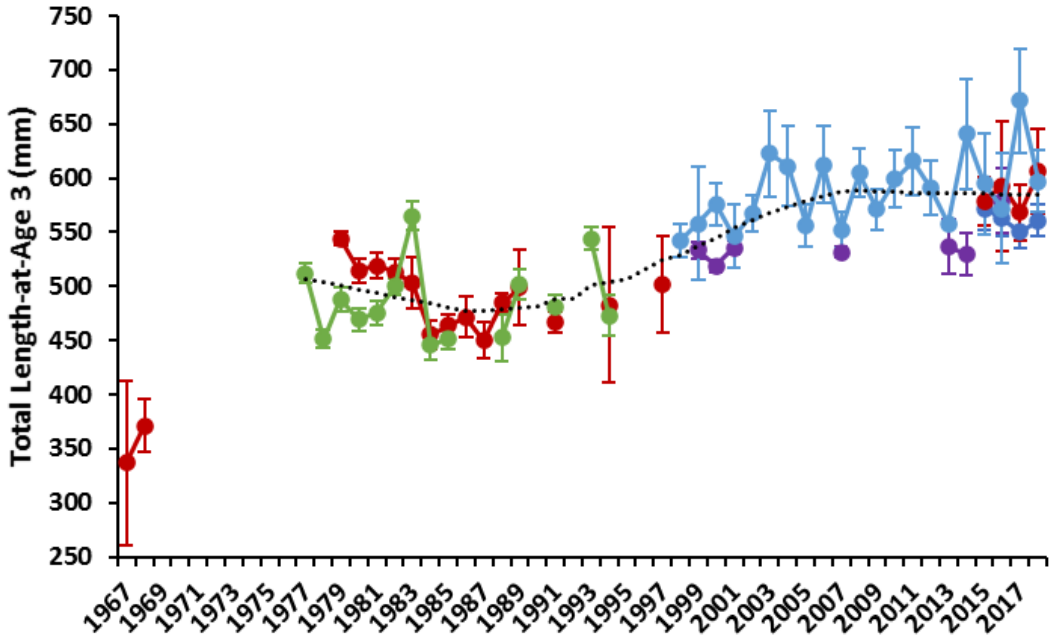

Figure 15. Northern Pike total length-at-age 3 (average ±95% confidence limits) from winter creel surveys (dark blue), open water creel surveys (red), summer index trap netting (green), ice out trap netting (purple), and fall Walleye index netting (light blue) 1967 to 2018 (Significant trend line (LOESS regression) for pooled size-at-age 3 time series 1977 to 2018 also plotted).

Estimated von Bertalanffy growth parameters for Northern Pike captured in the 1998 to 2018 fall Walleye index netting projects are shown in Table 3. The predicted von Bertalanffy and observed growth trajectories are shown in Figure 16. Northern Pike exhibited sexually dimorphic growth with males exhibiting a lower growth trajectory than females.

Table 3. Male and female Northern Pike von Bertalanffy growth parameters from fish captured during the 1998 to 2018 fall Walleye index netting projects.

Sex	L_∞		k		t_0		Sample Size
	Estimate (95% CL[1])	Standard Error	Estimate (95% CL)	Standard Error	Estimate (95% CL)	Standard Error	
Males	713 (678 to 748)	18.0	0.30 (0.24 to 0.36)	0.030	-1.89 (-2.29 to -1.49)	0.204	722
Females	1156 (1047 to 1226)	55.4	0.13 (0.10 to 0.15)	0.014	-2.89 (-3.36 to -2.41)	0.243	1072
All	1155 (1033 to 1278)	62.4	0.11 (0.09 to 0.14)	0.013	-3.34 (-3.82 to -2.85)	0.247	1810

1. 95% Confidence limits.

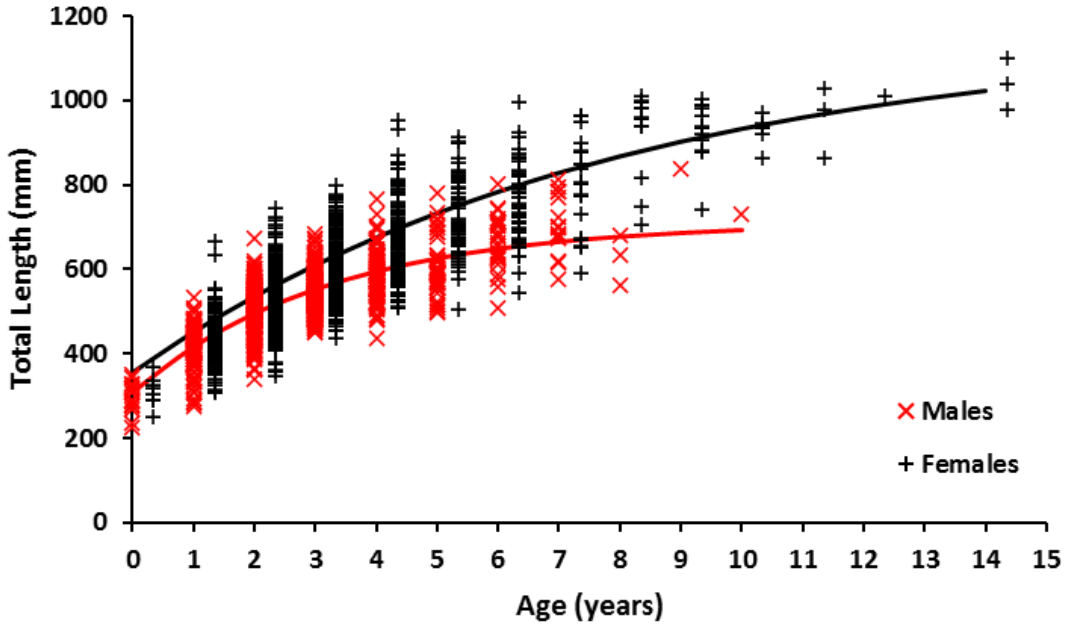

Figure 16. Observed (x and +) and von Bertalanffy predicted growth trajectory (line) for total length-at-age of male and female Northern Pike captured during the fall Walleye index netting projects 1998 to 2018.

The condition of Northern Pike based on all fall Walleye index netting data are provided in Table 4. The 95% confidence limits of the condition coefficient (the slope – 'β') from the fall Walleye index netting sampling did not overlap between males and females. Homogeneity (equality of) of slopes was rejected ($F_{1,1781} = 36.28$, $p<0.001$) using analysis of covariance (Whitlock and Schluter 2009). This suggests that condition was consistently higher in females compared to males (across all lengths).

Table 4. Condition (total length-weight regression of log_{10} transformed data) of male and female Northern Pike captured during the 1998 to 2018 fall Walleye index netting projects.

Sex	Slope (β)		Intercept (α)		r^2	Sample Size
	Estimate	95% Confidence Limits	Estimate	95% confidence Limits		
Males	3.16	312 to 3.19	$2.19x10^{-6}$	$1.75x10^{-6}$ to $2.73x10^{-6}$	0.98	718
Females	3.30	3.27 to 3.33	$8.67x10^{-7}$	$7.24x10^{-7}$ to $1.04x10^{-6}$	0.98	1065

Northern Pike total adult mortality ($Z_{\geq Age\ 3}$) rates varied three-fold over the last half century (Figure 17 - Note: A summary of the mortality estimates from the fishery-dependent and fishery-independent sampling programs is provided in Appendix 5. Selectivity adjusted age frequency distributions from the 1998 to 2018 fall Walleye index netting surveys are displayed in Appendix 6). The average for the entire time series was $Z_{\geq Age\ 3}$ = 0.80 (or an annual mortality rate of 54%).

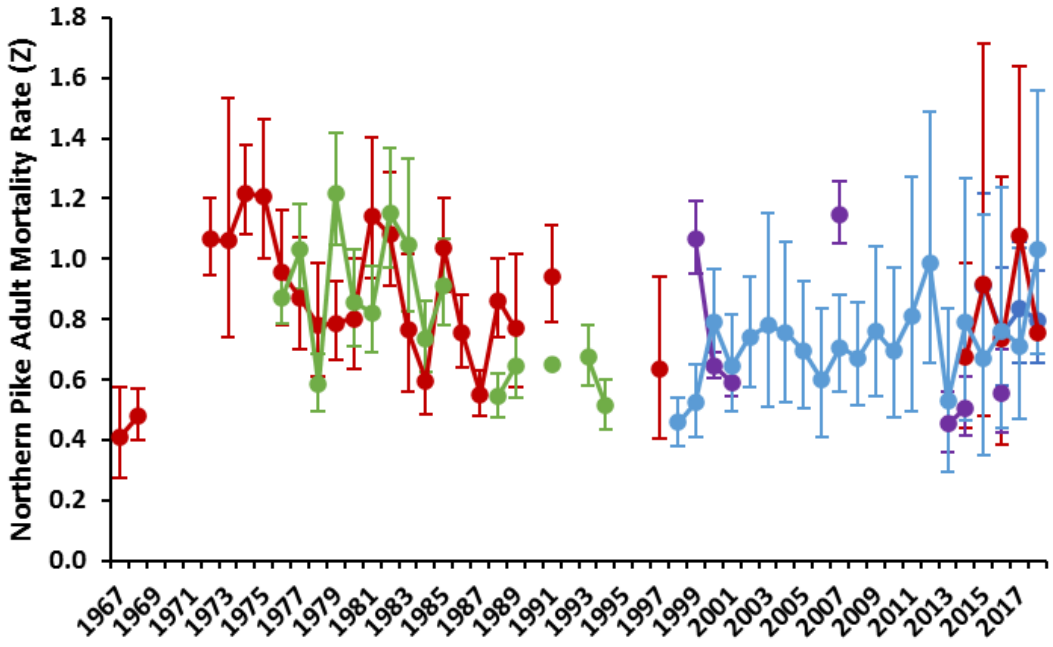

Figure 17. Northern Pike adult (≥3 years old) mortality rates ($Z_{\geq Age\ 3}$ ±95% confidence limits) estimated from age distributions of winter creel surveys (dark blue), open water creel surveys (red), summer index trap netting (green), ice out trap netting (purple), and fall Walleye index netting (light blue) 1967 to 2018.

The natural mortality rate (M) estimated from the modification of the Lester et al. 2014 life history model (using the average growing degree-day ≥5°C from 1967 to 2018) was M ≈ 0.28•$year^{-1}$ (Cindy Chu, Ontario Ministry of Natural Resources and Forestry, personal communication). The estimate was M ≈ 0.26•$year^{-1}$ from the Then et al. (2015) model using the von Bertalanffy growth parameters (fitted to the 1998 to 2018 fall Walleye index netting observations).

Northern Pike exploitation rate decreased from ≈50% in the 1970s to ≈20% in the late 1990s (Figure 18, S = -289, $p < 0.01$). Exploitation increased to ≈33% in the 2000s and has remained at that rate. Using the reference approach of Lester et al. (2014) a safe adult mortality rate would be where $F \leq M$ (F = fishing

mortality rate and M = natural mortality rate), which equates to an exploitation rate of less than 21%), and mortality rates where F > 2M (exploitation rate of more than 37%) should be avoided. Since the mid 1980s the Northern Pike population in Lake Nipissing have been exploited between theses two reference points (Figure 18).

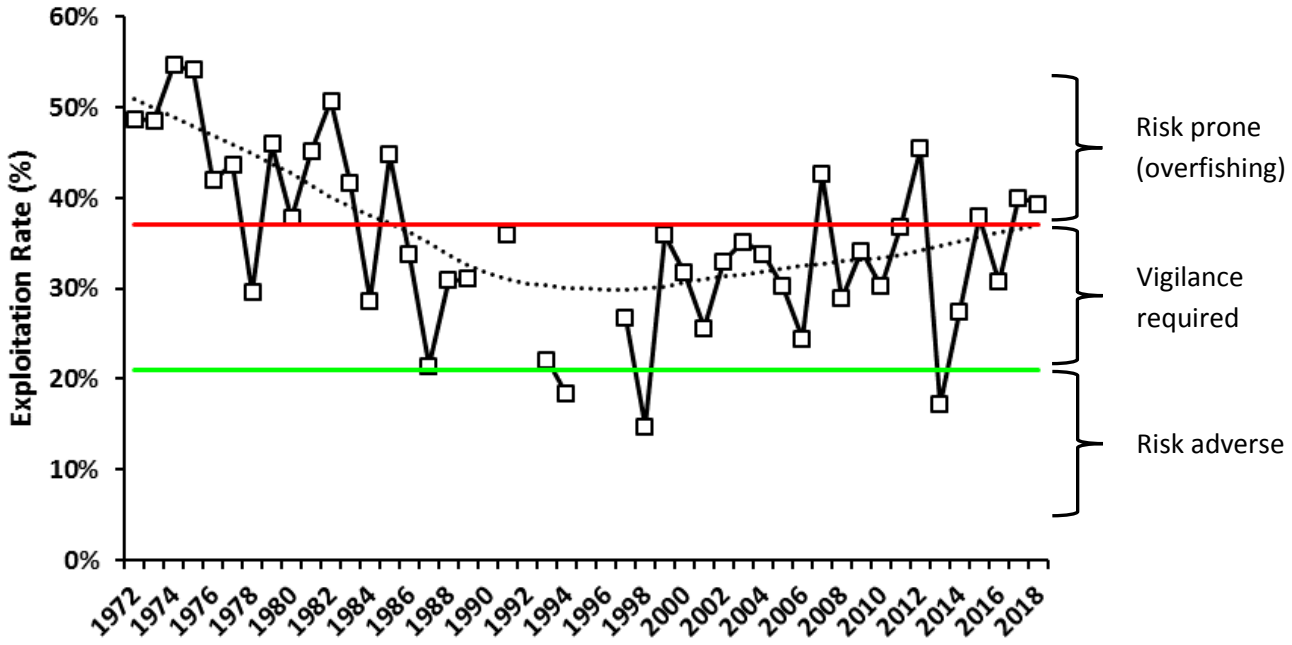

Figure 18. Estimated Northern Pike exploitation rates (u) from 1972 to 2018. Reference lines are unsustainable fishing mortality where F = 2M or u = 37% (red) and safe level of fishing mortality where F = M or u = 21% (green) (Significant trend line (LOESS regression) for exploitation rate time series also plotted).

The reconstructed exploitable Northern Pike stock biomass from the combined (angling and commercial gill net fisheries) yield (kg) and exploitation rate (i.e., biomass = Yield•u^{-1}) is presented in Figure 19. Biomass varied from ≈100000 to 175000 kg from 1972 to the end of the 1990s. Since that time Northern Pike biomass has significantly declined to less than 50000 kg ($S = -554$, $p < 0.0001$). With such high fishing exploitation, it is not surprising that the current exploitable stock biomass is less than one-third of that seen in the 1970s and 1980s.

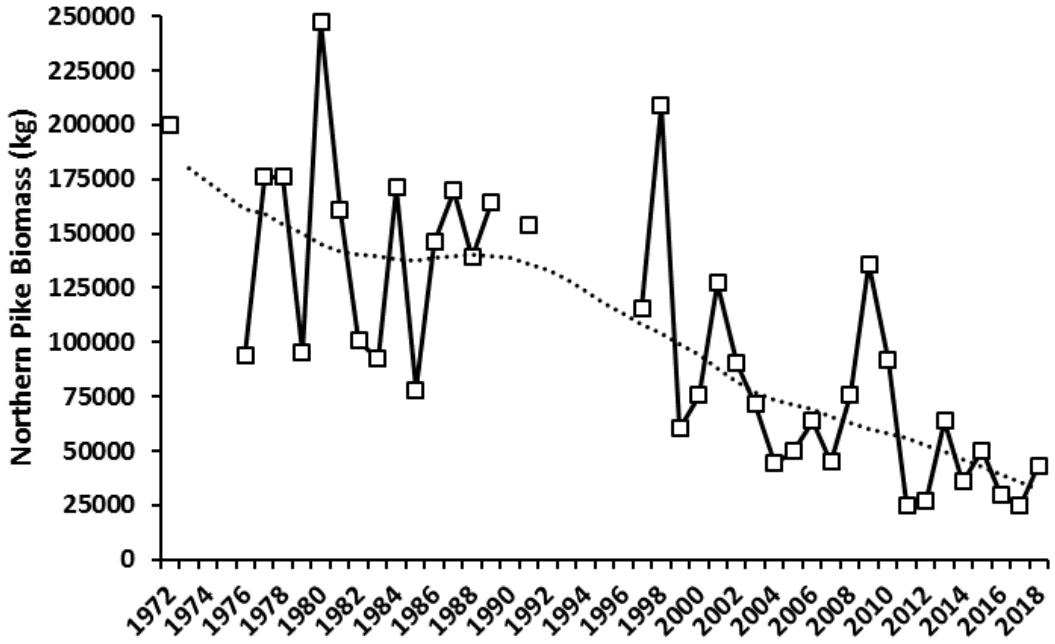

Figure 19. Reconstructed Northern Pike biomass (kg) from 1972 to 2018 (using M = 0.27) (Significant trend line (LOESS regression) for estimated biomass time series also plotted).

Northern Pike growth rate (i.e., average size of Northern Pike at age 3) increased as biomass decreased (Figure 20). This growth compensation-biomass trade off implies a density-dependent relationship.

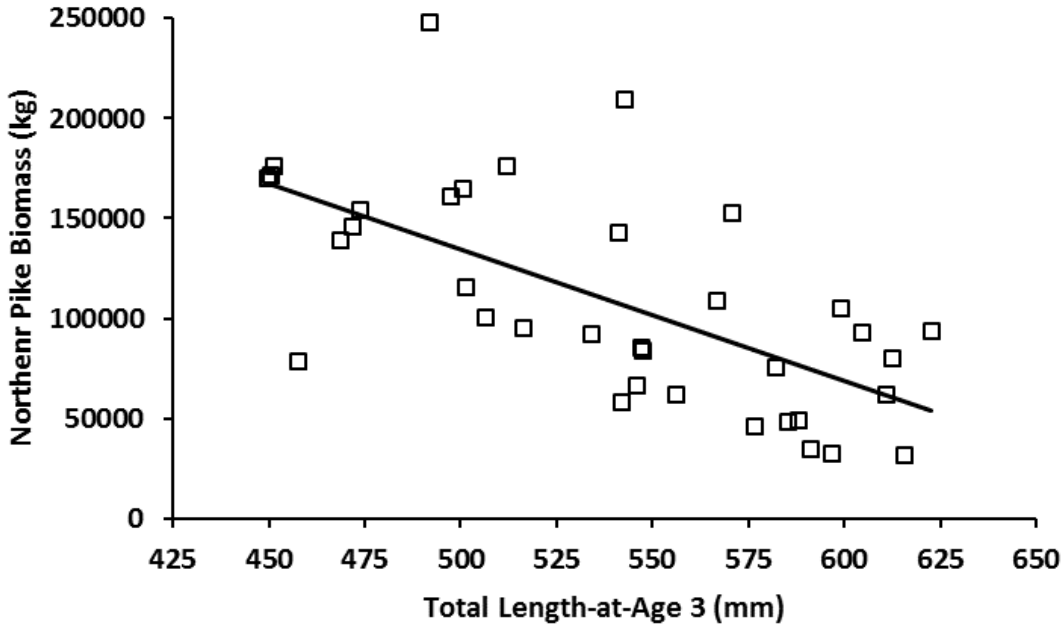

Figure 20. Relationship between observed average Northern Pike total length-at-age 3 (mm) and estimated biomass (kg). Biomass = -655.37(total length-at-age 3) + 462244 (n = 36, r^2 =0.42, p<0.001)

Open water angler effort tracked Northern Pike biomass (Table 5) while winter effort was not correlated (r^2 = 0.28, p = 0.09, n = 38).

Table 5. Linear regression models of Northern Pike biomass and open water fishing effort 1972 to 2018 fall Walleye index netting projects.

Model	Slope (β)		Intercept (α)		r^2	Sample Size
	Estimate	95% Confidence Limits	Estimate	95% confidence Limits		
$Y = \beta x + \alpha$	2.47	1.69 to 3.26	79995[1]	-13031 to 173022	0.53	38
$Y = \beta x$	3.06	2.66 to 3.46	-	-	0.87	

1. Intercept not significantly different from 0 (p=0.09).

6 Summary

The status of Northern Pike in Lake Nipissing was assessed using a combination of fishery-dependent (i.e., recreational winter and open water angling surveys, and commercial harvest data) and fishery-independent data (i.e., trap net and fall Walleye index netting surveys). The biological performance indicators (from both the fishery-dependent and fishery-independent) data that were considered were total length-at-age 3 (mm) and the population age structure (for estimating adult mortality – $Z_{\geq Age\ 3}$).

The Northern Pike population experienced relatively high levels of biomass through the 1990s. Subsequent declines in fishery metrics demonstrates a rapid and substantial decrease in harvestable biomass, reflective of unsustainable levels of exploitation. Changes in growth rate (i.e., total length-at-age 3) appeared to be negatively density-dependent. Recreational fishing effort during the open water period tracked the exploitable biomass. Efforts to reduce the harvest of Northern Pike should be focussed on angler harvest during the winter and open water periods.

The combination of fishery-independent estimates of mortality ($Z_{\geq Age\ 3}$) and patterns in size (total length-at-age 3) from the annual fall Walleye index netting program provide the most compelling source of information to assess Lake Nipissing's Northern Pike status.

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Appendix 1: Lake Nipissing recreational fishing effort and Northern Pike catch, harvest, and angler success data 1970 to 2018.

Year	Effort (angler-hours)		% Effort Targeting Northern Pike		Number of Northern Pike Caught		Number of Northern Pike Harvested		Weight of Northern Pike Harvested (kg)		Angler Success (number•hour^{-1})	
	Winter	Open Water	Winter	Open Water	Winter	Open Water	Winter	Open Water	Winter	Open Water	Winter	Open Water
1970	-	668068	-	-	-	-	-	65462	-	76656	-	-
1971	-	-	-	-	-	-	-	-	-	-	-	-
1972	180219	644195	-	-	-	-	16505	70689	14656	82777	-	-
1973	168985	-	-	-	-	-	27472	-	24395	-	-	-
1974	-	-	-	-	-	-	-	-	-	-	-	-
1975	-	867843	-	-	-	-	-	40972	-	47978	-	-
1976	326335	666843	-	-	-	-	24510	98942	21765	17709	-	-
1977	251020	803462	-	-	-	-	19074	51288	16938	60058	-	-
1978	298013	576737	-	-	-	-	16326	32112	14497	37603	-	-
1979	238138	562255	-	-	-	-	16738	24656	14863	28872	-	-
1980	643255	642261	-	-	-	-	48688	43029	43235	50387	-	-
1981	367704	650999	-	-	-	-	39592	31946	35158	37409	-	-
1982	319260	524281	-	22%	-	58129	23970	25956	20686	30394	-	0.315
1983	389005	471469	18%	22%	13196	45863	11989	21559	13176	25246	0.197	0.252
1984	258606	513199	-	-	-	-	20942	21337	24062	24986	-	-
1985	251940	376986	-	23%	-	54688	20081	18362	19920	15094	-	0.444
1986	300593	502855	-	32%	25860	56280	24057	31683	21315	27913	0.184	0.340
1987	234076	386598	41%	28%	15755	42019	14504	20474	14069	22296	0.161	0.300
1988	327051	499103	39%	-	18003	-	16518	22966	20895	22116	0.141	-
1989	466934	390644	39%	-	27784	-	24628	17614	31031	20098	0.153	-
1990	481194	405818	37%	25%	37699	61341	31629	19365	34665	22095	0.196	0.404
1991	472906	427579	46%	24%	46078	57915	40401	17172	40603	14716	0.204	0.369
1992	423399	100510	-	33%	-	4773	27775	2232	27914	1913	-	0.156
1993	345043	135265	-	9%	-	8099	18766	1436	22125	1231	-	0.430
1994	300837	388850	-	13%	-	29300	13789	10436	16257	11104	-	0.299
1995	289680	377061	20%	12%	17299	24879	13626	9631	13599	9573	0.247	0.349
1996	422574	437011	11%	10%	25122	36793	21321	15123	18976	21883	0.127	0.482
1997	287630	363335	0%	7%	12838	23963	11231	10112	9996	15663	0.186	0.321
1998	322785	308433	6%	11%	11499	23983	9761	10231	8687	15848	0.212	0.350
1999	288215	269360	13%	28%	8943	22953	7411	6235	9101	9658	0.153	0.245
2000	216442	190621	13%	23%	10649	18234	9268	5231	12697	8103	0.189	0.328
2001	262980	189072	10%	17%	18570	23093	13775	6837	18872	8457	0.147	0.447
2002	342518	252121	9%	18%	16475	22980	11880	4599	16276	5859	0.171	0.345
2003	340324	269146	6%	18%	8554	26939	5825	6401	7980	7048	0.068	0.393
2004	284684	153668	8%	22%	7702	19541	2639	3487	3615	3839	0.066	0.468
2005	321770	123285	9%	12%	8066	7434	7309	2416	7674	2660	0.163	0.344
2006	213523	205571	13%	26%	7798	17927	5408	3111	6592	3879	0.180	0.291
2007	310389	172574	11%	13%	7144	26818	4718	6785	5237	6459	0.154	0.565
2008	248992	167038	13%	13%	12509	10400	10157	3690	11335	4291	0.254	0.355
2009	276118	195841	13%	13%	27945	15179	23675	6739	32056	7137	0.658	0.390
2010	470358	77238	23%	18%	27514	7225	18475	2550	19584	2958	0.196	0.490
2011	332918	123490	11%	17%	4449	7368	3159	2900	3668	2393	0.062	0.270
2012	328991	126218	11%	14%	9077	12274	4754	2548	5120	2981	0.135	0.313
2013	277988	127797	8%	18%	5175	11453	3123	1955	3541	2686	0.153	0.328
2014	296059	109290	7%	17%	4388	9768	2854	1772	3248	2387	0.071	0.293
2015	255005	174255	11%	19%	5604	14988	3855	1398	4684	1780	0.134	0.302
2016	201168	139857	8%	12%	3170	8031	1440	756	1644	1175	0.102	0.193
2017	317370	170932	7%	31%	6602	16004	3184	2077	3551	2511	0.081	0.248
2018	392786	182643	25%	39%	16475	26840	7449	2290	9907	4026	0.132	0.299

Appendix 2: Nipissing First Nation commercial gill netting Northern Pike harvest data 1995 to 2018.

Year	Commercial Gill Net Northern Pike Harvest	
	Number[1]	Weight (kg)[2]
1995	2285	3489
1996	3690	5635
1997	3508	5357
1998	4101	6262
1999	1926	2941
2000	2151	3284
2001	3448	5265
2002	5061	7728
2003	6638	10136
2004	4929	7527
2005	3122	4767
2006	3376	5154
2007	4857	7417
2008	4142	6325
2009	4772	7287
2010	3387	5172
2011	2056	3140
2012	2790	4260
2013	3117	4759
2014	2812	4293
2015	8214	12542
2016	4156	6346
2017	2529	3862
2018	1990	3038

1. The 1995 to 1998 Northern Pike harvest data (number and weight) are from McLeod (1999). The number of Northern Pike harvested from 1999 to 2018 was based on the reported Walleye harvest and the ratio of Northern Pike-to-Walleye reported in the daily catch forms (Nikki Commanda, NFN natural resources biologist, personal communication).

2. The weight of Northern Pike harvested was calculated from the number harvested multiplied by the average weight (kg) of Northern Pike sampled in the 2014 to 2018 commercial catch monitoring programs (1.527 kg).

Appendix 3: Summary of Northern Pike total length-at-age 3 data from winter and open water creel surveys, summer index trap netting, ice out trap netting, and fall Walleye index netting 1967 to 2018.

Winter Creel Surveys

Year	Total Length-at-Age 3 (mm)	Lower 95% Confidence Limit	Upper 95% Confidence Limit	Number Age 3 Northern Pike
1967	-	-	-	-
1968	-	-	-	-
1969	-	-	-	-
1970	-	-	-	-
1971	-	-	-	-
1972	-	-	-	-
1973	-	-	-	-
1974	-	-	-	-
1975	-	-	-	-
1976	-	-	-	-
1977	-	-	-	-
1978	-	-	-	-
1979	-	-	-	-
1980	-	-	-	-
1981	-	-	-	-
1982	-	-	-	-
1983	-	-	-	-
1984	-	-	-	-
1985	-	-	-	-
1986	-	-	-	-
1987	-	-	-	-
1988	-	-	-	-
1989	-	-	-	-
1990	-	-	-	-
1991	-	-	-	-
1992	-	-	-	-
1993	-	-	-	-
1994	-	-	-	-
1995	-	-	-	-
1996	-	-	-	-
1997	-	-	-	-
1998	-	-	-	-
1999	-	-	-	-
2000	-	-	-	-
2001	-	-	-	-
2002	-	-	-	-
2003	-	-	-	-
2004	-	-	-	-
2005	-	-	-	-
2006	-	-	-	-
2007	-	-	-	-
2008	-	-	-	-
2009	-	-	-	-
2010	-	-	-	-
2011	-	-	-	-
2012	-	-	-	-
2013	-	-	-	-
2014	-	-	-	-
2015	572.3	552.1	592.4	15
2016	562.9	546.0	579.8	20
2017	550.6	535.5	565.7	32
2018	560.8	546.2	575.3	40

Appendix 3. (continued)

Open Water Surveys

Year	Total Length-at-Age 3 (mm)	Lower 95% Confidence Limit	Upper 95% Confidence Limit	Number of Age 3 Northern Pike
1967	337.0	261.2	412.8	3
1968	371.3	346.9	395.8	8
1969	-	-	-	-
1970	-	-	-	-
1971	-	-	-	-
1972	-	-	-	-
1973	-	-	-	-
1974	-	-	-	-
1975	-	-	-	-
1976	-	-	-	-
1977	-	-	-	-
1978	-	-	-	-
1979	544.4	538.2	550.6	205
1980	514.6	503.6	525.6	70
1981	519.3	507.6	530.9	81
1982	513.7	501.7	525.6	95
1983	503.1	479.8	526.3	26
1984	455.6	442.1	469.1	33
1985	463.8	453.4	474.3	115
1986	471.8	452.4	491.2	57
1987	449.9	433.0	466.8	35
1988	484.9	476.3	493.5	79
1989	498.9	464.0	533.9	13
1990	-	-	-	-
1991	467.2	457.3	477.0	69
1992	-	-	-	-
1993	-	-	-	-
1994	482.8	411.2	554.5	6
1995	-	-	-	-
1996	-	-	-	-
1997	501.5	456.7	546.3	7
1998	-	-	-	-
1999	-	-	-	-
2000	-	-	-	-
2001	-	-	-	-
2002	-	-	-	-
2003	-	-	-	-
2004	-	-	-	-
2005	-	-	-	-
2006	-	-	-	-
2007	-	-	-	-
2008	-	-	-	-
2009	-	-	-	-
2010	-	-	-	-
2011	-	-	-	-
2012	-	-	-	-
2013	-	-	-	-
2014	-	-	-	-
2015	579.1	556.7	601.5	10
2016	592.5	532.3	652.7	6
2017	568.3	542.4	594.2	16
2018	606.4	566.9	645.9	5

Appendix 3. (continued)

Summer Index Trap Netting

Year	Total Length-at-Age 3 (mm)	Lower 95% Confidence Limit	Upper 95% Confidence Limit	Number of Age 3 Northern Pike
1967	-	-	--	-
1968	-	-	--	-
1969	-	-	--	-
1970	-	-	--	-
1971	-	-	--	-
1972	-	-	--	-
1973	-	-	--	-
1974	-	-	--	-
1975	-	-	--	-
1976	-	-	--	-
1977	512.1	502.6	521.6	129
1978	451.5	443.2	459.9	101
1979	488.1	477.4	498.9	133
1980	469.3	458.6	480.0	71
1981	475.6	463.9	487.2	61
1982	499.8	491.8	507.8	97
1983	565.2	552.1	578.2	40
1984	445.8	432.1	459.5	72
1985	451.7	441.9	461.5	99
1986	-	-	--	-
1987	-	-	--	-
1988	452.5	431.2	473.7	70
1989	502.0	488.0	516.0	57
1990	-	-	--	-
1991	480.7	468.7	492.6	74
1992	-	-	--	-
1993	544.1	533.4	554.9	37
1994	472.8	454.0	491.6	
1995	-	-	--	-
1996	-	-	--	-
1997	-	-	--	-
1998	-	-	--	-
1999	-	-	--	-
2000	-	-	--	-
2001	-	-	--	-
2002	-	-	--	-
2003	-	-	--	-
2004	-	-	--	-
2005	-	-	--	-
2006	-	-	--	-
2007	-	-	--	-
2008	-	-	--	-
2009	-	-	--	-
2010	-	-	--	-
2011	-	-	--	-
2012	-	-	--	-
2013	-	-	--	-
2014	-	-	--	-
2015	-	-	--	-
2016	-	-	--	-
2017	-	-	--	-
2018	-	-	--	-

Appendix 3. (continued)

Ice Out Trap Netting

Year	Total Length-at-Age 3 (mm)	Lower 95% Confidence Limit	Upper 95% Confidence Limit	Number of Age 3 Northern Pike
1967	-	-	-	-
1968	-	-	-	-
1969	-	-	-	-
1970	-	-	-	-
1971	-	-	-	-
1972	-	-	-	-
1973	-	-	-	-
1974	-	-	-	-
1975	-	-	-	-
1976	-	-	-	-
1977	-	-	-	-
1978	-	-	-	-
1979	-	-	-	-
1980	-	-	-	-
1981	-	-	-	-
1982	-	-	-	-
1983	-	-	-	-
1984	-	-	-	-
1985	-	-	-	-
1986	-	-	-	-
1987	-	-	-	-
1988	-	-	-	-
1989	-	-	-	-
1990	-	-	-	-
1991	-	-	-	-
1992	-	-	-	-
1993	-	-	-	-
1994	-	-	-	-
1995	-	-	-	-
1996	-	-	-	-
1997	-	-	-	-
1998	-	-	-	-
1999	533.6	525.6	541.5	214
2000	518.8	513.6	523.9	368
2001	535.7	529.4	541.9	278
2002	-	-	-	-
2003	-	-	-	-
2004	-	-	-	-
2005	-	-	-	-
2006	-	-	-	-
2007	531.8	527.1	536.6	329
2008	-	-	-	-
2009	-	-	-	-
2010	-	-	-	-
2011	-	-	-	-
2012	-	-	-	-
2013	536.3	511.3	561.2	25
2014	530.1	510.4	549.8	39
2015	-	-	-	-
2016	579.1	548.6	609.5	29
2017	-	-	-	-
2018	-	-	-	-

Appendix 3. (continued)

Fall Walleye Index Netting

Year	Total Length-at-Age 3 (mm)	Lower 95% Confidence Limit	Upper 95% Confidence Limit	Number of Age 3 Northern Pike
1967	-	-	-	-
1968	-	-	-	-
1969	-	-	-	-
1970	-	-	-	-
1971	-	-	-	-
1972	-	-	-	-
1973	-	-	-	-
1974	-	-	-	-
1975	-	-	-	-
1976	-	-	-	-
1977	-	-	-	-
1978	-	-	-	-
1979	-	-	-	-
1980	-	-	-	-
1981	-	-	-	-
1982	-	-	-	-
1983	-	-	-	-
1984	-	-	-	-
1985	-	-	-	-
1986	-	-	-	-
1987	-	-	-	-
1988	-	-	-	-
1989	-	-	-	-
1990	-	-	-	-
1991	-	-	-	-
1992	-	-	-	-
1993	-	-	-	-
1994	-	-	-	-
1995	-	-	-	-
1996	-	-	-	-
1997	-	-	-	-
1998	542.7	527.4	558.0	46
1999	558.0	505.7	610.2	32
2000	576.3	556.9	595.8	53
2001	546.4	516.7	576.1	29
2002	567.0	550.3	583.6	68
2003	622.6	583.3	661.9	16
2004	610.9	573.7	648.0	20
2005	556.4	536.9	575.9	22
2006	612.7	576.5	648.8	15
2007	552.0	534.8	569.2	48
2008	604.8	582.6	627.0	38
2009	570.9	551.5	590.4	18
2010	599.0	572.4	625.6	16
2011	615.6	584.0	647.2	14
2012	591.4	566.4	616.4	20
2013	557.8	370.6	745.0	5
2014	640.7	590.2	691.2	10
2015	594.8	547.8	641.8	11
2016	572.0	521.2	622.8	6
2017	671.8	623.8	719.8	9
2018	597.3	568.4	626.1	15

Appendix 3. (continued)

Pooled Data (Winter and Open Water Creel, Summer Index Trap Netting, Ice Out Trap Netting, and Fall Walleye Index Netting)

Year	Total Length-at-Age 3 (mm)	Lower 95% Confidence Limit	Upper 95% Confidence Limit	Number of Age 3 Northern Pike
1967	337.0	302.4	371.5	3
1968	371.3	351.1	391.6	8
1969	-	-	-	-
1970	-	-	-	-
1971	-	-	-	-
1972	-	-	-	-
1973	-	-	-	-
1974	-	-	-	-
1975	-	-	-	-
1976	-	-	-	-
1977	512.1	502.7	521.5	129
1978	451.5	443.3	459.8	101
1979	522.2	515.9	528.6	338
1980	491.8	483.4	500.2	141
1981	500.5	491.6	509.4	142
1982	506.6	499.5	513.8	192
1983	540.7	527.0	554.4	66
1984	448.9	438.8	458.9	105
1985	458.2	451.1	465.4	214
1986	471.8	452.8	490.8	57
1987	449.9	433.6	466.2	35
1988	469.7	458.6	480.7	149
1989	501.4	488.9	513.9	70
1990	-	-	-	-
1991	474.1	466.4	481.8	142
1992	-	-	-	-
1993	544.1	533.6	554.7	74
1994	474.2	457.1	491.3	43
1995	-	-	-	-
1996	-	-	-	-
1997	501.5	465.6	537.4	7
1998	542.7	527.8	557.6	46
1999	536.8	527.3	546.2	246
2000	526.0	520.6	531.4	421
2001	536.7	530.4	542.9	307
2002	567.0	550.6	583.3	68
2003	622.6	586.5	658.8	16
2004	610.9	576.1	645.6	20
2005	556.4	538.0	574.7	22
2006	612.7	579.6	645.7	15
2007	534.4	529.7	539.1	377
2008	604.8	583.4	626.3	38
2009	570.9	552.9	589.0	18
2010	599.0	574.5	623.5	16
2011	615.6	586.9	644.2	14
2012	591.4	568.0	614.8	20
2013	539.9	511.6	568.1	30
2014	552.7	531.2	574.1	49
2015	578.7	562.6	594.8	49
2016	572.0	557.3	586.7	61
2017	575.1	557.7	592.6	56
2018	571.8	558.9	584.8	70

Appendix 4: Summary of Northern Pike total length-at-age data from winter and open water creel surveys, commercial catch sampling, summer index trap netting, ice out trap netting, and fall Walleye index netting 1967 to 2018.

Winter Creel Surveys 2014 to 2018

Age (years)	Northern Pike Total Length-at-Age (mm)								
	Average	Minimum	Maximum	Standard Error	Coefficient of Variation	25% Quartile	Median	75% Quartile	Sample Size
0	-	-	-	-	-	-	-	-	-
1	-	-	-	-	-	-	-	-	-
2	489	361	645	5.6	12%	484	450	524	106
3	560	417	660	4.2	9%	562	525	592	147
4	603	410	795	5.4	10%	593	570	642	131
5	628	355	755	10.3	12%	625	591	670	51
6	672	560	830	22.1	13%	635	605	745	15
7	616	540	745	64.8	18%	563	540	745	3
8	637	565	682	36.5	10%	665	565	682	3
9	-	-	-	-	-	-	-	-	-
10	-	-	-	-	-	-	-	-	-
11	-	-	-	-	-	-	-	-	-
12	-	-	-	-	-	-	-	-	-
13	-	-	-	-	-	-	-	-	-
14	-	-	-	-	-	-	-	-	-

Open Water Surveys 1967, 1968, 1972 to 1989, 1991, 1994, 1997, and 2015 to 2018

Age (years)	Northern Pike Total Length-at-Age (mm)								
	Average	Minimum	Maximum	Standard Error	Coefficient of Variation	25% Quartile	Median	75% Quartile	Sample Size
0	-	-	-	-	-	-	-	-	-
1	379	317	449	12.7	13%	383	327	426	14
2	456	276	650	3.5	13%	454	413	499	297
3	502	58	835	2.1	13%	502	459	543	939
4	544	50	874	2.9	14%	539	500	586	691
5	581	65	830	5.9	17%	567	531	630	270
6	662	502	940	11.4	15%	630	585	740	73
7	773	599	952	17.1	12%	769	698	847	30
8	852	632	945	34.0	12%	904	796	923	9
9	842	656	1023	44.9	15%	834	729	959	8
10	909	806	952	34.4	8%	938	838	949	4
11	991	941	1041	50.0	7%	991	706	783	2
12	-	-	-	-	-	-	-	-	-
13	-	-	-	-	-	-	-	-	-
14	-	-	-	-	-	-	-	-	-

Appendix 4 (continued)

Nipissing First Nation Commercial Catch Sampling 2014 to 2018

Age (years)	Northern Pike Total Length-at-Age (mm)								
	Average	Minimum	Maximum	Standard Error	Coefficient of Variation	25% Quartile	Median	75% Quartile	Sample Size
0	-	-	-	-	-	-	-	-	-
1	-	-	-	-	-	-	-	-	-
2	526	396	663	13.4	12%	538	493	560.5	21
3	592	457	694	6.6	9%	603	557	630	63
4	634	550	790	7.5	9%	628	592	668	52
5	650	509	800	13.4	11%	640	602	703	31
6	676	546	804	15.9	10%	687	631	720	17
7	748	680	833	45.0	10%	731	680	833	3
8	869	869	869	-	-	869	-	-	1
9	-	-	-	-	-	-	-	-	-
10	-	-	-	-	-	-	-	-	-
11	-	-	-	-	-	-	-	-	-
12	-	-	-	-	-	-	-	-	-
13	-	-	-	-	-	-	-	-	-
14	-	-	-	-	-	-	-	-	-

Summer Index Trap Netting 1977 to 1985, 1988, 1989, 1991, 1993, and 1994

Age (years)	Northern Pike Total Length-at-Age (mm)								
	Average	Minimum	Maximum	Standard Error	Coefficient of Variation	25% Quartile	Median	75% Quartile	Sample Size
0	-	-	-	-	-	-	-	-	-
1	332	235	517	13.0	22%	312	283	390	32
2	420	234	567	2.2	12%	425	393	450	518
3	485	58	685	1.9	13%	484	449	520	1114
4	556	167	810	2.7	13%	554	517	598	723
5	618	223	885	6.0	18%	618	563	690	338
6	716	223	940	12.8	21%	740	666	810	133
7	825	316	1041	11.9	12%	824	788	886	67
8	893	767	1021	12.3	7%	896	848	931	24
9	862	806	941	28.6	7%	850	815	920	4
10	1057	952	1161	104.5	14%	1057	714	873	2
11	-	-	-	-	-	-	-	-	-
12	-	-	-	-	-	-	-	-	-
13	-	-	-	-	-	-	-	-	-
14	-	-	-	-	-	-	-	-	-

Appendix 4 (continued)

Ice Out Trap Netting 1999 to 2001, 2007, 2013, 2014, and 2016

Age (years)	Northern Pike Total Length-at-Age (mm)								
	Average	Minimum	Maximum	Standard Error	Coefficient of Variation	25% Quartile	Median	75% Quartile	Sample Size
0	-	-	-	-	-	-	-	-	-
1	333	213	430	6.0	12%	334	300	359	45
2	458	149	882	1.8	11%	458	427	489	867
3	530	338	740	1.5	10%	525	495	561	1273
4	582	399	794	2.2	10%	574	545	620	769
5	647	383	923	4.9	15%	635	573	706	371
6	701	410	1010	9.6	18%	693	598	787	170
7	758	372	1025	22.4	24%	777	616	916	64
8	865	395	1080	28.8	18%	905	804	967	30
9	942	690	1100	27.9	12%	999	855	1020	16
10	795	442	1060	85.2	34%	898	481	1046	10
11	794	440	1041	181.5	40%	900	440	1041	3
12	1040	1040	1040	-	-	1040	-	-	1
13	-	-	-	-	-	-	-	-	-
14	-	-	-	-	-	-	-	-	-

Fall Walleye Index Netting 1998 to 2018

Age (years)	Northern Pike Total Length-at-Age (mm)								
	Average	Minimum	Maximum	Standard Error	Coefficient of Variation	25% Quartile	Median	75% Quartile	Sample Size
0	297	206	369	7.8	13%	292	277	325	25
1	430	235	667	3.7	14%	436	393	467	264
2	527	147	744	3.1	13%	534	485	569	489
3	578	163	798	3.4	13%	571	529	625	511
4	635	437	952	5.3	13%	623	574	682	263
5	679	498	915	9.7	15%	672	596	758	108
6	726	509	996	10.2	13%	714	663	790	82
7	759	575	965	18.4	14%	772	673	841	34
8	861	563	1010	39.8	18%	940	706	981	15
9	920	741	1002	20.4	8%	936	879	985	13
10	900	730	970	31.0	9%	934	863	947	7
11	956	862	1030	49.6	9%	977	862	1030	3
12	1010	1010	1010	-	-	1010	-	-	1
13	-	-	-	-	-	-	-	-	-
14	1040	980	1100	34.6	6%	1040	980	1100	3

Appendix 5. Age frequency data and estimated adult Northern Pike mortality rates ($Z_{\geq Age\ 3}$) from winter and open water creel surveys, summer index trap netting, ice out trap netting, and fall Walleye index netting 1967 to 2018.

Winter Creel Surveys

Age (years)	Number of Northern Pike with Age Interpretation by Year			
	2015	2016	2017	2018
0	-	-	-	-
1	24	8	19	43
2	28	29	31	50
3	15	20	32	40
4	4	9	9	19
5	2	3	2	3
6	1	2	-	-
7	-	-	-	1
8	-	-	-	-
9	-	-	-	-
10	-	-	-	-
11	-	-	-	-
12	-	-	-	-
13	-	-	-	-
14	-	-	-	-
Total	74	71	93	156
Average Age (yrs)	3.1	3.7	3.4	3.3

Open Water Creel Surveys

Age (years)	Number of Northern Pike with Age Interpretation by Year							
	1967	1968	1972	1973	1974	1975	1976	1977
0	-	-	-	-	-	-	-	-
1	-	-	32	7	36	29	17	-
2	1	-	74	15	173	117	63	13
3	3	8	190	23	211	80	62	45
4	7	55	73	9	70	37	33	37
5	12	44	20	1	19	8	8	7
6	8	16	3	1	5	-	4	4
7	1	3	-	1	-	-	-	1
8	-	-	5	-	1	-	-	-
9	-	-	1	-	-	-	1	-
10	-	-	-	-	-	-	-	-
11	-	-	-	-	-	-	-	-
12	-	-	-	-	-	-	-	-
13	-	-	-	-	-	-	-	-
14	-	-	-	-	-	-	-	-
Total	32	126	398	55	515	271	188	107
Average Age (yrs)	4.8	4.6	3.0	2.9	2.8	2.5	2.8	3.5

Appendix 5 (continued)

Open Water Creel Surveys (continued)

Age (years)	Number of Northern Pike with Age Interpretation by Year							
	1978	1979	1980	1981	1982	1983	1984	1985
0	-	-	-	-	-	-	3	-
1	1	-	-	4	5	-	16	13
2	11	30	18	82	70	5	33	115
3	28	79	42	80	96	18	46	56
4	34	34	24	21	31	20	29	10
5	7	21	7	3	10	9	8	3
6	3	10	6	2	2	1	5	3
7	1	3	1	2	4	-	2	-
8	-	1	1	2	-	-	4	1
9	-	-	-	-	-	-	3	-
10	-	-	-	-	-	-	2	-
11	-	-	-	-	-	-	3	-
12	-	-	-	-	-	-	-	-
13	-	-	-	-	-	-	-	-
14	-	-	-	-	-	-	-	-
Total	85	178	99	196	218	53	151	201
Average Age (yrs)	3.6	3.5	3.5	2.8	3.0	3.7	4.3	3.4

Open Water Creel Surveys (continued)

Age (years)	Number of Northern Pike with Age Interpretation by Year							
	1986	1987	1988	1989	1991	1997	2014	2015
0	-	-	-	-	-	-	-	-
1	-	-	-	-	-	-	1	-
2	7	1	8	2	2	4	6	4
3	57	35	79	13	69	7	11	10
4	70	90	83	34	67	13	7	1
5	20	76	16	5	11	2	7	1
6	5	7	5	-	2	2	2	-
7	1	2	1	-	-	1	-	-
8	-	-	-	-	-	-	-	1
9	-	-	-	-	-	-	-	-
10	-	-	-	-	-	-	-	-
11	-	-	-	-	-	-	-	-
12	-	-	-	-	-	-	-	-
13	-	-	-	-	-	-	-	-
14	-	-	-	-	-	-	-	-
Total	160	211	192	54	151	29	34	17
Average Age (yrs)	3.8	4.3	3.7	3.8	3.6	3.4	3.6	3.2

Appendix 5 (continued)

Open Water Creel Surveys (continued)

Age (years)	Number of Northern Pike with Age Interpretation by Year		
	2016	2017	2018
0	-	-	-
1	-	1	1
2	2	4	10
3	7	16	5
4	5	10	5
5	2	2	3
6	1	-	2
7	-	-	3
8	-	-	-
9	-	-	1
10	-	-	-
11	-	-	-
12	-	-	-
13	-	-	-
14	-	-	-
Total	17	33	30
Average Age (yrs)	3.7	3.2	3.9

Summer Index Trap Netting

Age (years)	Number of Northern Pike with Age Interpretation by Year							
	1976	1977	1978	1979	1980	1981	1982	1983
0	-	-	-	-	-	-	-	-
1	-	1	-	6	1	-	9	-
2	2	123	22	82	37	19	74	4
3	8	138	52	133	71	61	98	40
4	66	67	44	44	30	50	45	33
5	184	20	30	13	6	17	5	4
6	154	7	13	2	7	7	1	-
7	42	-	10	-	2	-	3	-
8	9	-	1	1	2	-	-	-
9	4	-	-	-	1	-	-	-
10	-	-	-	-	-	-	-	-
11	-	-	-	-	-	-	-	-
12	-	-	-	-	-	-	-	-
13	-	-	-	-	-	-	-	-
14	-	-	-	-	-	-	-	-
Total	469	356	172	281	157	154	235	81
Average Age (yrs)	5.4	3.0	4.0	3.0	3.3	3.6	2.9	3.5

Appendix 5 (continued)

Summer Index Trap Netting (continued)

Age (years)	Number of Northern Pike with Age Interpretation by Year						
	1984	1985	1988	1989	1991	1993	1994
0	-	-	-	-	-	-	-
1	-	-	1	6	-	4	-
2	27	25	11	17	3	26	16
3	72	99	70	57	73	74	37
4	46	40	70	47	62	59	47
5	29	22	40	18	30	39	35
6	6	4	35	8	12	4	14
7	3	1	11	7	6	2	11
8	1	1	3	4	3	4	3
9	1	-	-	-	1	1	-
10	-	1	-	-	-	1	-
11	-	-	-	-	-	-	-
12	-	-	-	-	-	-	-
13	-	-	-	-	-	-	-
14	-	-	-	-	-	-	-
Total	185	193	241	164	190	214	163
Average Age (yrs)	3.6	3.5	4.2	3.8	4.1	3.7	4.2

Ice Out Trap Netting

Age (years)	Number of Northern Pike with Age Interpretation by Year						
	1999	2000	2001	2007	2013	2014	2016
0	-	-	-	-	-	-	-
1	17	10	8	1	5	4	-
2	171	215	100	293	48	35	3
3	191	368	278	326	24	40	20
4	40	290	157	161	21	29	23
5	9	171	108	32	12	14	11
6	4	74	59	4	8	9	9
7	3	16	28	-	2	7	-
8	1	2	16	-	1	4	2
9	-	3	2	-	5	2	1
10	-	2	1	1	3	-	-
11	-	1	-	-	-	1	-
12	-	-	-	-	-	1	-
13	-	-	-	-	-	-	-
14	-	-	-	-	-	-	-
Total	436	1152	757	818	129	146	69
Average Age (yrs)	2.7	3.6	3.9	2.9	3.6	3.8	4.2

Appendix 5 (continued)

Fall Walleye Index Netting

Age (years)	Number of Northern Pike with Age Interpretation by Year							
	1998	1999	2000	2001	2002	2003	2004	2005
0	4	1	1	1	-	-	1	3
1	13	17	17	9	27	1	4	7
2	37	21	21	25	29	28	9	22
3	46	29	29	29	45	15	20	22
4	25	20	20	18	8	6	6	13
5	19	12	12	8	1	4	5	5
6	20	12	12	7	10	-	5	3
7	9	-	-	3	-	2	-	2
8	4	-	-	1	3	-	-	1
9	1	3	3	-	1	-	-	-
10	4	2	2	-	-	-	-	-
11	1	-	-	-	-	-	-	-
12	-	-	-	-	-	-	-	-
13	-	-	-	-	-	-	-	-
14	1	-	-	-	-	-	-	-
Total	184	117	117	101	124	56	50	78
Average Age (yrs)	3.9	3.5	2.6	3.3	2.8	2.9	3.2	3.0

Fall Walleye Index Netting (continued)

Age (years)	Number of Northern Pike with Age Interpretation by Year							
	2006	2007	2008	2009	2010	2011	2012	2013
0	1	-	-	-	2	1	3	-
1	10	3	-	5	8	4	23	18
2	11	41	9	18	23	14	18	23
3	15	40	34	17	16	14	20	5
4	10	21	18	19	12	5	2	6
5	5	11	-	3	3	-	4	3
6	-	5	4	-	-	-	2	1
7	-	-	5	1	1	-	-	2
8	-	1	2	-	1	1	-	-
9	2	1	1	1	1	1	-	-
10	1	-	-	-	-	-	-	-
11	-	1	-	-	-	-	-	-
12	-	-	-	-	1	1	-	-
13	-	-	-	-	-	-	-	-
14	-	-	1	-	-	-	-	-
Total	55	124	74	64	68	41	72	58
Average Age (yrs)	3.1	3.2	3.9	3.1	3.0	2.8	2.2	2.4

Appendix 5 (continued)

Fall Walleye Index Netting (continued)

Age (years)	Number of Northern Pike with Age Interpretation by Year				
	2014	2015	2016	2017	2018
0	2	0	3	1	0
1	13	12	3	6	10
2	16	8	12	10	15
3	10	11	6	9	17
4	4	5	6	5	7
5	4	1	4	0	2
6	1	2	0	0	1
7	0	2	0	0	0
8	0	0	0	0	0
9	0	0	0	1	0
10	0	0	0	0	0
11	0	0	0	0	0
12	0	0	0	0	0
13	0	0	0	0	0
14	0	1	0	0	0
Total	50	42	34	32	52
Average Age (yrs)	2.3	3.0	2.5	2.4	2.5

Appendix 5 (continued)

Winter Creel Surveys

Year	$Z_{\geq Age\ 3}$	Lower 95% Confidence Limit	Upper 95% Confidence Limit	Number of Northern Pike ≥Age 3
1967	-	-	-	-
1968	-	-	-	-
1969	-	-	-	-
1970	-	-	-	-
1971	-	-	-	-
1972	-	-	-	-
1973	-	-	-	-
1974	-	-	-	-
1975	-	-	-	-
1976	-	-	-	-
1977	-	-	-	-
1978	-	-	-	-
1979	-	-	-	-
1980	-	-	-	-
1981	-	-	-	-
1982	-	-	-	-
1983	-	-	-	-
1984	-	-	-	-
1985	-	-	-	-
1986	-	-	-	-
1987	-	-	-	-
1988	-	-	-	-
1989	-	-	-	-
1990	-	-	-	-
1991	-	-	-	-
1992	-	-	-	-
1993	-	-	-	-
1994	-	-	-	-
1995	-	-	-	-
1996	-	-	-	-
1997	-	-	-	-
1998	-	-	-	-
1999	-	-	-	-
2000	-	-	-	-
2001	-	-	-	-
2002	-	-	-	-
2003	-	-	-	-
2004	-	-	-	-
2005	-	-	-	-
2006	-	-	-	-
2007	-	-	-	-
2008	-	-	-	-
2009	-	-	-	-
2010	-	-	-	-
2011	-	-	-	-
2012	-	-	-	-
2013	-	-	-	-
2014	-	-	-	-
2015	0.9102	0.6748	1.2186	50
2016	0.7548	0.5782	0.9695	63
2017	0.8345	0.6540	1.0549	74
2018	0.7963	0.6550	0.9610	113

Appendix 5. (continued)

Open Water Creel Surveys

Year	$Z_{\geq Age\ 3}$	Lower 95% Confidence Limit	Upper 95% Confidence Limit	Number of Northern Pike ≥Age 3
1967	0.4111	0.2722	0.5724	31
1968	0.4798	0.3982	0.5687	126
1969	-	-	-	-
1970	-	-	-	-
1971	-	-	-	-
1972	1.0654	0.9446	1.2028	292
1973	1.0609	0.7408	1.5344	35
1974	1.2187	1.0828	1.3760	306
1975	1.2059	1.0021	1.4620	125
1976	0.9544	0.7818	1.1630	108
1977	0.8705	0.7023	1.0728	94
1978	0.7795	0.6094	0.9845	73
1979	0.7862	0.6635	0.9262	148
1980	0.8023	0.6358	1.0023	81
1981	1.1433	0.9386	1.4011	110
1982	1.0802	0.9089	1.2870	143
1983	0.7638	0.5608	1.0186	48
1984	0.5970	0.4835	0.7251	132
1985	1.0352	0.8907	1.2040	188
1986	0.7533	0.6382	0.8835	153
1987	0.5522	0.4797	0.6303	210
1988	0.8611	0.7399	0.9990	184
1989	0.7697	0.5728	1.0151	52
1990	-	-	-	-
1991	0.9392	0.7931	1.1103	149
1992	-	-	-	-
1993	-	-	-	-
1994	-	-	-	-
1995	-	-	-	-
1996	-	-	-	-
1997	0.6360	0.4038	0.9389	25
1998	-	-	-	-
1999	-	-	-	-
2000	-	-	-	-
2001	-	-	-	-
2002	-	-	-	-
2003	-	-	-	-
2004	-	-	-	-
2005	-	-	-	-
2006	-	-	-	-
2007	-	-	-	-
2008	-	-	-	-
2009	-	-	-	-
2010	-	-	-	-
2011	-	-	-	-
2012	-	-	-	-
2013	-	-	-	-
2014	0.6745	0.4380	0.9847	27
2015	0.9163	0.4776	1.7164	13
2016	0.7340	0.3858	1.2725	15
2017	1.0745	0.7166	1.6373	28
2018	0.7538	0.4449	1.2030	19

Appendix 5. (continued)

Summer Index Trap Netting

Year	$Z_{\geq Age\ 3}$	Lower 95% Confidence Limit	Upper 95% Confidence Limit	Number of Northern Pike ≥Age 3
1967	-	-	-	-
1968	-	-	-	-
1969	-	-	-	-
1970	-	-	-	-
1971	-	-	-	-
1972	-	-	-	-
1973	-	-	-	-
1974	-	-	-	-
1975	-	-	-	-
1976	0.8734	0.7879	0.9669	467
1977	1.0308	0.9006	1.1805	232
1978	0.5836	0.4927	0.6837	150
1979	1.2150	1.0470	1.4171	193
1980	0.8571	0.7088	1.0312	119
1981	0.8225	0.6884	0.9774	135
1982	1.1497	0.9723	1.3654	152
1983	1.0486	0.8272	1.3333	77
1984	0.7337	0.6226	0.8588	158
1985	0.9127	0.7786	1.0677	168
1986	-	-	-	-
1987	-	-	-	-
1988	0.5459	0.4765	0.6204	229
1989	0.6436	0.5404	0.7586	141
1990	-	-	-	-
1991	0.6504	0.5594	0.7505	187
1992	-	-	-	-
1993	0.6746	0.5795	0.7796	184
1994	0.5127	0.4318	0.6006	147
1995	-	-	-	-
1996	-	-	-	-
1997	-	-	-	-
1998	-	-	-	-
1999	-	-	-	-
2000	-	-	-	-
2001	-	-	-	-
2002	-	-	-	-
2003	-	-	-	-
2004	-	-	-	-
2005	-	-	-	-
2006	-	-	-	-
2007	-	-	-	-
2008	-	-	-	-
2009	-	-	-	-
2010	-	-	-	-
2011	-	-	-	-
2012	-	-	-	-
2013	-	-	-	-
2014	-	-	-	-
2015	-	-	-	-
2016	-	-	-	-
2017	-	-	-	-
2018	-	-	-	-

Appendix 5. (continued)

Ice Out Trap Netting

Year	$Z_{\geq Age\ 3}$	Lower 95% Confidence Limit	Upper 95% Confidence Limit	Number of Northern Pike ≥Age 3
1967	-	-	-	-
1968	-	-	-	-
1969	-	-	-	-
1970	-	-	-	-
1971	-	-	-	-
1972	-	-	-	-
1973	-	-	-	-
1974	-	-	-	-
1975	-	-	-	-
1976	-	-	-	-
1977	-	-	-	-
1978	-	-	-	-
1979	-	-	-	-
1980	-	-	-	-
1981	-	-	-	-
1982	-	-	-	-
1983	-	-	-	-
1984	-	-	-	-
1985	-	-	-	-
1986	-	-	-	-
1987	-	-	-	-
1988	-	-	-	-
1989	-	-	-	-
1990	-	-	-	-
1991	-	-	-	-
1992	-	-	-	-
1993	-	-	-	-
1994	-	-	-	-
1995	-	-	-	-
1996	-	-	-	-
1997	-	-	-	-
1998	-	-	-	-
1999	1.0655	0.9518	1.1938	248
2000	0.6468	0.6057	0.6897	927
2001	0.5908	0.5460	0.6377	649
2002	-	-	-	-
2003	-	-	-	-
2004	-	-	-	-
2005	-	-	-	-
2006	-	-	-	-
2007	1.1477	1.0492	1.2570	524
2008	-	-	-	-
2009	-	-	-	-
2010	-	-	-	-
2011	-	-	-	-
2012	-	-	-	-
2013	0.4533	0.3565	0.5606	76
2014	0.5058	0.4128	0.6084	107
2015	-	-	-	-
2016	0.5531	0.4250	0.7000	66
2017	-	-	-	-
2018	-	-	-	-

Appendix 5. (continued)

Fall Walleye Index Netting

Year	$Z_{\geq Age\ 3}$	Lower 95% Confidence Limit	Upper 95% Confidence Limit	Number of Northern Pike ≥Age 3
1967	-	-	-	-
1968	-	-	-	-
1969	-	-	-	-
1970	-	-	-	-
1971	-	-	-	-
1972	-	-	-	-
1973	-	-	-	-
1974	-	-	-	-
1975	-	-	-	-
1976	-	-	-	-
1977	-	-	-	-
1978	-	-	-	-
1979	-	-	-	-
1980	-	-	-	-
1981	-	-	-	-
1982	-	-	-	-
1983	-	-	-	-
1984	-	-	-	-
1985	-	-	-	-
1986	-	-	-	-
1987	-	-	-	-
1988	-	-	-	-
1989	-	-	-	-
1990	-	-	-	-
1991	-	-	-	-
1992	-	-	-	-
1993	-	-	-	-
1994	-	-	-	-
1995	-	-	-	-
1996	-	-	-	-
1997	-	-	-	-
1998	0.4569	0.3800	0.5402	141
1999	0.5232	0.4112	0.6494	92
2000	0.7906	0.6427	0.9644	110
2001	0.6433	0.4952	0.8173	72
2002	0.7412	0.5737	0.9424	73
2003	0.7802	0.5095	1.1524	29
2004	0.7557	0.5259	1.0545	39
2005	0.6931	0.5044	0.9260	50
2006	0.5991	0.4067	0.8376	35
2007	0.7061	0.5581	0.8798	87
2008	0.6702	0.5138	0.8556	70
2009	0.7621	0.5441	1.0413	44
2010	0.6931	0.4755	0.9717	38
2011	0.8109	0.4958	1.2736	24
2012	0.9886	0.6572	1.4876	30
2013	0.5281	0.2928	0.8362	18
2014	0.7885	0.4667	1.2658	21
2015	0.6690	0.4048	1.0292	24
2016	0.7621	0.4335	1.2550	17
2017	0.7122	0.4677	1.0365	16
2018	1.0296	0.6855	1.5584	28

Appendix 6. Northern Pike age frequency distributions from 1998 to 2018 fall Walleye index netting surveys (selectivity adjusted relative abundance; number•net^{-1}).