Wildlife, Fisheries and Resource Enforcement Branch Report **2020**

Lake Manitoba

2020 Fish Stock Assessment

Agriculture and Resource Development
2020 - 2021

Lake Manitoba Fish Stock Assessment 2020

Introduction

Lake Manitoba has been a commercial fishery since 1895. It also has a long history as a recreational fishery, and an even longer one as a subsistence fishery. The first written record of subsistence net fishing in Lake Manitoba appears in the *Journal of Henry the Younger*. Henry visits the house of a Mr. Desjarlais near Maple Island at the Narrows on February 3, 1804 and reports:

> "He takes daily a number of fine large White Fish in his nets. This fishing never fails but is abundant the whole year round, but more particularly in the Autumn when almost any number may be caught. They generally weigh from 12 to 20 lbs."

In modern times, Lake Manitoba is underperforming socially and economically. The Lake Whitefish (*Coregonus clupeaformis*) that never failed Desjarlais, has fallen to a trace species in the subsistence and commercial fisheries, and the largest specimen caught in the index netting program since 2009 has only weighed 3.3 pounds. Commercial fishing for high-value Yellow Perch (*Perca flavescens*) – the motivation for the introduction of small mesh fishing in 1985 – has led to the near extirpation of Sauger (*Sander canadensis*); a species that used to contribute 200,000 kilograms to the annual harvest. Small mesh fishing also led to commercial Walleye (*Sander vitreus*) production at only half the potential level. Wisely, commercial fishers have suspended small mesh fishing for the past three years, beginning in 2017.

Growth and age analyses in stock assessment show that Lake Manitoba has the potential to produce trophy-sized Walleye. Master Angler record submissions from Lake Manitoba's limited recreational fishery confirm the ability of the lake to produce trophy Walleye (Appendix 2). Interestingly, Lake Manitoba's large, recreationally caught Walleye are submitted predominately by Manitobans (only ⅛ of Master Angler submissions are from non-residents) signalling it as an undiscovered drive-to trophy fishery that could be attractive to tourist anglers; the anglers who bring new wealth to Manitoba. March is a particularly good month to attract American anglers to Manitoba. The ice fishing industry is the fastest growing sector in recreational fishing, and at a time of year when ice conditions are beginning to deteriorate in Midwestern states, Manitoba ice is safe and the weather is pleasant. In March of 2015, Lake Winnipeg registered 259 Master Angler Walleye; 27% by out-of-province anglers. Lake Manitoba only registered four Walleye in that period, all caught by Manitobans, even though every Walleye in Lake Manitoba has greater potential to become a trophy than every Lake Winnipeg Walleye.

Commercial Regulations

The Lake Manitoba commercial fishery has a maximum allowable commercial quota of 907.2 tonnes roundweight of Walleye and Sauger combined. In 2015 there were 554 fishers eligible for licensing. If equally divided, each fisher would have 1638 kg of quota. Commercial fishers were split into Category 'A' and Category 'B' in 1987 depending on whether or not they had caught an average of at least 200 kg per year in the preceding three years. Category A licenses, awarded to those who exceeded the threshold, can be transferred to new individuals wishing to become fishers. Category B licenses cannot be transferred once the holder is done his fishing career; the license retires with the fisher. Birth years of B license holders in 2015 ranged from 1918 to 1969 with a median of 1949. The B license holders are steadily aging out of the fishery as intended back in 1987. There were 441 Category A licenses in 2015 and 113 Category B licenses. Eligibility to acquire an A license requires a minimum age of 18 years, two years fishing experience, and residency in a rural municipality or the unorganized territory adjacent to Lake Manitoba. In order to transfer the right to acquire a license, an A license fisher makes an application through the regional fisheries manager to sell his fishing enterprise to a prospective fisher. The actual tenure to acquire a license remains the property of the Crown, but is transferred along with the enterprise as a courtesy to the fisher and to enhance the confidence and stability required for a fisher to invest in a fishing enterprise.

Large Mesh Winter Fishery

The regular commercial season for most species only operates in winter and has done since 1905. The season begins when ice makes after November 1st; that is, a fisher may only set his nets through the ice, he may not set in open water. Anxious fishers have been known to set their first nets using planks and sheets of plywood to distribute their weight over early ice. Due to the vagaries of wind and weather, first deliveries have been made anywhere from the second week of November to the first week of December. The long-term median start date is in the fourth week of November. The regular season ends on March 31. The minimum mesh size allowed in the large mesh winter season is 95 mm, 3¾". The maximum mesh size allowed in the fishery is 127 mm, or 5" stretched mesh.

Small Mesh Fishery

In 1985, a 76 mm, 3", fishery officially began, although hearsay and delivery records suggest some 3" fishing started a few years before. When the 3" fishery is operating, a fisher may continue to fish nets from 3¾" – 5", but nothing between 3" and 3¾"; 76 – 95 mm. That said, the legal tolerance is 3 mm before a fisher must remove a net from the water and charges are laid when a 4 mm tolerance is exceeded. In practice, the gap between small mesh and large mesh can be as small as 79 – 92 mm.

The large mesh fishery begins to capture Walleye at a fork length of 350 mm. The small mesh fishery catches Walleye as small as 300 mm and because the length:frequency curves, particularly for smaller meshes, are skewed to the right, no size Walleye between 300 and 680 mm is protected when the 3" fishery is operating (Figure 1). The steep ascending limb of the 3" mesh curve reflects the size gap between one year old and two year old Walleye in the population (Figure 2). There are not many fish below 300 mm to be caught, only a few very fast growing one year olds, and a few slow growing two year olds.

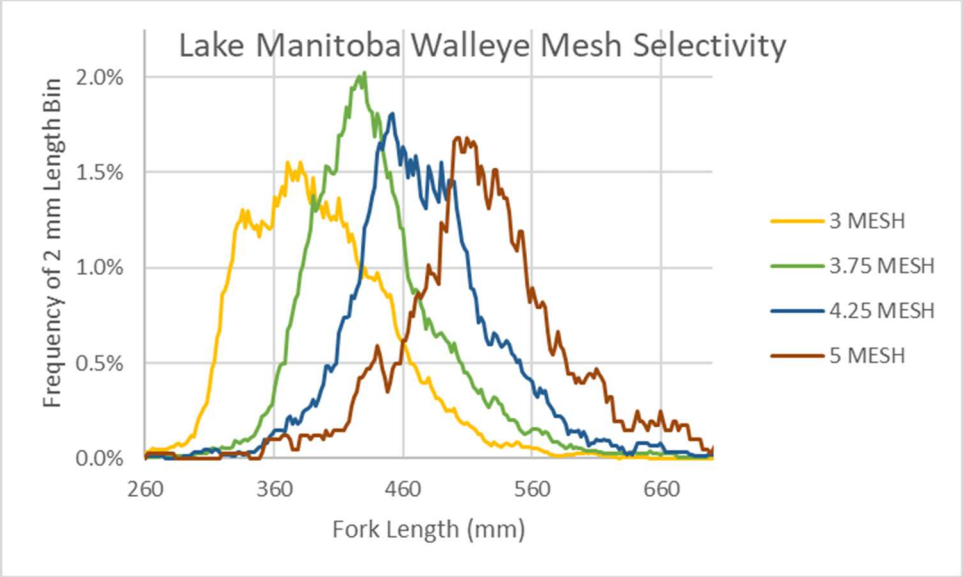

Figure 1. Mesh size selectivities in the Lake Manitoba index netting program, 2009-2019.

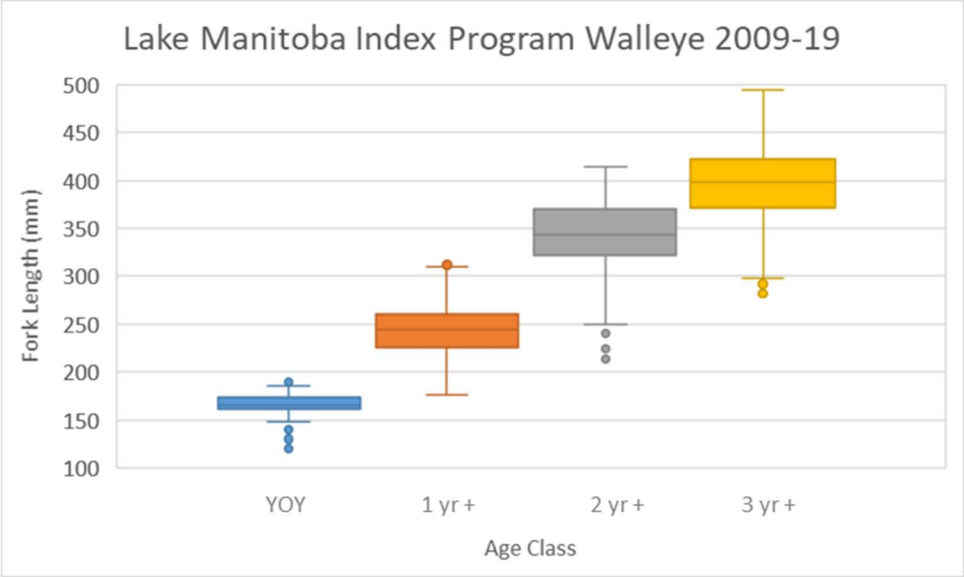

Figure 2. Box and whisker plot of median Walleye lengths at age from the index netting program 2009 – 2019. Boxes delineate middle two quartiles. Note there is very little overlap in size between young-of-the-year (YOY) and 1^+ year old fish, and 1^+ and 2^+ fish. The size separation between 1^+ and 2^+ fish results in the steep rising limb of the 3" selectivity curve in Figure 1. Fish are measured in September. A YOY fish will be four months old, a 1^+ year old fish is sixteen months old, and so on.

Initially the small mesh season lasted for 5 weeks. By 1992 the small mesh season had been extended from January 1 to March 15. In subsequent years, the close date was moved earlier to the end of February, and then in 2005 the open window was moved two weeks later; January 15 to March 15 where it has remained since. In an attempt to offset the harm to the fish stocks caused by the smaller mesh, the season for large mesh winter fishing was shortened from March 31 to March 15 coinciding with the small mesh close date. The small mesh fishery in the north basin was discontinued in 2001 restoring the March 31 season end date there.

In 2011, flooding of Lake Manitoba resulted in a very large year class of Northern Pike. By 2013, the irruption of pike was making small mesh fishing on Lake Manitoba difficult. Pike ate most of the Yellow Perch targeted by the small mesh nets leaving few perch available to the fishery. At the same time, remaining fish gilled in the small mesh nets baited pike into the nets. Pike became entangled by their teeth, and while struggling would roll the nets into a much shallower profile that no longer fished effectively. Disentangling low value pike from their nets cost fishers additional time to remove the rolled up pike. As a result, fishers became progressively less interested in fishing small mesh and for the 2017/18, 2018/19, and 2019/20

seasons agreed not to fish small mesh in exchange for the opportunity to fish in the south basin until the end of March instead of March 15.

Carp Fishery

Common Carp (*Cyprinus carpio*) is an invasive species to Lake Manitoba. The first commercial deliveries were made in 1938. Fishers may pursue carp year round with an additional license. Fishers can use gill nets or beach seines to capture carp. The minimum mesh size allowed in the gillnet fishery is 203 mm, 8" stretch, and the maximum 250 mm, or 10" stretch mesh. There is no quota on carp. Mullet is a colloquial name for any mix of sucker species. Mullet caught as bycatch in the carp fishery may be retained for sale. On Lake Manitoba, mullet will refer to primarily White Sucker (*Catostomus commersoni*), with a very small percentage of Shorthead Redhorse (*Moxostoma macrolepidotum*). In 2014, when a smoked market for Freshwater Drum (*Aplodinotus grunniens*) briefly emerged in Russia, that species was also permitted under carp licenses. Russia embargoed the fish the following year over Canada's support for Ukraine during Russia's annexation of Crimea.

Delta Marsh Carp Fishery

A spring and summer carp fishery is permitted in tributaries that enter the southern shore of Lake Manitoba from Delta Marsh, under a separate fishing license. Carp ascend these tributaries to access the marsh to spawn in the spring and summer. In recent years attempts to protect the marsh from ecological damage caused by carp have included the installation of metal grates that deny access to large carp and cause them to aggregate below the gates. The areas around the gates have been designed to allow a directed carp seining fishery. Allowable mesh sizes are the same as those that are permitted on Lake Manitoba proper. There is no quota for invasive carp for this fishery.

Spring Creek Mullet Fishery

When Lake Manitoba tributaries swell with snowmelt running off the land in springtime, White suckers ascend streams and drains to spawn. Commercial fishers may purchase an additional license to capture the mullet using trap nets, hoop nets, or other impoundment gear. The gear may not block more than 2/3 of the channel width and must be checked daily. Sites are granted on a stream by stream basis. There is no quota on mullet. Some streams, like those along the north shore of Lake Manitoba are not permitted due to concerns related to Walleye spawning and constructed riffles. Conservation Officers may close sites on a location by location basis if they consider the operation is negatively affecting spawning migrations of other species; Walleye in particular. Usually no bycatch is allowed, but in 2013 at the request of fishers to help dampen the irruption of pike, an allowance for 65 t of pike was made in the spring creek

fishery. Only a few thousand pike were caught, as was the case the following year under a smaller allowance.

Recreational Angling Regulations

Lake Manitoba is in the southern angling zone, therefore the recreational season proceeds from the second Saturday in May, until the end of the Manitoba school spring break at the end of March or first week of April. Species-specific bag limits depend on the type of license held by an angler. Lake Manitoba limits for the 2020/21 angling year are listed in Table 1.

Table 1. Angling daily bag limits for Lake Manitoba 2020/21.

Species	Conservation License Limit	Regular License Limit	Maximum Size Limit
Brown and Black bullhead combined	25	25	
Burbot	No limit	No limit	
Freshwater drum	10	10	None over 60cm
Northern pike	4	6	One over 75cm
Walleye and Sauger combined	4	6	One over 55cm
Lake cisco	No limit	No limit	
Lake whitefish	25	25	
Yellow perch	25	25	
All other species	No limit	No limit	

Index Netting Program

The Lake Manitoba index netting program has been in place in its current form since 2009 when small mesh was added to the Manitoba standard nets and the netting areas were doubled with the addition of the Manipogo and Whitemud sites. Eleven repeatable net sets is the goal for each netting area, which has been achieved with varying success (Table 2). In 1985, the Lake Manitoba commercial fishery added a 3” stretched mesh to the fishery in addition to the 3¾” – 5” meshes used until then. In 2009 smaller meshes were added to the Manitoba standard index nets in order to better assess species and ages caught in the smaller mesh commercial fishery (Table 3). In 2010, a 6” mesh panel was added to the index net gang to capture the presence of large Walleye. The netting program begins at the beginning of September at the Manipogo site, then Steeprock, Lundar, and finally Whitemud at the end of September. Beginning in 2021, regional staff will alter the site schedule according to forecast

winds. Three or four nets are set each afternoon and lifted the following morning, so nets soak for two crepuscular periods.

Table 2: Number of monitoring gillnet sets by location since 2009.

Year	Manipogo	Steeprock	Lundar	Whitemud
2009	9	11	11	11
2010	12	11	10	11
2011	10	11	8	11
2012	11	7	7	8
2013	11	11	10	11
2014	11	11	11	11
2015	11	11	*	*
2016	**	**	**	**
2017	11	10	10	8
2018	11	11	10	4
2019	9	9	***	***

*** South basin sites dropped in 2015 due to budget decrease**
**** Data from 2016 unavailable**
***** Weather and low water precluded south basin access**

Table 3: Index net conformations from 2009 – 2019 in the Lake Manitoba monitoring program. Each panel is tied to the next in ascending order of mesh sizes with a gap of about two metres between successive panels. Manitoba standard net panels are in black. Panels added for Lake Manitoba appear in blue.

Year	38 mm	51 mm	64 mm	76 mm	89 mm	95 mm	108 mm	127 mm	152 mm
2009	12.5 yds	25 yds	12.5 yds	25 yds	12.5 yds	25 yds	25 yds	25 yds	0 yds
2010	12.5 yds	25 yds	12.5 yds	25 yds	12.5 yds	25 yds	25 yds	25 yds	12.5 yds
2011	12.5 yds	25 yds	12.5 yds	25 yds	12.5 yds	25 yds	25 yds	25 yds	12.5 yds
2012	12.5 yds	25 yds	12.5 yds	25 yds	12.5 yds	25 yds	25 yds	25 yds	12.5 yds
2013	12.5 yds	25 yds	12.5 yds	25 yds	12.5 yds	25 yds	25 yds	25 yds	12.5 yds
2014	12.5 yds	25 yds	12.5 yds	25 yds	12.5 yds	25 yds	25 yds	25 yds	12.5 yds
2015	12.5 yds	25 yds	12.5 yds	25 yds	12.5 yds	25 yds	25 yds	25 yds	12.5 yds

2016	12.5 yds	12.5 yds	12.5 yds	25 yds	12.5 yds	25 yds	25 yds	25 yds	25 yds
2017	12.5 yds	12.5 yds	12.5 yds	25 yds	12.5 yds	25 yds	25 yds	25 yds	25 yds
2018	12.5 yds	25 yds	12.5 yds	25 yds	12.5 yds	25 yds	25 yds	25 yds	25 yds
2019	12.5 yds	25 yds	12.5 yds	25 yds	12.5 yds	25 yds	25 yds	25 yds	25 yds

Walleye

Walleye is the target species of the large mesh gillnet fishery. It has generally been the highest value fish on a per kilogram basis since 1943, except for the period from 1981 to 2001 when that honour passed back and forth between Walleye and Yellow Perch. Walleye is the only real extant contributor to the Walleye/Sauger quota having averaged 314 tonnes in the commercial fishery over the past decade compared to just 4.5 tonnes of Sauger.

Mortality Rates

From 2009 to 2011 the maximum age Walleye caught in the index netting program was 17 years old suggesting a natural mortality rate of $M = 0.246$, or an annual natural mortality rate of $n = 21.8\%$. The most recent years with complete lakewide data were 2017 and 2018. In 2017-18, the maximum age was 20 years; implying $M = 0.209$, $n = 18.8\%$. Lakewide in 2017 and 2018 combined, the length at old age from the von Bertalanffy growth equation was 709 mm, and the growth coefficient was 0.163 (Figure 3). The Pauly estimate of annual natural mortality for the latter period is 17.7%. Charnov's estimate of natural mortality rates at maturity would put the Lake Manitoba rate (M_α) slightly higher at 25.7%. Taken together, the mean of the three estimates is 20.7%. The implication for the total annual mortality rate at maximum sustainable yield would be $A_{MSY} \approx 42\%$. The estimated mortality rate from the combined 2017 and 2018 catch curve is 54%. This puts the current mortality rate above the total annual mortality rate that produces the maximum sustainable yield. The ratio of $A/A_{MSY} = 1.28$.

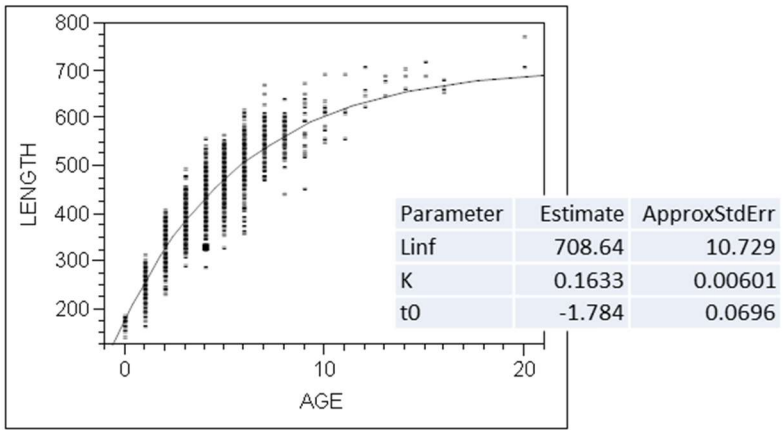

Figure 3. Von Bertalanffy growth curve for Lake Manitoba Walleye using data from the 2017 and 2018 index netting years. Fish were collected in September.

Abundance

Walleye abundance in Lake Manitoba is at a very high level at the time of writing (May 2020). The area of Lake Manitoba is 466,000 ha. Lakes in southern Manitoba are able to produce about 1 kg/ha/yr of Walleye at maximum sustainable yield (MSY). Colby and Baccante would estimate a lower potential based on lake surface area. Their estimate does not take into account the shallowness of Lake Manitoba and the potential for internal phosphorus loading to support productivity. As a baseline, and subject to re-assessment in the future, 450,000 kg will be used as the production at MSY. It is somewhat encouraging that the relationship describing the commercial production of Walleye from Lake Manitoba between 1970 and 2010 achieves 461 t at the highest level of effort in that period; 16,388 deliveries (Figure 4). The biomass target at MSY (B_{MSY}) where *n* = 21% is then about 2100 t, and biomass limit threshold reference point (B_{LIM} or equally $B_{20\%}$) is estimated at 1050 t. In the 2016-17 fishing season the commercial Walleye harvest was 261,989 kg. The following year it was 504,629 kg, for a two year average of 383,309 kg. The estimated recreational mortality was 15,361 kg according to the 2015 recreational fishing survey. The estimated subsistence harvest of Walleye on Lake Manitoba is 147,417 kg (Appendix 1). The total harvest of commercial, recreational, and indigenous users is estimated at 546,087 kg for the 2016 and 2017 fishing years. The estimated total biomass for those years was then 1655 t, well above $B_{20\%}$ of 1050 t; a ratio of 1.58. The estimated biomass is less than $B_{MSY;}$ B/B_{MSY} = 0.79.

The calculations in the preceding paragraph apply to the 2016-7 and 2017-18 fishing seasons. The most recent two fishing seasons had much higher commercial yields generated by

a very large 2013 Walleye year class. If the total mortality rate remained at 54%, B = 2750 t and B/B_{MSY} = 1.31.

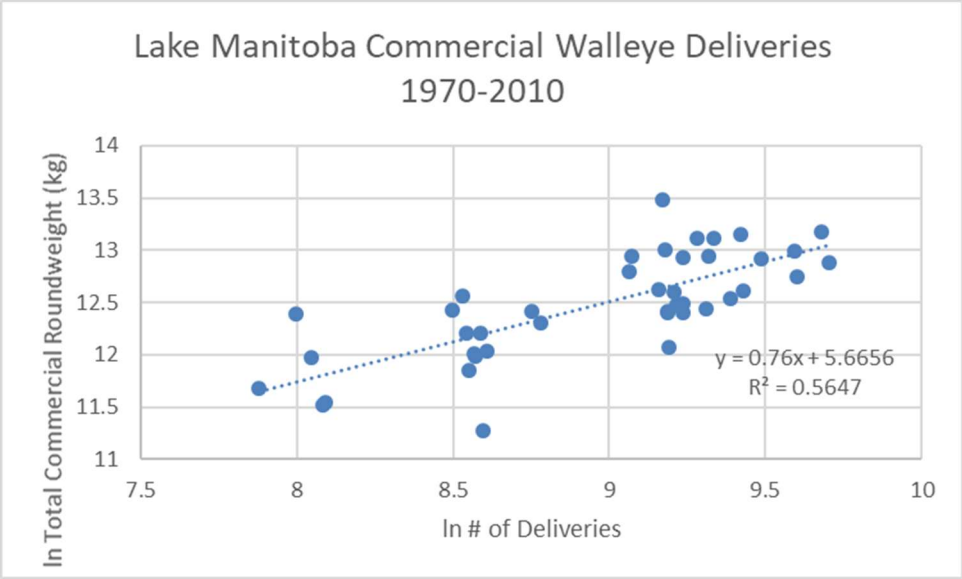

Figure 4. Commercial production of Walleye on Lake Manitoba as a function of the number of deliveries as a proxy for effort. At the highest level of recorded effort in that period (16,388 deliveries), the commercial production averages 461 tonnes. The slope of the relation above is less than unity, indicating diminishing returns despite increased effort.

Long term, spawner-per-recruit modeling indicates the current mortality rates fall short of achieving spawning biomass associated with a spawner potential ratio of 35% ($F_{35\%}$). Even at the mortality rate that produces MSY (F_{MSY}) and a minimum mesh size of 3¾" spawning biomass will fall short over the long term (Figure 5). Still, at least a doubling of long term average spawning biomass is anticipated by either reducing fishing mortality to F_{MSY} or increasing the minimum allowable mesh size to 3¾" from 3". The spawning biomass associated with $F_{35\%}$ was not achieved in modelling until a minimum mesh size of 4" was combined with F_{MSY}.

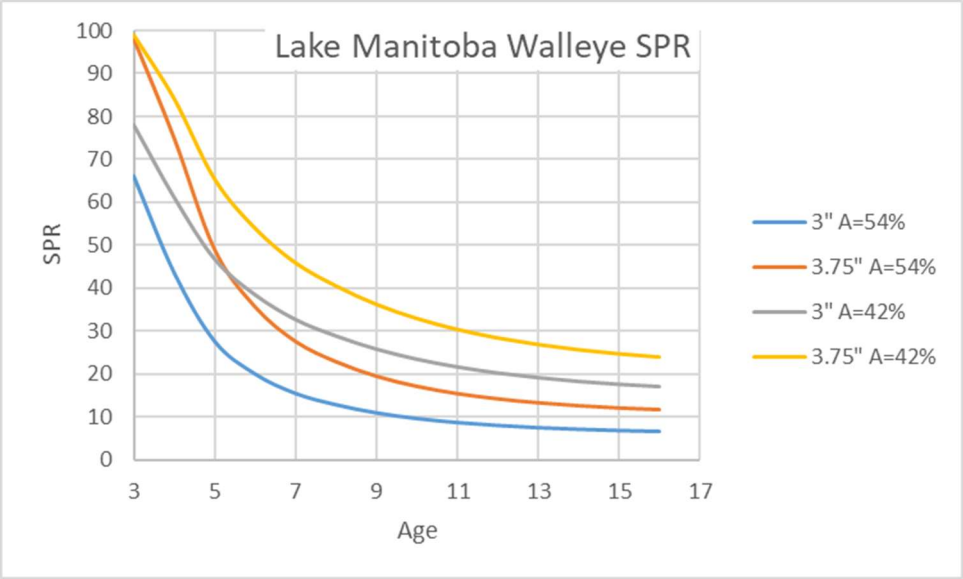

Figure 5. Spawner-per-recruit curves for Lake Manitoba Walleye modeled using mortality rates from 2017 and 2018 (A=54%) compared to A_{MSY} (A=42%), and alternative minimum mesh sizes sometimes permitted in the fishery.

Differences between Basins

Lake Manitoba fisheries are managed as though each species is a distinct stock unit. In reality, there are reasons this might not be appropriate. Fishers recognized this formally when they elected to discontinue small mesh fishing in the north basin in 2001, but not the south. Fish are free to swim between basins through the Narrows, but measurable differences in growth and maturity regimes exist between the basins.

The north basin and south basin differ hydrologically. The south basin is something of a blind appendix to the lake and river complex that connects headwater lakes to Lake Winnipegosis, through Waterhen Lake, the north basin of Lake Manitoba, Lake St. Martin, and finally Lake Winnipeg. The south basin has a relatively low turnover because it has little inflow. The major inflow to the south basin is the Whitemud River delivering an annual average of 11.9 m^3s^{-1} into the south basin volume of 3107 km^2 (Last 1980). Exceptional inflows occur when the Portage Diversion operates. The Portage Diversion is a large trapezoidal channel constructed in the 1970s to divert Winnipeg-bound flood waters of the Assiniboine River north into the extreme south end of Lake Manitoba instead of allowing the high water to continue to its confluence with the Red River.

The Waterhen River is the largest natural inflow to the north basin and to Lake Manitoba as a whole, delivering 81.3 m^3s^{-1} to the north basin which has a volume of 1593 km^3.

The north basin boasts 523 km of shoreline or 328 m of shoreline for every square kilometre of surface area. By contrast, the south basin has a meagre 392 km of shoreline enclosing its waters; only 126 metres of shoreline for every square kilometre of water. The differences in water residency times can be as great as a speedy two years in the north basin to twenty-eight years in the south basin (Last 1980).

Page (2011) measured chemical differences between the basins in 2005 and 2006. She found total phosphorus to be 82% higher in the south, chlorophyll[a] 180% higher in the south, turbidity 145% higher in the south (NTUs), and transparency higher in the north. Operation of the Portage Diversion continues to elevate turbidity and productivity of the south basin compared to the north.

Relative weights of Walleye collected in the index netting program demonstrate similarity in condition of fish within each basin, and differences between basins (Figure 6). Quality sized fish, those with a total length between 38 and 51 cm, in the south basin are very heavy at length indicating an excess of available forage relative to the standing biomass of Walleye. North basin fish hover around global average relative weights or slightly above. Never during the index program has relative weight been measured at levels that would indicate compromised growth. As would be expected to follow, south basin growth rates are higher than north basin growth rates, and both are fast compared to North American standards (Figure 7). Both sexes attain sizes at age between the 50th and 75th percentile notwithstanding their northern latitude, and south basin males outpace the 75th percentile in growth.

Figure 6. Relative weights of 38-51 cm Walleye in Lake Manitoba. Lundar and Whitemud locations are both in the south basin. Manipogo and Steeprock are north basin sites.

Female lengths at maturity (50% mature) are the same between north and south basins; around 480 mm (Figure 8). The quicker growth rate in the south basin however, results in south basin female Walleye reaching maturity almost a full year before north basin fish (Figure 9). Lengths at 50% maturity in female Walleye are coincident with the modal selectivity of 4 ¼" mesh in Figure 1. Male lengths at 50% maturity align with the modal selectivity of 3" mesh.

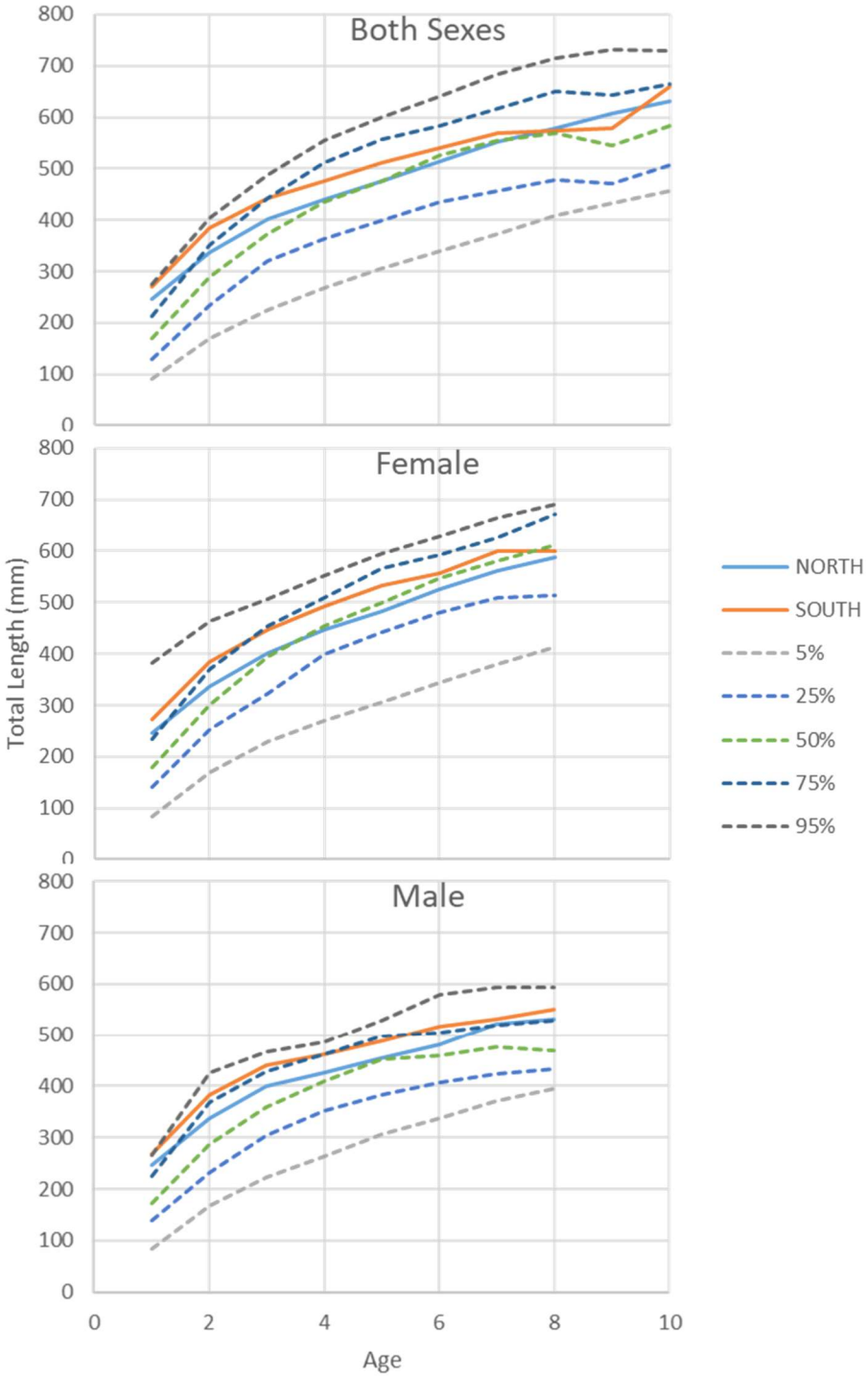

Figure 7. Growth rates of Walleye from the north and south basins of Lake Manitoba compared to North American growth standards (from Quist *et al* 2003). Upper frame shows both sexes combined for which the standards are available to the age of ten. Lower two frames are separated by sex. The standards by sex are available to age eight.

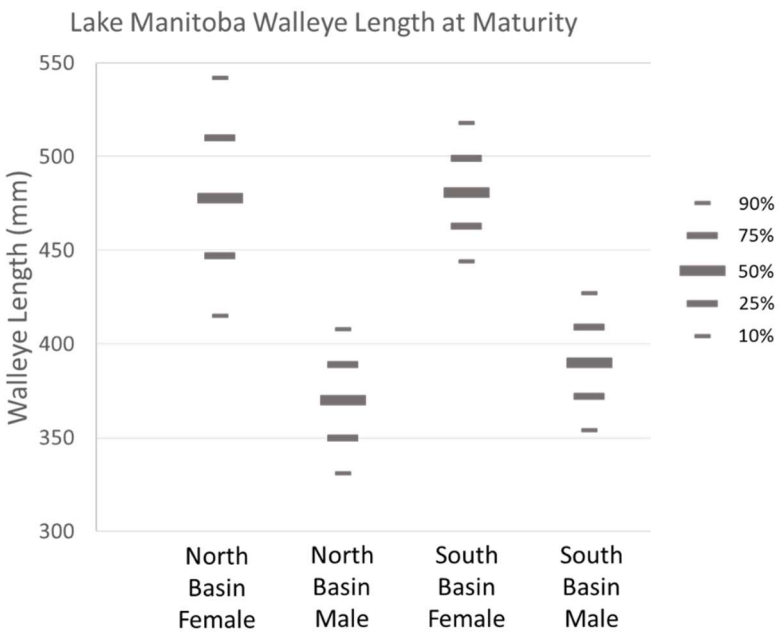

Figure 8. Lengths at maturity of Lake Manitoba Walleye derived from a logistic curve fitted to 2017 and 2018 index netting data. Females in the north and south basins reach length at 50% maturity – the length where half of females are sexually mature – at the same length; around 480 mm. North basin fish are measured in the first half of September, and south basin fish in the latter half.

Summary

There has been an increase in Walleye stock biomass coincident with the diminished use of small mesh gillnets in the south basin of Lake Manitoba since 2013. This result is expected according to this assessment. The current biomass is above that required to maintain MSY. There are additional Walleye to be harvested over and above the long term yield at MSY of 450 tonnes. It is less certain whether biomass would continue to be above B_{MSY} when the 2013 year class moves through the fishery. Spawner per recruit modelling suggests it would not. The recommended allowable harvest (RAH) for the past fishing season 2019-20 would have been 960 tonnes based on Freshwater Fish Marketing Corporation deliveries, with a commercial allocation of 797 t. The commercial fishery declared 675 t, 85% of the RAH. The RAH for the 2020-21 fishing season is 775 t, with a commercial allocation of 612 t. This estimate may be conservative if a good year class has emerged since 2013. The 2016 year class appeared strong as two year olds in 2018, but a full set of index data is not available from 2019 to confirm its size.

Walleye can move freely between the north and south basins, but differing patterns in fish condition, growth and maturity, suggest the two basin's fisheries could be managed independently.

Walleye throughout the lake have high growth rates and good condition suggesting there is no food limitation. The standing stock could be increased with decreased mortality rates leading to higher commercial, subsistence and recreational catch rates. Growth rates would be monitored to ensure a potential recreational trophy fishery would not be put at risk. A decrease in the maximum allowable mesh size in the commercial fishery from 5" to 4 ½" would help achieve a trophy recreational fishery attractive to tourist anglers.

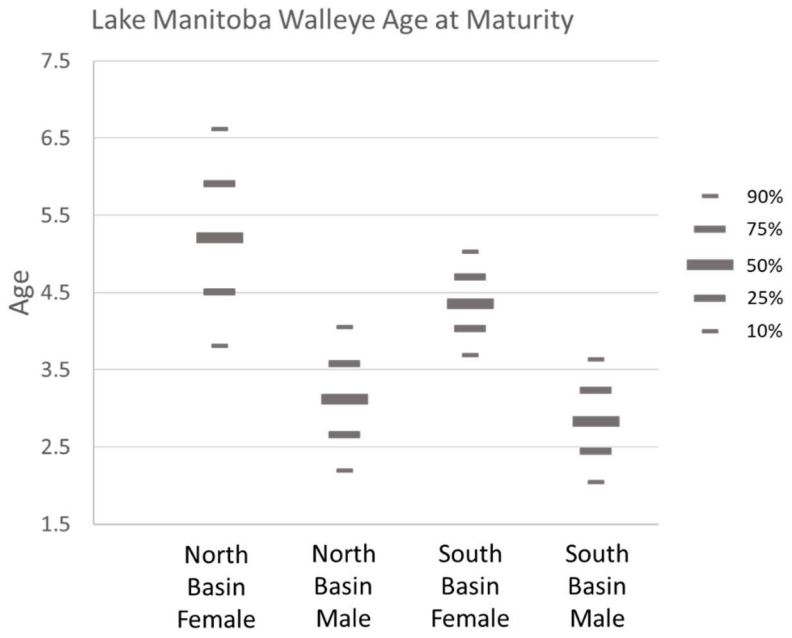

Figure 9. Ages at maturity of Lake Manitoba Walleye derived from a logistic curve fitted to 2017 and 2018 index netting data. Females in the north basin reach age at 50% maturity – the age where half of females are sexually mature – at 5.21 years. South basin females reach 50% maturity at 4.36 years. Fish ages are determined from otoliths extracted in September. Maturity is determined in September at the time of index netting by the presence of ovaries maturing for the following spring. The actual age when the fish will spawn is therefore one year older than indicated.

Bycatch Species in Commercial Net Fishery for Walleye

Eight species are listed in the Freshwater Fish Marketing Corporation delivery system for Lake Manitoba commercial deliveries. Only Walleye, mullet and Northern Pike exceed 5% of the total catch. Sauger does not constitute more than 5% of the total catch, but due to its low modern abundance compared to its historic abundance, Sauger is considered overfished and a species of conservation concern in Lake Manitoba (Table 4). White Sucker and Shorthead Redhorse comprise the commercial mullet category. In the index netting program, Shorthead Redhorse make up 15%, 10%, and 6% by weight, in the 3 ¾", 4 ¼", and 5" mesh panels. Assuming Shorthead Redhorse makes up 15% -- at most -- of the winter mullet catch, they will only account for 2.8% of the total winter commercial catch, and are not considered a major bycatch species.

Table 4. Species occurrences in the Lake Manitoba winter Walleye commercial net fishery from the most recent two years of Freshwater Fish Marketing Corporation daily catch records. Weights are in kilograms roundweight. Only records during the winter fishing season are included. Records of large deliveries of carp that appeared as though carp may have been the target species were also removed. Major bycatch species and species of concern appear in red.

Species	2018-19	2019-20	Percentage
Walleye	751,508	675,062	61.3
Mullet	222,446	212,466	18.7
White Sucker			15.9
Shorthead Redhorse			2.8
Northern Pike	223,593	158,040	16.4
Common Carp	19,533	12,815	1.4
Lake Whitefish	13,000	15,021	1.2
Sauger	6,714	11,886	0.8
Yellow Perch	1,345	3,933	0.2
Lake Cisco	526	913	0.1
Total	1,238,665	1,090,136	

Sauger

Abundance

Sauger abundance remains at critically low levels in Lake Manitoba (Figure 10). Fishers have variously suggested the causes of the low abundance to be the small mesh perch fishery, operation of the Portage Diversion, and construction of the Fairford Dam. The present incarnation of the Fairford Dam was built in the 1960s across Lake Manitoba's outflow to Lake St. Martin, the Fairford River. Fishers have suggested the lost connectivity to the Fairford River, Lake St. Martin, and further downstream Dauphin River and Lake Winnipeg harmed the Sauger stock. In the 1980s a Denil fishway was constructed in the third bay from the south of the Fairford Dam; there are nine bays. The efficacy of the fishway in passing fish has been controversial ever since. The Portage Diversion has operated since 1972 to protect communities downstream of Portage la Prairie from flooding. The Diversion shunts water from the swollen Assiniboine River north into the south basin of Lake Manitoba. Fishers have suggested the springtime operation of the Diversion occurs when the Sauger have spawned, and covers their eggs with a layer of asphyxiating silt. First steps in developing a fisheries plan for Lake Manitoba were taken by government in 2009 and 2010 when a series of consultations were held in communities around Lake Manitoba. The process was derailed by flooding in the following years, but community meetings produced some candid comments including one retired fisher who confided that the man who taught him to fish warned him to resist the push to return to small mesh fishing in the 1980s. The elder fisher recalled the harm caused to the fishery following the use of 3 ¼" mesh at the time of the Second World War. Another fisher at another meeting suggested both management and fishers understood the risk to Sauger of using 3" mesh in the 1980s, but the economic potential of fishing Yellow Perch outweighed the risk to Sauger.

Fisheries managers do not discount the other various explanations for Sauger decline, but consider the most likely cause of low Sauger numbers to be small mesh fishing based on other fisheries where Sauger decline and commercial extirpation has coincided with the use of small mesh: Lake Erie, Lake Huron, Lake Nipigon, and Lake Winnipegosis. Small mesh fishing is also the only proposed cause where change can potentially happen, other than improved fish passage at the Fairford Dam. There would also be value in studying Sauger bycatch in the spring mullet fishery on the Whitemud River.

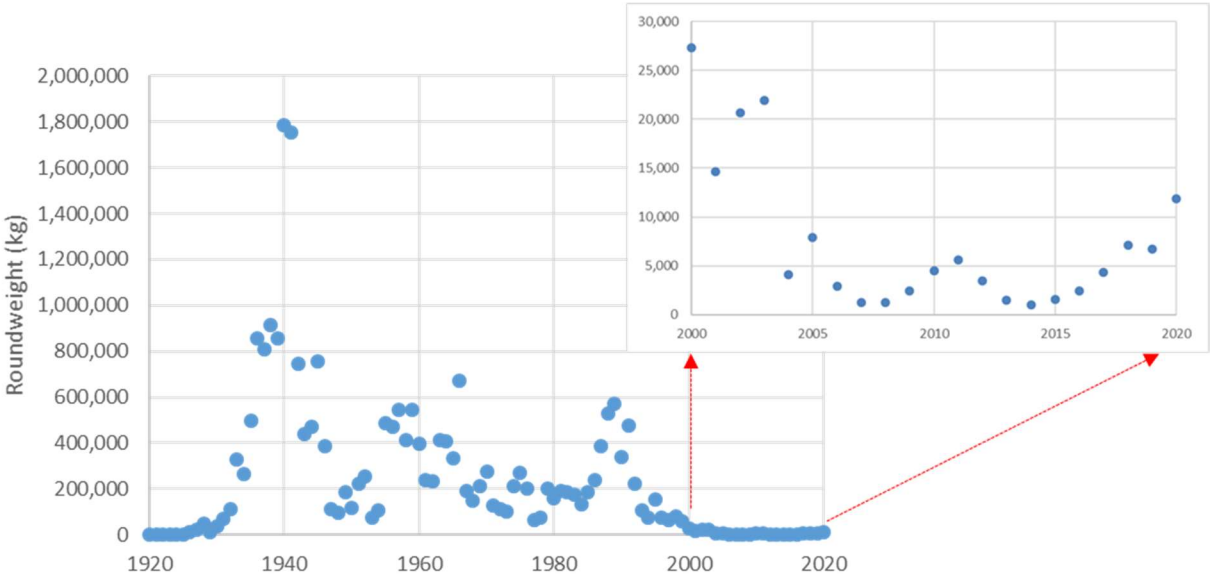

Figure 10. Time series of Lake Manitoba Sauger commercial deliveries over the past century. Notable peaks in production occur during the Second World War when 3 ¼" minimum mesh size was used in the fishery, and in the 1980s when 3" mesh was used until 2017. The inset is a rescaling of the period from 2000 to present to show more recent trends in deliveries.

The Lake Manitoba fishery produced a relatively stable 170 t/year in the years 1967 to 1985 leading up to the second attempt at small mesh fishing. This will be used as the catch at maximum sustainable yield when 3 ¾" is the minimum allowable mesh size. During that period the harvest was not constrained by quota except for 1979 when 918 t were caught of the 900 t combined Walleye and Sauger quota. The next closest year was 1982 when 702 t were caught. Sauger also averaged 76% the value per kilogram of Walleye making it the second most valuable fish to commercial fishers until the end of the period when developing Great Lakes markets for Yellow Perch caused the perch price to eclipse even Walleye. There is no reason to assume fishers were not delivering all the Sauger they could.

Relative weights of Sauger indicate no shortage of forage in Lake Manitoba. Both basins have very high relative weights, and as with Walleye, relative weights are higher in the south basin than in the north (Figure 11). Interestingly, the high relative weights of Lake Manitoba do not result in high growth rates as they do in Walleye. Sauger growth rates are between the 25th and 50th percentiles of the species' growth standard. This is more likely a result of intensive cropping due to harvest than food limitation. Fast growing Sauger are removed from the stock. Lake Manitoba Sauger are also geographically positioned further north in their range compared

to congeneric Walleye relative to their range, so there may be an effect of available degree days compared to the populations used to construct the growth standards.

The increasing trend in Sauger abundance over the past six years is encouraging, and the larger minimum mesh in the fishery today will help the large 2013 year class grow the population further by delaying their harvest two years. Still, the Lake Manitoba Sauger stock remains in a collapsed state with $B:B_{MSY} = 0.06$. The Sauger stock is below the limit reference point of 20%.

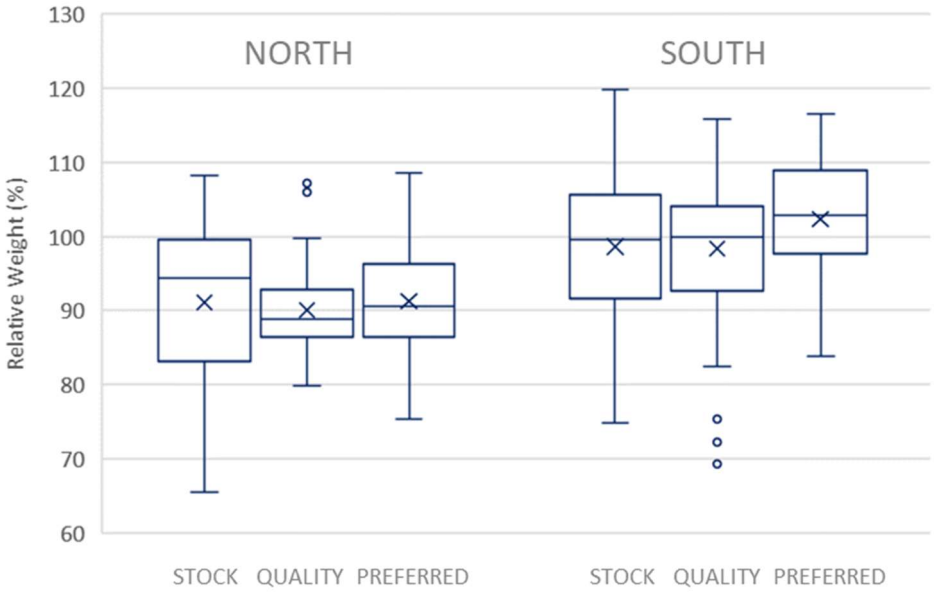

Figure 11. Relative weights of Sauger caught in the index netting program from 2009 - 2019 in the north and south basins of Lake Manitoba. Stock length fish are 20-30cm, Quality length fish are 30-38 cm, and Preferred length fish are 38-51 cm long.

Mortality

The change in minimum mesh size confers a positive benefit to the Lake Manitoba Sauger stock. The upper size range of fish captured by 3" and 3 ¾" mesh is the same, near L^{∞} (Figure 12). When fish first become vulnerable really increases with the increase in mesh size. In the larger mesh fish first become vulnerable to harvest in their fourth year instead of their

second, and the median age of harvest is delayed three years, so the typical Sauger will spawn two or three more times under the 3 ¾" minimum (Figure 13).

Additional support for stock improvement can be found in the Master Angler reports. In the years between 2000 and 2014, only a single Master Angler Sauger was registered from Lake Manitoba. From 2014 to 2019, the years when 3" fishing was effectively and then officially (after 2017) ended, nine Master Angler Sauger have been registered from Lake Manitoba.

The estimated natural mortality rate for Lake Manitoba Sauger is M = 0.38 based on age (11 years old), and M = 0.37 based on growth (Figure 12). The average annual natural mortality rate is *n* = 31%. Total annual mortality rate at MSY is 58%. The calculated total annual mortality rate for Lake Manitoba Sauger from the index netting program is 49%. The ratio of estimated current fishing mortality to fishing mortality at maximum sustainable yield is 0.67; further support of a growing stock

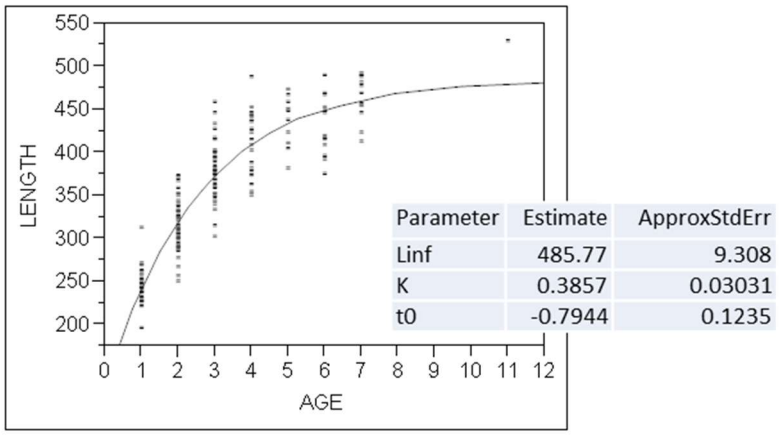

Figure 12. Von Bertalanffy growth curve of Lake Manitoba Sauger caught in the index netting program 2009 – 2018. The single eleven year old fish was not included in the calculation of the von Bertalanffy growth equation.

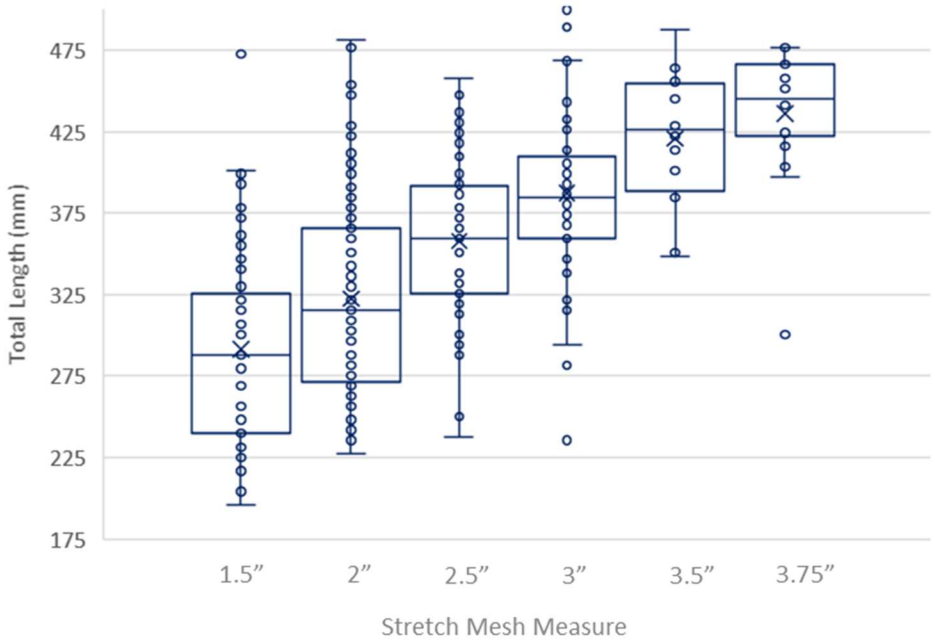

Figure 13. Box and whisker plot of mesh size vulnerabilities of Lake Manitoba Sauger.

Northern Pike

Abundance

Northern Pike is a low value species generally less than a fifth the value per kilogram of Walleye. Pike are usually a bycatch species in Walleye fisheries, and such is the case in Lake Manitoba. Aging structures are not taken as part of the Lake Manitoba index netting program. Pike are usually bulk-weighed by mesh size, by set*. A productivity-susceptibility analysis was done due to the lack of stock information. The productivity attribute scored 1.55; not surprising, pike are very productive and are not considered a conservation concern anywhere in Manitoba. The susceptibility attribute scored high at 2.325 due to the high overlap of the Walleye fishery with pike distribution. Vulnerability ($V = (Prod^2 + Susc^2)^{½}$) then scored 2.79, or medium vulnerability. The lack of assessment makes pike a moderate conservation concern.

*Beginning in 2019 staff started recording individual lengths and weights for all specimens caught in gillnets instead of bulk weighing them by species, by set, by mesh size.

Mortality

Mortality is not estimated in pike in the Lake Manitoba, since no demographic or meristic data is collected. Judging by proxies from other lakes' fisheries, and looking at historical deliveries, small mesh (3") fishing holds pike below B_{MSY}, but 3 ¾" fishing does not exert sufficient fishing mortality to achieve F_{MSY}, because the low value of pike relative to Walleye is no incentive for fishers to target pike.

White Sucker

Abundance

Even less data is collected regarding White Sucker in the index netting program than Northern Pike. White Sucker are bulk weighed by mesh, by set. As for Northern Pike, a productivity-susceptibility analysis was completed. The susceptibility attribute was the same as for pike; 2.325. The productivity of White Sucker was even higher than that of pike; the productivity attribute scored 1.22. Vulnerability was 2.62 setting White Sucker in the low vulnerability score range. The species, like pike, would be scored as of moderate conservation concern under various third party review schemes assessing sustainable fishing certification. In actuality, the conservation concern is low, but lack of data makes that classification objectively difficult.

Mortality

White Sucker mortality is not measured in Lake Manitoba for the same reasons as pike above. White sucker is considered a nuisance species. It is native to Lake Manitoba, and has a significant role in the ecosystem by way of its ability to tie up productive biomass in the lake. In lakes where Walleye stocks have been overfished, White Sucker numbers become an obstacle to recovery of Walleye. It is a management goal to keep adult White Sucker biomass to a target level below B_{MSY} and mortality to a target level above F_{MSY}. Spring creek mullet fisheries are licensed to help achieve this.

Summary: Seafood Watch Rating and Gap Analysis

In 2015, SeaChoice carried out an unsolicited review of the sustainability of the Lake Manitoba commercial net fishery. The review made media headlines when it advised seafood consumers avoid Lake Manitoba Walleye, because -- according to the rating scheme SeaChoice borrowed from the Monterrey Bay Aquarium's Seafood Watch program -- the Walleye fishery on Lake Manitoba would not be sustainable at a high level as it was managed in 2015. In the five years since that report, the fishers elected to stop fishing three inch mesh, which has led to

a high biomass of Walleye and a nascent recovery of a collapsed Sauger stock. Notwithstanding these improvements, if re-assessed today the Seafood Watch rating for the large mesh (3 ¾" minimum) fishery on Lake Manitoba would still receive an "avoid" rating. The "avoid" rating however, could be upgraded to "best alternative" with minor adjustments to the management and monitoring regimes.

The Seafood Watch scheme is comprised of four criteria. Criterion 1 is concerned with the status of the target species in the fishery. Criterion 2 assesses bycatch species. Criterion 3 focusses on management. And Criterion 4 rates habitat impacts of the fishery.

The target species in the fishery is Walleye. The suspension of small mesh fishing over the past three years has allowed improvement to the fishery. In particular, Criterion 1 would now receive a moderate score because Walleye biomass is above B_{MSY}, but mortality rates are still high.

Criterion 2 still reflects a high conservation concern for bycatch species after the increase in minimum mesh size, but the situation has improved somewhat. Sauger is no longer the limiting bycatch species since the suspension of small mesh fishing. Sauger is now of moderate conservation concern. Sauger mortality rates are acceptable, but biomass is still extremely low, although increasing. The limiting bycatch species now is Northern Pike, which receives a red rating only because little data are collected for Northern Pike. White Sucker would also receive a rating of high conservation concern for the same reason. Collection of biometric data for these two species would allow their ratings, and the overall bycatch rating under Criterion 2, to increase to moderate concern.

Criterion 3 rates management under five factors. Management of the target and bycatch species is ranked ineffective because the management regime is not responsive to the stock and targets are not identified for Northern Pike and White Sucker.

Criterion 4 relates to habitat impacts. The large mesh fishery on Lake Manitoba scores a moderate rating on Criterion 4.

To upgrade from "Avoid" to a "Best Alternative" rating under the Seafood Watch seafood recommendation program, scientifically defined management targets will need to be identified for Northern Pike, and White Sucker. Data exists now to do this for Walleye and Sauger and targets are recommended in this document, but demographic data will be required for Northern Pike and White Sucker. "Best Alternative" is only a possibility as long as 3 ¾" mesh remains the minimum mesh size and the fishery does not return to a 3" minimum.

Appendix 1

Subsistence Harvest Estimate

Population statistics from the 2016 federal census were used to estimate the number of subsistence users on Lake Manitoba. There are four Reserves on Lake Manitoba not including Fairford. The population total of the Reserves is 5174; Sandy Bay 2515, Ebb and Flow 1340, Crane River 444, and Lake Manitoba 875. Two Métis communities were included. St. Laurent is recorded as having 850 aboriginal residents among its population of 1335, and St. Ambroise 1160 of 5685. Altogether the number of 7184 subsistence users was applied. The estimated consumption per subsistence user is 10 kg/yr. Nine of those ten kilograms were assumed to be Walleye. To return the consumption estimate to roundweight, the provincial fillet to roundweight conversion of 2.2 was used. The total annual aboriginal harvest based on the 2016 survey data was 147,417 kg.

Appendix 2

Master Angler Records

Walleye

Manitoba's Master Angler Program offers a good data stream to help assess fisheries. Many factors affect the number of fish reported in the program: increased knowledge of the program, ease of reporting, whether a fish is caught with the assistance of an outfitter who recognizes the advertising advantage of Master Angler submissions, the minimum size standard; and of course, the number of trophy fish in a population, their catchability, and the amount of effort direct at those fish. Since 2005, the size standard for Walleye in the Master Angler Program has been 71 cm. The first Walleye report for Lake Manitoba comes from 1962. The highest numbers of Master Angler size Walleye were reported from 1989 – 1993. The largest fish are reported during periods of high abundance (Figure A3-1). It is a numbers game. The more fish that survive to reach a large (Master Angler) size – the more likely one is to grow to a very large size. The past decade has yielded the lowest sustained number of entries since the 1980s. Not many fish since 2010 have been greater than 80 cm (Figure A3-1).

Most trophy Walleye are reported to the Master Angler Program in the month following the opening of the recreational fishing season on the second Saturday of May. Reports fall off after mid-June, but it is not known how the peak reports compare with fishing effort as effort by date is not reported. Most winter-caught Master fish are reported in the last two weeks of March (Figure A3-2). The share of Master Angler Walleye caught through the ice has been

increasing exponentially since the 1980s (Figure A3-3). Today one quarter of Master Angler submissions from Lake Manitoba come from ice fishing. This change reflects the increased mobility of fishers in winter using snowmobiles and ATVs, and improvements to winter fishing equipment. Fishing equipment like power augers, flasher units, improved lures, and fluorocarbon lines have all increased catchability of Walleye in winter.

Another major change in the recreational Walleye fishery is the increase in catch-and-release angling. Forty years ago, no Walleye were released. Almost four of every five Master Walleye are released now (Figure A3-4). The frequency with which trophy Walleye are released is higher than the 58% average for all Walleye on Lake Manitoba reflecting the value anglers place on large Walleye relative to smaller fish, and a preference for consuming smaller fish.

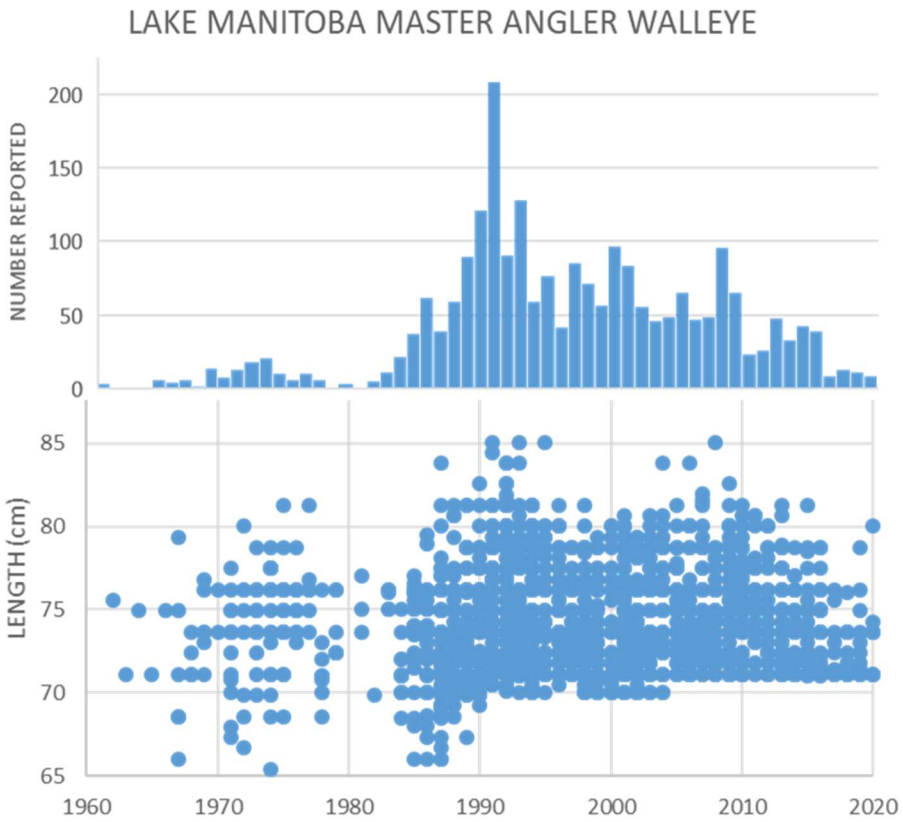

Figure A3-1. Master Angler Walleye reports for Lake Manitoba since 1962. The upper frame shows the highest number of Master Angler sized Walleye were caught in 1991. The standard since 2005 has been 71 cm or greater. The lower frame shows the lengths of Walleye registered in the program from Lake Manitoba.

The very largest fish are registered when the abundance of large fish is highest.

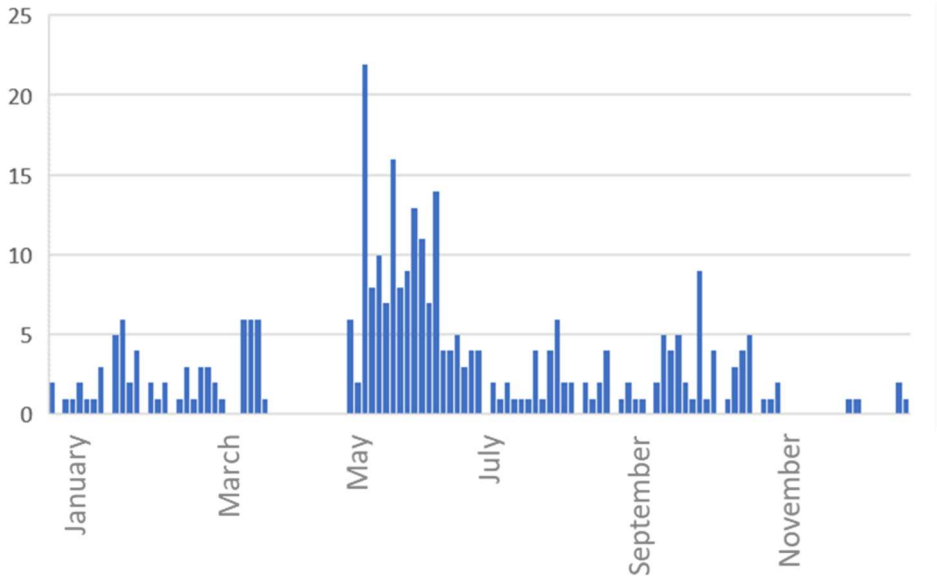

Figure A3-2. Master Angler Walleye reports from 2010 – 2020 organized by the day of the year in which they were caught. Each frequency bin covers three days. The season is closed from the end of the Manitoba school spring break in the first week of April until the second Saturday in May. Most large Walleye in Lake Manitoba are caught in May and early June.

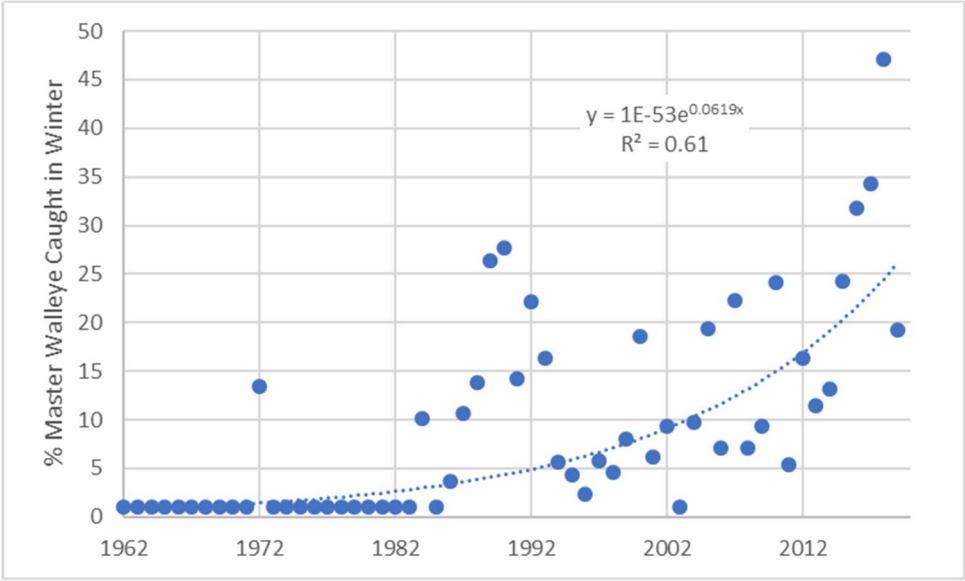

Figure A3-3. The percentage of all Master Angler Walleye reported since 1962 caught ice fishing. The percentage of Walleye angled in winter has been increasing exponentially on Lake Manitoba. Data were transformed to % + 1.

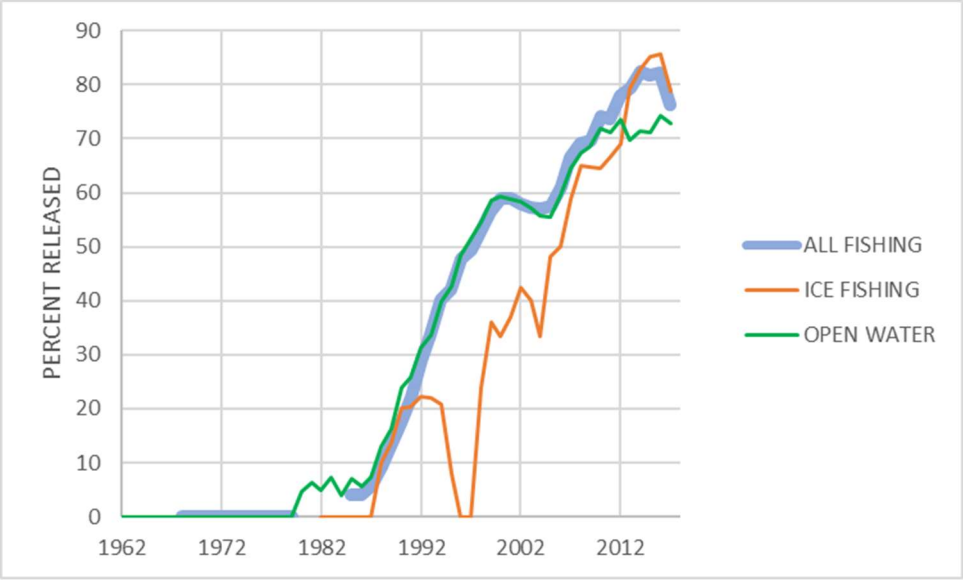

Figure A3-4. The percentage of Master Angler Walleye in Lake Manitoba released by anglers instead of being retained since 1962.