DEPARTMENT OF NATURAL RESOURCES

Fisheries Management Plan for Leech Lake

2021-2025

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EXECUTIVE SUMMARY

PURPOSE

The purpose of this plan is to guide fisheries management on Leech Lake. It is written for use by both the DNR and citizens that are interested in the management of the fishery resource. This plan is based on a fish community approach to fisheries management and serves as an extension of the 2016-2020 Leech Lake Fisheries Management Plan

Background

Declines in Walleye and Yellow Perch populations during the early to mid-2000s prompted the development of an evolving series of management objectives and actions with more citizen involvement in management plan development. Walleye and perch populations recovered as a result of these actions but perch abundance again declined. Current management efforts, such as relaxed walleye harvest regulations, are aimed at striking a balance between the predator/prey relationships in the lake.

The Minnesota Department of Natural Resources (DNR) continues to work with a group of stakeholders which comprise the Leech Lake Fisheries Input Group (LLFIG). This group provides diverse local and statewide perspectives and input on Leech Lake fisheries management. This plan builds upon the successes of and knowledge gained from previous plans by recommending specific goals, objectives, and management actions aimed at preserving a high-quality, species-diverse fishery in Leech Lake. The 2016-2020 management plan was the first to use 3-year moving averages (most recent three observations) for most of the objectives. Moving averages are used to smooth the year to year variability to more closely reflect current trends. In most cases the 2021-2025 plan will use the same goals and objectives established in previous plans. The DNR will continue to hold annual update meetings with the LLFIG and other interested stakeholders to review the previous year's information and status with regards to the management plan. A weight of evidence approach will be used annually to assess if deviations from the management plan are necessary and appropriate.

SPORTFISH POPULATION GOALS AND OBJECTIVES

Walleye Goal:

Support a self-sustaining Walleye population that balances harvest opportunity, with the opportunity to catch quality-sized fish, all while meeting reproductive needs.

Walleye Objectives:

- *Abundance:* Maintain gill net catch rate (3-year moving average) of 7-10 fish/net (29^{th}-85^{th} percentiles).
- *Reproductive Potential:* Maintain mature female biomass (3-year moving average) between 1.5-2.0 pounds/acre (40^{th}-77^{th} percentiles*).*
- *Size Structure:* Maintain the percentage of Walleye sampled in gill nets (3-year moving average) ≥20 inches between 10 and 20% (39^{th}-70^{th} percentiles).
- *Recruitment:* Maintain year class strength index (3-year moving average) greater than 0.80 (25^{th} percentile).
- *Angler Catch Rate:* Maintain a targeting angler summer catch rate of 0.30 fish/hour or higher (60^{th} percentile).
- *Angler Harvest:* Sustain an annual total Walleye harvest within a target range of 130,000 and 190,000 pounds (53^{rd}-78^{th} percentile).
- *Condition:* Maintain condition factor (3-year moving average) between 81 and 85 (25^{th}-75^{th} percentiles).

Yellow Perch Goal:

Support a self-sustaining Yellow Perch population that provides both a stable prey base for sportfish and harvest opportunities for anglers.

Yellow Perch Objectives:

- *Abundance:* Maintain gill net catch rate (3-year moving average) of ≥15 fish/net (25th percentile).
- *Size Structure:* The percentage of Yellow Perch sampled in gill nets (3-year moving average) ≥8 inches should exceed 30% (25th percentile).
- *Recruitment:* Maintain gill net catch rate (3-year moving average) of age-4 Yellow Perch ≥3.3 fish/net (25th percentile).
- *Angler Harvest:* The annual total Yellow Perch harvest should be less than 98,000 pounds.
- *Maturity:* Female length at 50% maturity exceeds 5.5 inches.

Northern Pike Goal:

Support a self-sustaining Northern Pike population that balances harvest opportunity with catch quality.
Northern Pike Objectives:

- *Abundance:* Maintain gill net catch rate (3-year moving average) between 4.1 and 5.3 fish/net (25th and 75th percentiles).
- *Size Structure:* The percentage of Northern Pike sampled in gill nets (3-year moving average) ≥22 inches should exceed 31% (25th percentile).
- *Recruitment:* Maintain gill net catch rate (3-year moving average) of age-3 Northern Pike between 1.0 and 1.7 (25th and 75th percentiles).

Management Actions

Fisheries assessments

- Conduct standardized annual assessments, including seining, trawling, electrofishing, gill netting, zooplankton, water quality and temperature monitoring.
- Conduct summer and winter creel surveys every 4 years. The next scheduled surveys are summer of 2024 and the winter of 2024-2025. Pursue additional funding to add unscheduled creel survey for regulation review.
- Continue to improve upon young-of-the-year predictors of potential Walleye year class strength.
- Conduct lake wide Bluegill, Black Crappie, Largemouth Bass assessments every four years based on standardized gears, locations, and timing from 2018. Monitor for potential changes in size structure. Establish Smallmouth Bass electrofishing stations prior to 2022. The next scheduled survey is in 2022.
- Annually collect data from a subsample of Tullibee (Cisco) and Whitefish when possible in coordination with the Leech Lake Band of Ojibwe, Division of Resource Management commercial fishery.
- Annually collect and analyze data from a subsample of Burbot registered at the Leech Lake Eelpout Festival.

Stocking & related activities

- Stock 7.5 million Boy River Strain Walleye fry (OTC marked) if the 3-year moving average (year class strength index values) falls below the 25th percentile.
- Stock sufficient numbers (low density) of Walleye fry (Boy River strain) to estimate wild fry production when mature female density falls below 1.25 or exceeds 2.75 pounds/acre. The purpose of this stocking is to expand on the existing range of total fry density observations. Information gained from these stocking events will increase understanding of the relationship between total fry density and recruitment. Stocking should not occur if Walleye condition and Yellow Perch abundance remain low.
- Conduct Muskellunge spawn take operations every four years in Miller's Bay to maintain genetic diversity in statewide brood stock lakes. Return 600 Muskellunge fingerlings to Leech Lake during spawn take years. The next scheduled spawn take is 2021.

Regulations

- The existing Walleye regulation (only 1 over 20 inch with 4 fish possession limit) will be continued. Adjustments to the existing regulation will be considered if mature female biomass is outside the objective range of 1.5-2.0 pounds/acre for multiple years and other key population metrics indicate signs of an unbalanced Walleye population. The DNR will review the status of key population metrics with the LLFIG annually.
- The existing bag limits of 50 Cisco (Tullibee) and 25 Lake Whitefish within the Leech Lake Indian Reservation will be continued. Daily and Possession limits are the same.
- If changes to statewide regulations occur, implement regulations consistent with statewide recommendations and evaluate angler and fish population responses through standardized creel and fish population surveys.

Habitat

Note: many of these initiatives will only be possible with additional resources (funding and staff)

- Continue to partner with and/or provide support to government and non-governmental organizations to acquire via fee title or conservation easement shoreland areas within the Leech Lake watershed with the intent to protect key habitats and to implement best management practices (BMPs) where appropriate.
- Continue identification and mapping emergent aquatic plant stands.
- Explore options for performing a telemetry study to identify additional Muskellunge spawning locations to guide future priorities for shoreland protection.
- Coordinate with DNR Ecological and Water Resources staff and Cass County Environmental Services to assist with aquatic invasive species prevention, education, and management efforts by DNR Ecological and Water Resources Division and other agencies.

Other Considerations

- Continue to provide financial and technical support to the Leech Lake Band of Ojibwe, Division of Resource Management for Double-Crested Cormorant control and evaluation efforts on Leech Lake.
- Continue to monitor the food chain dynamics to assess potential impacts of aquatic invasive species on Walleye population and carrying capacity.
- Continue to monitor potential effects of climate change on Walleye populations, specifically the length and intensity of the growing season (i.e. growing degree days).
- Evaluate the potential of collecting additional data from annual Muskellunge tournaments.
- Encourage CPR (Catch Photo Release) formats for tournaments to the extent possible.
- Hold annual meetings to update the LLFIG and other interested stakeholders to share the previous year's information and track status with regards to the management plan.

TABLE OF CONTENTS

Executive Summary 3
Purpose 3
Background and Current Status 3
Sportfish Population Goals and Objectives 3
Walleye Goal: 3
Walleye Objectives: 3
Yellow Perch Goal: 4
Yellow Perch Objectives: 4
Northern Pike Goal: 4
Northern Pike Objectives: 4
Management Actions 5
Fisheries assessments 5
Stocking & related activities 5
Regulations 5
Habitat 6
Other Considerations 6
Table of Contents 7
Minnesota Department of Natural Resources Mission Statement 10
Purpose 10
Lake Characteristics 10
Survey History 11
DNR: 11
Other Management Agencies: 12
Aquatic Invasive Species (AIS): 12
Recent Fisheries Trends and Status 13
Walleye: 13
Yellow Perch: 14
Northern Pike: 14
Other Sportfish Species: 14
Social considerations 14
Sportfish Population Goals, Objectives, and Actions 15
Walleye Goal: 16
Walleye Objectives: 16
Abundance. 16
Reproductive Potential. 17
Size Structure. 18
Recruitment. 19
Angler Catch Rate. 20

Angler Harvest. 21
Condition. 21
Yellow Perch Goal: 22
Yellow Perch Objectives: 22
Abundance. 22
Size Structure. 23
Recruitment. 24
Angler Harvest. 25
Maturity. 26
Northern Pike Goal: 27
Northern Pike Objectives: 27
Abundance. 27
Size Structure. 28
Recruitment. 29
Management Actions 30
Fisheries Assessments 30
Annual Large Lake surveys 30
Creel surveys 30
Fall Electrofishing for YOY Walleye 30
Bluegill, Black Crappie, Largemouth Bass, and Smallmouth Bass Sampling 30
Muskellunge Sampling 30
Cisco and Whitefish Sampling 30
Burbot Sampling 30
Stocking & related activities 32
Walleye Fry Stocking 32
Muskellunge Spawn Take and Fingerling Stocking 33
Regulations 33
Walleye regulations 33
Whitefish and Cisco regulations 33
Potential Sunfish and Black Crappie regulations 33
Other species managed with statewide regulations 33
Habitat 33
Protection 33
Nearshore Habitat Inventory 34
Aquatic Vegetation Inventory 34
Muskellunge Spawning Habitat Assessment 34
Aquatic Invasive Species (AIS) management & education 34
Other Considerations 34
Double-crested cormorant control & evaluation 34
Climate effects on Walleye populations 35
Muskellunge Tournament Data 36

Fishing Tournaments 36
Annual stakeholder meetings 36
Literature Cited 37
Appendix A. 40
Appendix B 42
Appendix C 45

Fisheries Management Plan for Leech Lake, 2021-2025

MINNESOTA DEPARTMENT OF NATURAL RESOURCES MISSION STATEMENT

The mission of the Minnesota Department of Natural Resources (DNR) is to work with citizens to conserve and manage the state's natural resources, to provide outdoor recreation opportunities, and to provide for commercial uses of natural resources in a way that creates a sustainable quality of life.

PURPOSE

Management plans describe goals, objectives, and actions that support the DNR mission statement. The purpose of this plan is to guide fisheries management on Leech Lake. It is written for use by both the DNR and citizens that are interested in the management of the fishery resource. This plan is based on a fish community approach to fisheries management and highlights why this approach is important. This plan is designed to guide effective and efficient allocation of staff and fiscal resources to protect the fish community and provide for its sustained use. The goals, objectives, and actions identified will focus the work of the DNR over the next five years. Although this plan contains clearly defined goals, objectives, and actions, it is written to be flexible and deviations can occur based on changes to the fishery or the citizens that utilize it. Citizen participation is a major component in the development of this plan and will continue to be critical throughout its life. The success of the plan will ultimately be determined by its benefits to the resource and users.

LAKE CHARACTERISTICS

Leech Lake has approximately 112,000 surface acres. In its original state the lake covered about 106,000 acres. In 1884 a dam was built on the Leech River, raising the water level about two feet and increasing the surface area to its present size (Wilcox 1979). The maximum depth of the lake is near 150 feet; however, nearly 80 percent of the lake is less than 35 feet deep. Leech Lake has approximately 58,000 littoral acres (≤15 feet).

Leech Lake is located in three glacial zones and has an irregular shape with many large and small bays. The lake varies considerably from a morphological perspective. Some large bays, such as Steamboat, Boy, and Headquarters, display eutrophic water characteristics (high in productivity) whereas other large bays, such as Walker, Kabekona, and Agency have properties more congruent with oligotrophic lakes (low in productivity). The main portion of the lake (including Sucker, Portage, and Traders bays), is mesotrophic (moderate in productivity). Shoreline length based on remote sensing technology is 201 miles. Approximately 23% of the shoreline consists of a windswept gravel-rubble-boulder mixture, nearly all of which is suitable Walleye spawning habitat (Wilcox 1979), and numerous off-shore gravel-rock-boulder reefs are also available.

The diversity of the shoreline and substrate, as well as its extensive littoral zone, provides excellent spawning and nursery habitats for a number of species. Walleye *Sander vitreus*, Northern Pike *Esox lucius* and Muskellunge *E. masquinongy* are the principal predators and are common throughout the lake. Although most fish species are found in every portion of the lake, Walleye and Muskellunge abundances are highest in the mesotrophic areas. Northern Pike are most prominent in vegetated eutrophic bays. Yellow Perch *Perca flavescens* are found throughout the lake and are the primary forage for most predators. Tullibee (Cisco) *Coregonus artedi* and Lake Whitefish *C. clupeaformis* are an important forage species for larger predators and are typically found in the mesotrophic and oligotrophic areas. Juvenile Tullibee also comprise larger proportions of predator diets when large year classes are present. Other species present in the lake include: White Sucker *Catostomus commersoni*, Burbot *Lota lota*, Rock Bass *Ambloplites rupestris*, Bowfin *Amia calva*, Shorthead Redhorse *Moxostoma macrolepidotum*, Bullheads *Ameiurus spp.*, Pumpkinseed *Lepomis gibbosus*, Bluegill *L. macrochirus*, Largemouth Bass *Micropterus salmoides*, Smallmouth Bass *M. dolomieu*, and Black Crappie *Pomoxis nigromaculatus*.

SURVEY HISTORY

Minnesota Department of Natural Resources

Prior to the inception of the large lake program in 1983, non-standardized gill netting, seining, trawling, and creel survey assessments were infrequently conducted by the DNR. Gill net assessments were completed during 1943, 1944, 1950, 1976, and 1982. Seining assessments were completed from 1965-1968, 1970-1982. Trawling assessments were completed from 1965-1968, and in 1976. Summer creel surveys were conducted in 1965, 1966, and 1967, and a winter creel survey was conducted in 1965-66. Gear and locations used during these surveys were not consistent with the standardized protocols established with the inception of the Large Lake Program in 1983 (Wingate and Schupp 1984).

Annual Large Lake Program surveys initiated in 1983 included seining in mid-July and gill netting in mid-September; additional gears targeting specific species and age classes have been added over the past 37 years. Currently, in addition to the gill net and seine sampling, annual surveys include water quality in mid-July (1986-present), trawling in mid-August (1987-present), hourly water temperature loggers (2006-present) with the addition of water column light penetration and temperature monitoring beginning in 2018, electrofishing in mid-September (2007-present) and monthly zooplankton sampling (2012-present). Muskellunge are collected and spawned for the statewide broodstock program every four years, with the last spawning operations occurring in 2017. Summer creel surveys have been conducted in 1984-1985, 1991-1992, 1998-1999, 2004-2005, 2008-2011, 2014, 2016 and 2019. Winter creel surveys were conducted in 1984-85, 1990-91, 1991-92, 2004-05, 2005-06, 2010-11, 2014-15, 2015-2016 and 2019-2020. Spring Bluegill, Black Crappie and Largemouth Bass assessments were conducted in 2012, 2015 and 2018 and were originally planned for every three years but adjusted to every four years starting in 2022 to avoid conflict with Muskellunge spring spawning that is scheduled in 2021. Sampling specifically looking for Smallmouth Bass was conducted in 2013.

1965-68: The first extensive Walleye population survey was completed on Leech Lake from 1966-1968 by Schupp (1978) as part of a broader status update of the State's flagship Walleye fisheries. The first creel survey was also conducted from 1965-1967 and estimated annual fishing pressure to be 785,905 angler-hours/year, a harvest rate of 0.183 Walleye/hour, and total Walleye harvest of 208,120 pounds of Walleye per year (Schupp 1972).

1979-80: A Muskellunge telemetry study was conducted to identify spawning areas, seasonal distribution, and movement throughout 1979 and 1980 (Strand 1986). Six spawning locations were determined lake wide through the tracking of 14 females. Spawning sites were characterized as being approximately 3-6 feet deep with *Chara* spp. as the dominant vegetation type.

2002-2005: The first lake wide survey of aquatic vegetation distribution and assemblage (Perleberg and Loso 2010).

2005-2014: Walleye fry that were stocked into Leech Lake were marked with Oxytetracycline hydrochloride (OTC) in order to get an understanding of the contribution that stocking versus natural reproduction has for the fishery (Ward 2016).

2005-2010, 2017-2019: Double-crested cormorant studies assessed cormorant diets (Göktepe 2008; Hundt 2009; Göktepe et al. 2012), associated fish consumption, and trends in fish population metrics in response to management efforts (Schultz et al. 2013; Mortensen et al. 2020).

2007: A critical review of young-of-the-year Walleye sampling (Schultz et al. 2007) concluded Walleye year class strength was most accurately predicted using mid-August bottom trawling data, when compared to mid-July seining data. However, mid-September electrofishing data may serve as an additional tool to predict Walleye year class strength.

2012: Miller (2012) compared genetic variation in Leech Lake and Woman Lake Walleye populations. No declines in genetic diversity in Leech Lake were detected between the pre-stocking (pre-2005) and stocking (2005-present) time periods. Additionally, no signs of increased relatedness or inbreeding depression were observed and no increases in genetic diversity are needed.

2012: Ward et al. (2012) compared variation in juvenile Walleye growth rates in Leech Lake. Growth rates for both age-0 and age-1 Walleye for both stocked and naturally produced year classes were compared and no statistically meaningful differences were observed. Growth was negatively associated with higher fry densities and positively associated with longer and warmer growing seasons.

2016-2019: In cooperation with the Leech Lake Association, monthly water quality monitoring at a variety of sites throughout the lake was conducted. Phytoplankton samples were added beginning in 2017.

2018: Near shore habitat was mapped using Score the Shore protocols outlined in Perleberg et al. 2012. Score the Shore is a natural resources survey to describe the habitat nearest to the shoreline, determine shoreline changes over time and provide a ranking score to compare lakeshore habitat between Leech Lake and other lakes and watersheds to assess potential impacts and encourage proper shoreline maintenance.

2019: Emergent Aquatic vegetation mapping was initiated, starting in the western bays and moving towards the east. The plan is to map the emergent vegetation in the lake with a goal of having the entire lake mapped by 2023. This survey will be used to track long term changes to the emergent plant community.

2020: The COVID-19 pandemic had an impact on sampling, specifically cancelation of trawling activities and the planned 2020 summer creel.

Other Management Agencies

1978-79: The Army Corps of Engineers completed an assessment evaluating nearshore habitat and the effect of various water level regimes on fish production in Leech Lake (Wilcox 1979). It was recommended that water levels should be rising from April 15-May 15 to prevent exposure of Walleye and Northern Pike eggs, or limit the accessibility to or potentially strand Northern Pike in spawning areas.

1988-91: A hydrology and groundwater quality study was conducted from 1988-1991 (Lindgren 1996).

1992: The Leech Lake Band of Ojibwe completed a report evaluating water quality and productivity of Leech Lake (LLBO 1992). The report indicated good water quality was present and recommended alternatives for maintenance.

1993: Leech Lake River Basin Study Report: A watershed report and plan was sponsored by the Leech Lake Band of Ojibwe and the Cass, Hubbard, and Beltrami Soil and Water Conservation Districts (USDA 1993).

1997: A Water Quality Assessment of the Leech Lake Watershed: A watershed report sponsored by the Leech Lake Division of Resource Management and the Minnesota Chippewa Tribe (LLDRM 1997).

2010-2017: Watershed Restoration and Protection (WRAP) strategies outlined under the guidance of MN Pollution Control Agency (West et al. 2017).

Aquatic Invasive Species (AIS):

A survey of Leech Lake boat harbors in 2004 found established beds of Eurasian water milfoil (EWM) in several harbors between Stony and Rogers points. This invasive species continues to be discovered in new harbors and open water areas throughout the entire lake. EWM is now considered widespread across the main basin harbors of Leech Lake, and now is establishing in open areas of the main lake despite previous annual control efforts.

While conducting EWM harbor searches during 2009 curly-leaf pondweed (CLP) was identified and removed from a harbor near Whipholt Beach. This was not the first occurrence of CLP, as it has been previously documented in the Leech Lake River embayment near Federal Dam. Like EWM, CLP can be an aggressive invasive aquatic plant and DNR personnel will continue to monitor CLP presence in Leech Lake.

Rusty crayfish, native to the Ohio River drainage basin, were first recorded in the lake in the late 1980s. Staff began reporting the number of Rusty and native crayfish entangled per gill net during the annual gill net assessment in 2002 after Rusty Crayfish numbers had expanded. Crayfish entanglement rates reached a historic high in 2018, with a slight drop in 2019. In 2016 Zebra mussel veligers (larval stage) were found in zooplankton samples. No veligers were found in 2017 but adults were found in one location in the lake. Veligers were again found in a variety of samples in 2018. In 2019, adults were found in a number of locations throughout the western and some main lake bays, particularly on docks removed in the fall.

Zebra mussels are filter feeders with each individual capable of filtering up to a liter of water a day. They feed on algae, bacteria and some smaller zooplankton which is also the main food source for small fish. This competition for resources can affect the survival of young gamefish and minnows (Seagrant 2017). It is unclear what the long-term effects will be on the Leech Lake fishery but there are a few initial changes that can be expected. Declines in zooplankton density and shifts in species assemblage is expected. Increases in water clarity up to a meter (MacIsaac 1996) and declines in zooplankton biomass by up to 50% have been documented in some systems (Stayer et al. 2014). Concurrent with lower zooplankton densities and clearing water, a shift in primary production from the main water column (pelagic zone) of a lake to the bottom of the lake (benthic zone) (Higgins and Vander Zanden 2010) can be expected. This can potentially have a negative effect on growth of Walleye and Yellow Perch during their first year (Hansen et al. 2020) as well as species composition in the lake. Similar to nearby Cass Lake (Kennedy et al. 2019), a shift in targeted fishing pressure from daytime to more low light/nighttime periods is anticipated, particularly for Walleye anglers,

Other AIS currently found in Leech Lake include *Heterosporosis spp.* and Banded Mystery snail *Viviparus georgianus.*

RECENT FISHERIES TRENDS AND STATUS

Walleye are currently the only species of sportfish in Leech Lake with special regulations (possession limit of 4, only one of which can be over 20 inches), though reduced bag limits for Sunfish and Black Crappie are expected to begin in 2021. Reduced daily and possession limits on Tullibee (Cisco) and Lake Whitefish are in place on all waters within the Leech Lake Indian Reservation, which includes most of Leech Lake. Statewide regulations apply to all other species.

Walleye

Walleye abundance in the mid-2000s was low relative to the historical time series. Relatively high angler pressure and harvest in the late 1990s and into the 2000s (Sledge 1999, 2000) combined with increasing cormorant abundance and predation during 2000-2004 to produce five of the weakest seven Walleye year classes observed since 1983 (Schultz et al. 2013). Starting in 2005, conservative regulations, cormorant management, Walleye fry stocking, and increased habitat protection were implemented to improve the Walleye population.

Walleye abundance improved rapidly in response to combined management actions and has remained relatively stable since 2007. Gill net catch rates have exceeded the long-term average from 2007-2019, female spawner abundance has been within or above the management objective range since 2010 and year classes above management objectives were produced every year since 2005 except for one. Despite all the positive population metrics, targeting angler catch rates have dropped slightly below management objectives in the most recent creel surveys (Pedersen 2017, Pedersen 2020) Overall, the Walleye population has fully recovered but there is concern with the mature female density exceeding the management objective range for several years. This prompted the

removal of the protected slot limit in 2019 to allow for increased angler harvest on previously protected larger fish.

Yellow Perch

Increased predation by double-crested cormorants resulted in low abundances of Yellow Perch during the early to mid-2000s (Schultz et al. 2013). Yellow Perch gill net catch rates were below the 25th percentile in 2005 when cormorant culling commenced, and by 2007 catch rates exceeded the 75th percentile. This rapid change was attributed to predation relief in conjunction with fast growth and high survival rates of Yellow Perch. However, as Walleye abundance continued to increase at both the juvenile and adult levels, predation pressure on Yellow Perch by Walleye also increased and indices of Yellow Perch abundance again declined. Yellow perch are the primary prey species for Walleye and most other predatory sportfish in the lake.

Yellow Perch gill net catch rates have had a decreasing trend since 2007 with a slight increase in 2019. The Walleye population recovered during this time and Walleye management activities continued through 2019 which certainly take into account the health of the Yellow Perch population. Yellow Perch gill net catch rates were below the management objective of at least 16 fish/net six out of the last ten years including a historic low in 2016. The abundance of age-4 Yellow Perch recruiting to the fishery has fluctuated from slightly above the management threshold to below each of the past five years while the percentage of Yellow Perch in gill nets ≥8 inches has been above the management threshold three of the past four years. Elevated predation by juvenile and adult Walleye and increases in total harvest of Yellow Perch by winter anglers are both suspected as primary causes of the most recent decline. A strong negative relationship exists between Yellow Perch recruitment and total Walleye fry density estimates from the same year class (Appendix B, Figure 4), and record Yellow Perch harvest was documented during the 2010-11 and 2014-15 winter angling seasons (Schultz and Vondra 2011, Stevens and Ward 2015). Due to record harvest of Yellow Perch in the 2010-11 and 2014-15 winter creel surveys, an additional survey was conducted in the winter of 2015-16 to continue to monitor and evaluate harvest. Harvest dropped, both pounds and number of fish, in the 2015-16 and again in the 2019-20 winter season (Pedersen 2020b). The 2019-20 season harvest drop can be directly attributed to very poor on ice travel conditions for the majority of the winter season. Harvest during the summer season dropped between 2014 and 2016 but saw an increase in 2019 (Pedersen 2020a). Although some perceive that cormorant consumption of Yellow Perch continues to have a significant influence on Yellow Perch recruitment, cormorant predation has been reduced by 90% relative to 2004 levels and are similar to pre-2000 levels (Schultz et al. 2013, Mortenson 2020).

Northern Pike

All metrics indicate the population is stable and low to moderate in abundance. The lakewide abundance continues to remain similar to historical levels, with an average gill net catch rate of 4.8 fish/net (Figure 13). The gill net catch rate of age-3 fish/net (3 year moving average) has remained within or just above the 25th and 75th percentiles the past ten years, indicating a lakewide abundance of smaller individuals surviving to catchable sizes (i.e. stable recruitment). Additionally, the 3-year moving average percentage of Northern Pike sampled in gill nets ≥22 inches has exceeded 30% for fifteen years in a row, indicating a stable abundance of mid-size and larger fish.

Other Sportfish Species

Limited long-term data is available to review trends and status for other sportfish species, such as Black Crappie, Bluegill, Muskellunge, and Largemouth and Smallmouth Bass.

SOCIAL CONSIDERATIONS

The DNR recognizes the economic base supported by Leech Lake and the role fishing quality in Leech Lake has on the local quality of life. Communication and cooperation between the DNR and stakeholders, and the need for an adaptive management framework that provides context for framing biological and social questions and goals

with stakeholder involvement is critically important. Adaptive management promotes flexible decision making that can be adjusted over time as outcomes from management actions and other events become better understood (i.e. learning by doing).

To facilitate the adaptive management process the DNR convened a group of 16 stakeholders with diverse local and statewide interests in order to provide input to the DNR on proposed management goals, objectives, and actions as the Leech Lake Fisheries Management Plan was updated for 2016-2020. The Leech Lake Fisheries Input Group (LLFIG) was formed in February 2015 and was represented by eight organizations: Leech Lake Association, Leech Lake Fishing Task Force, City of Walker, Leech Lake Area Watershed Foundation (now Northern Waters Land Trust), Leech Lake Band of Ojibwe, Statewide Walleye Work Group, Statewide Northern Pike and Muskellunge Work Group, and the Statewide Bass Work Group. In addition, eight members were selected from a statewide web-based application process. Open seats include two resort owners, two local business owners, a local guide, local angler, statewide angler, and a Fisheries professor from Bemidji State University. The LLFIG built upon the successes of the previous plan by providing input and recommendations on specific goals, objectives, and/or actions aimed at preserving a quality fishery in Leech Lake. The DNR holds annual update meetings with the LLFIG and other interested stakeholders with the previous year's information and status with regards to the management plan. A weight of evidence approach was used annually to assess if deviations from the management plan were appropriate. This plan is an extension of that original process and will continue the collaborative management of Leech Lake.

SPORTFISH POPULATION GOALS, OBJECTIVES, AND ACTIONS

Outlining population goals, objectives, and associated management actions are important, as they are the tools for evaluating results that can be applied to future decision-making processes. Goals are broad qualitative statements encompassing what the management plan hopes to achieve for a particular species and objectives are specific quantitative statements that contribute to achieving the goal. Management actions are specific activities implemented either to build long-term data sets or provide a framework for action when an objective is exceeded or fails to be met. Placing proposed objectives within their proper historical context (1983-present) and relative to previous objectives is necessary for an expectation of what is either realistic or sustainable. For example, a Walleye gill net catch rate of 20 Walleye/net in Leech Lake is neither realistic nor sustainable as the Walleye gill net catch rate has never exceeded 14 Walleye/net. Similar to the 2015-2020 management plan is the use of 3-year moving averages (most recent three observations) for most of the objectives. Moving averages are used to smooth the year to year variability and more closely reflect current trends. This management plan also attempts to be representative of all sportfish species within the fish community, as Leech Lake supports a very strong and diverse multi-species fishery.

Walleye Goal:

Support a self-sustaining Walleye population that balances harvest opportunity with the opportunity to catch quality-sized fish all while meeting reproductive needs.

Walleye Objectives:

Abundance. *Maintain Walleye gill net catch rate (3-year moving average) of 7-10 fish/net (currently 29th-85th percentiles).*

Maintaining a stable abundance of Walleye benefits anglers and stabilizes recruitment. Walleye gill net catch rates have ranged from 4.6 fish/net (1993) to 13.4 fish/net (1988) during 1983-2020. The objective range of 7 to 10 fish/net (29th and 85th percentiles) is the same range from the 2015-2020 plan. The objective under the 2011-2015 management plan was to maintain a gill net catch rate of ≥8.5 fish/net, the 75th percentile at the time. Maintaining a gill net catch rate at or above the 75th percentile every year is not realistic in a natural system due to annual variability in the number of juvenile Walleye surviving to catchable sizes (i.e. recruitment) and impacts that would have on the prey base.

Peaks in gill net catch rates (i.e. catch rates ≥10 fish/net) have been attributed to a disproportionately large number of age-0 and/or age-1 fish being sampled relative to other years (1988, 1989, 1998, 2007 and 2015). Thus, gill net catch rates can be strongly influenced by recruitment variability, and the highs and lows in gill net catch rates tend to be driven by the frequency of unusually strong or weak year classes moving through the age-1 through age-6 age classes. Gill net catch rates can also be influenced by the growth rate of a particular cohort (gill net capture efficiency is related to the size of fish, particularly smaller and larger ones), and angler harvest which is typically correlated with pressure (angler hours). Maintaining the objective range of 7 to 10 fish/net will continue to allow for variability in catch rates over the duration of this plan, as gill net catch rates have remained within this range 14 of the past 16 years.

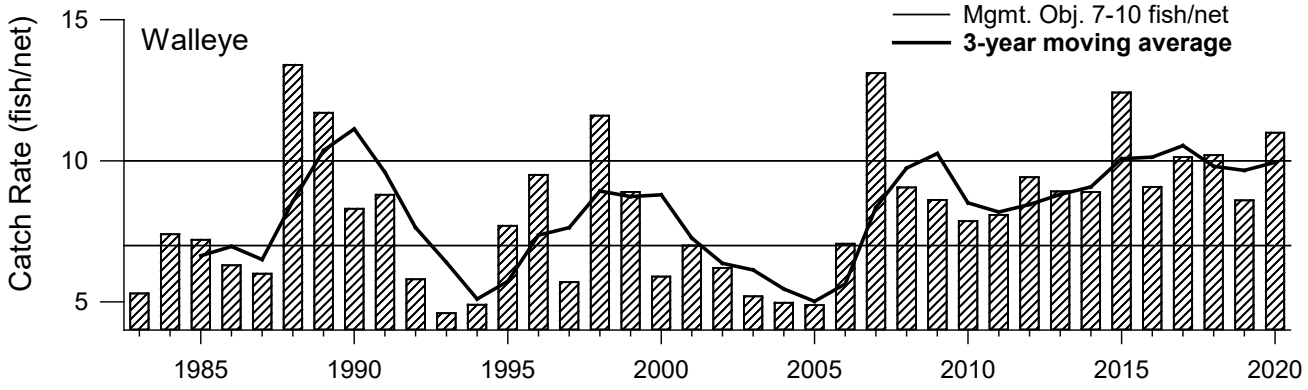

Figure 1. Gill net catch rates (fish/net) of Walleye in Leech Lake, 1983-2020. Horizontal lines represent the 29th and 85th percentiles. The darker line represents the 3-year moving average.

Reproductive Potential. *Maintain Walleye mature female biomass (3-year moving average) between 1.5-2.0 pounds/acre (currently 40th-77th percentiles).*

Maintaining an adequate density of mature females (i.e. spawners) reduces recruitment variability and increases the relative abundance of subsequent year classes. Uncontrollable factors, such as climate, growing conditions, forage availability, density-dependence, predation, and others, also influence year class strength. The density of mature females has ranged from 0.7 pounds/acre (1997) to 3.8 pounds/acre (2015) during 1989-2020. The values of 1.5 to 2.0 pounds/acre in the 2016-2020 management plan represented the 50th and 80th percentiles through the time series from 1989 to 2014. Prior to 1989, maturity observations were not recorded for Walleye. The recruitment potential objective under the 2011-2015 management plan was to maintain a mature female density between 1.5 and 2.0 pounds/acre, the 60th to 90th percentiles at that time. For the 1989 to the 2020 time series female densities of 1.5 and 2.0 would be the 40th and 77th percentiles.

In addition to mature female densities, wild fry densities were also tracked from 2005 to 2014. During the years when mature female density exceeded 1.5 pounds/acre wild fry densities averaged 348 fry/littoral acre. The years in which mature female densities were less than 1.5 coincided with the only subsequent years where Walleye year class strength index values were below average. Wild fry densities are expected to average between 270-370 fry/littoral acre relative to the mature female density range of 1.5-2.0 pounds/acre. Growth, survival, and recruitment of age-0 fish to the fishery increase as fry density decreases, and fry densities of 500 fry/littoral acre or higher have consistently resulted in lower recruitment. Given these observations and the state of the Walleye population, the current target range for spawner biomass is expected to continue to be appropriate for supporting consistent fry production.

Spawner density is influenced by the strength of year classes reaching maturity, fishing pressure, and angler harvest. Walleye harvest regulations are an important tool for managing the Reproductive Potential objective. Removal of the 20-26 inch protected slot limit in 2019 was based on the mature female biomass exceeding the objective range of 1.5-2.0 pounds/acre and other key population metrics. These metrics include Walleye and Yellow Perch gill net catch rates, the percentage of Walleye within the protected slot and Walleye density dependence which indicated signs of an unbalanced Walleye population. The DNR reviews the status of these metrics annually along with the LLFIG. Regulation adjustment(s) over time should be used cautiously to avoid compulsive responses to short-term dynamics common to and frequent in Walleye populations, as over-reactive modifications could be detrimental to population balance and, in particular, the fishery it supports. Summer and winter creel surveys provide critical information for considering potential Walleye regulation changes along with summer seine, trawl and gill net surveys.

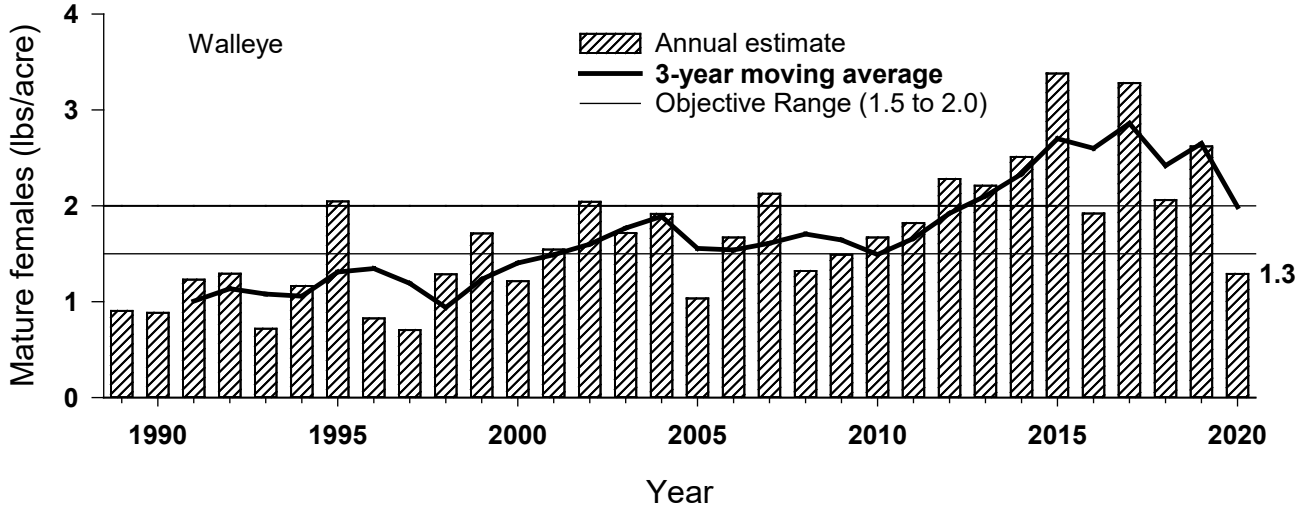

Figure 2. Estimated biomass (pounds/acre) of mature female Walleye in Leech Lake, 1989-2020. Horizontal lines represent the 40th and 77th percentiles. The darker line represents the 3-year moving average.

Size Structure. *Maintain the percentage of Walleye sampled in gill nets (3-year moving average) ≥20 inches between 10 and 20% (currently 39th-70th percentiles).*

Maintaining a balanced size distribution of Walleye in a population ensures there are fish available for spawning and angler harvest while also providing anglers the opportunity to catch larger sized individuals. Angler dissatisfaction with protective size regulations is often in response to the portion of their catch that they are required to release; this objective is intended to address that concern. The percentage of Walleye sampled in gill nets ≥20 inches has ranged from 2% (1984) to 26% (2006) during 1983 - 2020. The range of 10 to 20% represents the 39th to the 70th percentiles. The size structure objective under the 2011-2015 management plan stated that the proportion of Walleye sampled in gill nets ≤15 inches remain between 45-65%, the 25th - 75th percentiles at the time. The intent of this objective originally developed during the 2015-2020 management plan process was to quantify the abundance of smaller fish entering the population that would be available for angler harvest. The Walleye recruitment objective accomplishes this also. The new size structure objective better reflects the effects of special harvest regulations on angler harvest.

Peaks in the percentage of larger Walleye sampled in gill nets (exceeding 20%) have occurred twice. The peak from 2005-07 was attributed to increased cormorant predation on juvenile Walleye shifting size structure to primarily larger individuals, and the peak from 2012-2014 was attributed to overshooting the management objective goal for female spawner abundance and triggered the relaxation of the protected slot limit (PSL). Cormorant control measures, angler pressure and harvest, and the current regulation play a key role in accomplishing this objective. The continued exceedance of this management objective attributed to the weight of evidence for the appropriateness of the removal of the PSL in 2019. It is anticipated to take several years for the new Walleye harvest regulation to reduce the number of fish over 20 inches.

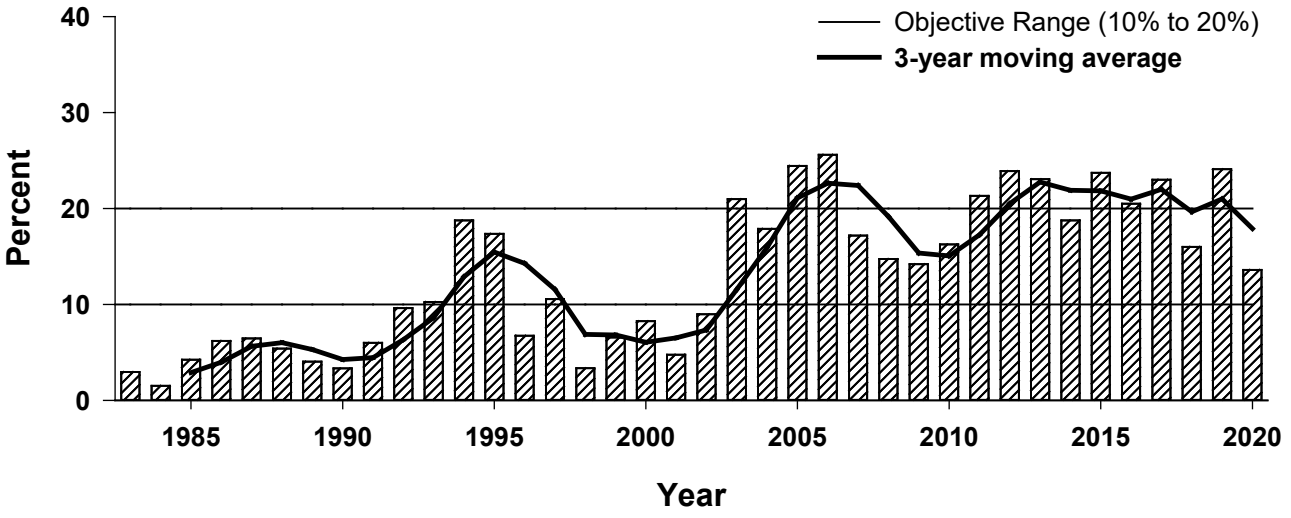

Figure 3. The percentage of Walleye in gill nets ≥20 inches in Leech Lake, 1983-2020. Horizontal lines represent the 39th and 70th percentiles. The darker line represents the 3-year moving average.

Recruitment. *Maintain Walleye year class strength index (3-year moving average) greater than 0.80 (currently 25th percentile).*

Maintaining a stable number of juvenile Walleye surviving to catchable sizes (i.e. recruitment) ensures there are both fish available for angler harvest and sexually mature individuals entering the spawning population. Recruitment variability, or the variability in the size or strength of a year class, is influenced by a number of factors. These include spawner abundance, spawning conditions, juvenile density, length and intensity of growing season, predation, and prey abundance among others. Most recruitment concerns center on consecutive years where the year class strength index (i.e. the relative abundance of Walleye produced in an individual year) is below the 25th percentile. The 25th percentile is a threshold below which year class strength is defined as poor. Year class strength values have ranged from 0.01 (1993) to 2.60 (1988) during 1983-2019. The recruitment objective under the 2011-2015 management plan stated that year classes should have a measured strength at or above the long-term average (1983-2009 = 1.35) during two of four consecutive years. This objective was exceeded and the result was elevated predation pressure on the prey base, specifically Yellow Perch, and corresponding reductions in Yellow Perch recruitment and depressed abundance. Consequently, the 2016-2020 management plan was revised to the three-year moving average staying above the 25th percentile. Using identical methods, percentile values will shift slightly as new observations continue to be added; using alternative index models, the scale (range of values on Y axis) will change but measures of central tendency (mean, median, mode, and percentiles) will remain equivalent regardless of approach. The threshold of 0.80 refers to the 25th percentile for the 1983-2017 time series and while it appears lower than the 2015-2020 YCS objective (1.1) it is similar based on the value being the 25th percentile of the time series. Since 1983, the year class strength index has dropped below the 25th percentile for two consecutive years on two occasions, from 1992-1993 and from 2000-2004. The low experienced in 1992 and 1993 was attributed to those summers being among the coldest on record (i.e. having the fewest days with average air temperatures ≥50°F), which led to colder water temperatures and poor growth, survival, and recruitment of Walleye statewide, (Schupp 2002). Year class strength values below the 25th percentile from 2000-2004 were attributed to increased cormorant predation (Schultz et al. 2013).

Iterations of recruitment indices on Leech Lake have included the Schupp model (unpublished) up to 2007, a catchability-adjusted version of the Macenia and Pereira (2007) model from 2007-2015, and more recently a mixed-effects version (Kutner et al. 2004) of the model described by Macenia and Pereria (2007). The purpose of these versions is to better meet statistical demands for data analysis, with one of the larger drivers behind this being the need to monitor and describe the effects of cormorant management on the population. The complete YCS is calculated using gill net catch rates of 1 to 3 year old fish. To determine the incomplete values, trawl data is used along with any available gill net data. Due to the COVID-19 pandemic, trawling was not conducted in 2020 so no value is available.

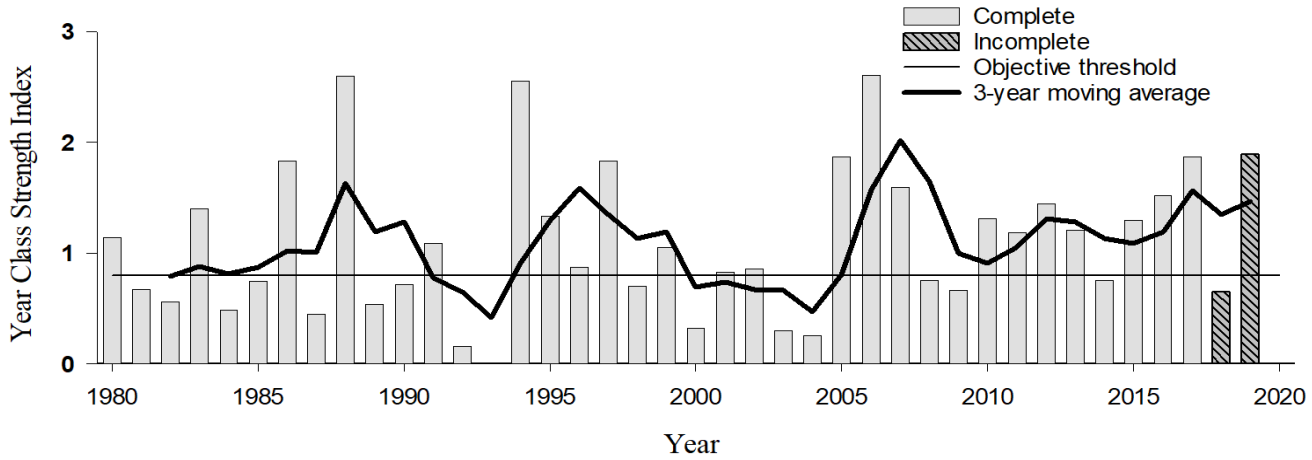

Figure 4. Year class strength index of Walleye in Leech Lake, 1983-2020. Both year classes fully recruited to the fishery and those still incomplete are indicated. The horizontal line represents the 25th percentile. The darker line represents the 3-year moving average.

Angler Catch Rate. *Maintain a targeting angler summer catch rate of 0.30 fish/hour or higher (currently 60th percentile).*

Maintaining stable abundance of Walleye for anglers to catch and harvest is important, as Walleye are the species most frequently targeted by summer and winter anglers. Length limits, such as protective slot limits (PSLs), are intended to reduce or eliminate harvest of a particular size group of fish, improve size structure and/or improve the quality of fishing with higher catch rates and larger fish. Uncontrollable factors such as weather and forage availability among other factors also influence angler catch rates

Targeting angler summer catch rates have ranged from 0.05 (2005) to 0.41 (2009) from 1991-2019. Prior to 1991, anglers were not asked what species they were fishing for and this metric could not be calculated. Targeting angler statistics are a more precise measure of fishing quality for a particular species than statistics generated across all anglers, as targeting anglers mainly fish for that particular species. The threshold of 0.30 represents the 50th percentile for the 1991-2014 time series, 60th for the 1991-2019 time series. This threshold tracks well with good fishing experienced throughout the 1990s and 0.30 is an above average catch rate compared to the nine other 'large Walleye lakes' in Minnesota (Wingate and Schupp 1984).

The only angler-oriented Walleye objective in the 2011-2015 management plan was harvest oriented. The angler oriented objective in the 2011-2015 management plan stated that the targeting angler summer harvest rate should be 0.25 fish/hour or higher. This objective was acknowledged as likely unachievable in light of the regulation change that was intended to reduce harvest. This objective also exceeded the 90th percentile for the 1991-2009 time series, which included pre-protected slot limit fishing seasons.

The two objectives added in the 2016-2020 management plan and retained here (Angler Catch Rate and Angler Harvest) were intended to recognize catch and release anglers, the harvest oriented anglers, and the contribution of fish that are released due to regulations. As Zebra mussel impacts begin to occur, this metric will likely be impacted by clearing water. As was previously stated on Cass Lake, fishing pressure and success shifted mainly to low-light/after dark conditions which would not be accurately measured by the standard surveys associated with this time series.

This objective is only applicable during years creel surveys are conducted.

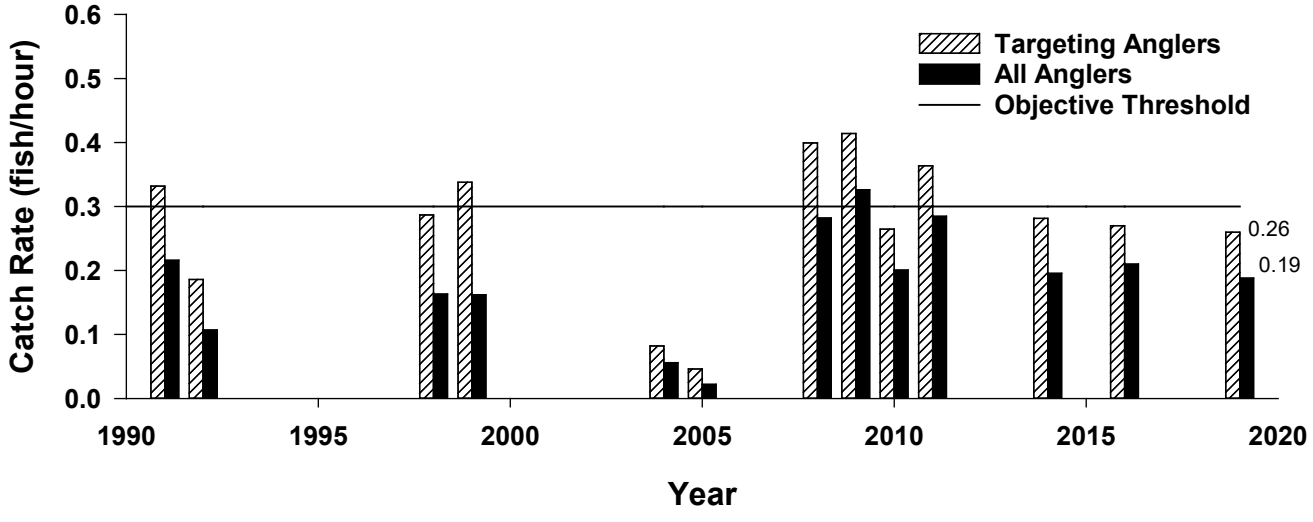

Figure 5. Summer angler catch rates of Walleye in Leech Lake, 1991-2019. Catch rates for targeting anglers and all anglers are indicated. The horizontal line represents the 60th percentile.

Angler Harvest. *Maintain annual total Walleye harvest between 130,000 - 190,000 pounds (currently 53th-78th percentiles).*

Maintaining an angler oriented Walleye harvest objective is important, as it is a measure of fish returned to the angler. The total annual pounds of Walleye harvested have ranged from 6,881 (2005) to 224,310 (1966) from 1965-2019. The objective range from 130,000 to 190,000 pounds represents the 53rd and 78th percentiles for the 1965-2019 time series, and is based on estimates of safe harvest levels. This range demonstrates that additional harvest is currently available and management steps have been taken to provide additional harvest opportunity (i.e. the removal of the protected slot effective 2019 Walleye opener). The total annual fishing pressure and regulation type will have strong influences on this objective and will continue to be evaluated when creel survey data is available. Zebra mussel expansion may impact overall lake productivity and yield (safe harvest) of the fishery. Rutherford et al. (1999) predicted reductions in Walleye recruitment and abundance of up to 30% and reductions in yield up to 10% as a result of Zebra mussel infestation. Therefore, 190,000 pounds of harvest may not be sustainable in a post-Zebra mussel condition.

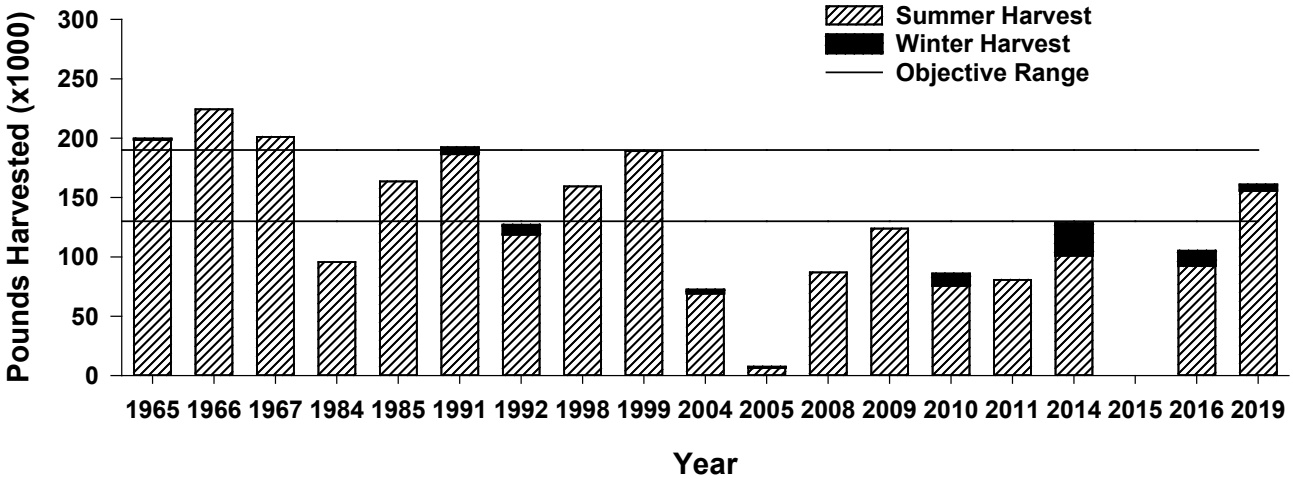

Figure 6. Total harvest (pounds x 1,000) of Walleye by Leech Lake anglers throughout summer and winter seasons, 1965-2019. Horizontal lines represent the 53rd and 78th percentiles.

Condition. *Maintain Walleye condition factor (3-year moving average) between 81 - 85 (currently 25th-75th percentiles).*

Walleye condition is assessed using relative weight (*Wr*), which is a ratio of individual weight versus its length (Murphy et al. 1990). Condition can be used as a surrogate to assess prey availability. If an individual has to increase the amount of energy expended to locate preferable prey or if it has to opt for less desirable prey, its condition values are lower. Lower Walleye condition values over the past several years coincide with the time period Yellow Perch gill net catch rates were below the 25th percentile. Walleye condition values have ranged from 78 (2011) to 90 (2004) from 1983-2019. Values of 81 and 85 are the 25th and 75th percentiles for the 1983-2020 time series.

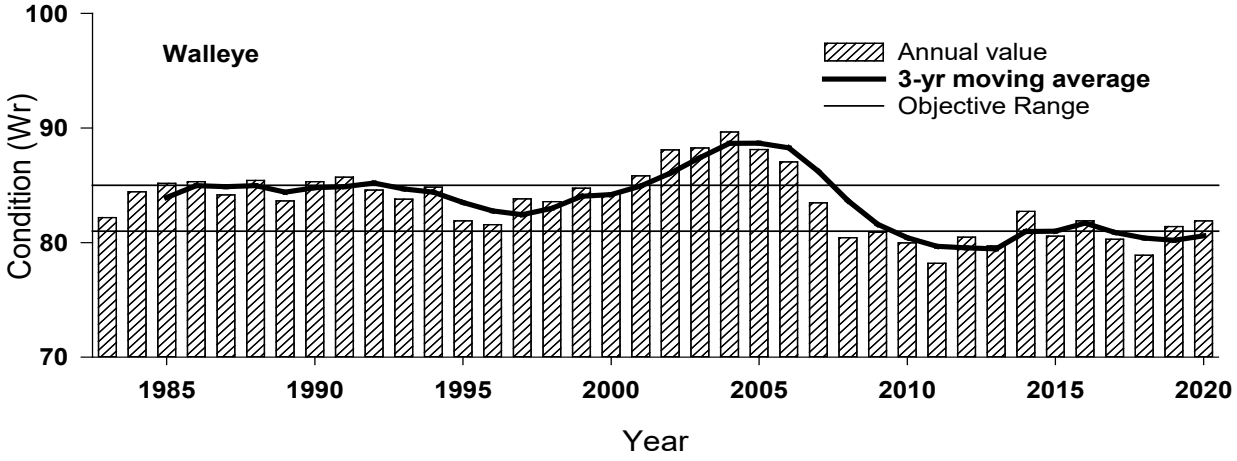

Figure 7. Annual mean condition (Wr) of Walleye in gill nets in Leech Lake, 1983-2020. Horizontal lines represent the 25th and 75th percentiles. The darker line represents the 3-year moving average.

Yellow Perch Goal:

Support a self-sustaining Yellow Perch population that provides both a stable prey base for sportfish and harvest opportunities for anglers.

Yellow Perch Objectives:

Abundance. *Maintain Yellow Perch gill net catch rate (3-year moving average) ≥15 fish/net (currently 25th percentile).*

Yellow Perch are the primary prey species for most predator sportfish. Anglers also harvest more Yellow Perch (by number) than any other species throughout the year. Yellow Perch gill net catch rates have ranged from 9.4 fish/net (2016) to 37.7 fish/net (1995) from 1983-2020. The objective threshold of 15 fish/net is the 25th percentile for the time series. The abundance objective under the 2011-2015 management plan was to maintain a gill net catch rate ≥16.3 fish/net, the 25th percentile for that time series, and ≥16.0 fish/net in the 2015-2020 management plan.

Although some variability in catch rates can be attributed to fluctuations in recruitment, the decline in perch catch rates from 1997-2005 occurred concurrently with marked increases in the cormorant population. Cormorant diet studies indicated that Yellow Perch were the principal prey of cormorants at that time (Schultz et al. 2013). Elevated predation by juvenile and adult Walleye and increases in total harvest of Yellow Perch by winter anglers are both suspected as primary causes of recent declines. In particular, a strong negative relationship exists between Yellow Perch recruitment and total Walleye fry density (Appendix 2, Figure 4). Steps taken to reduce predation pressure on Yellow Perch include continued cormorant control, discontinuation of Walleye fry stocking and expanded Walleye harvest opportunity for anglers. Based on the time series, the 25th percentile represents a threshold below which Yellow Perch recruitment and Walleye growth and condition are negatively impacted. From the perspective of sportfish management, maintaining Yellow Perch abundance above the 25th percentile is necessary.

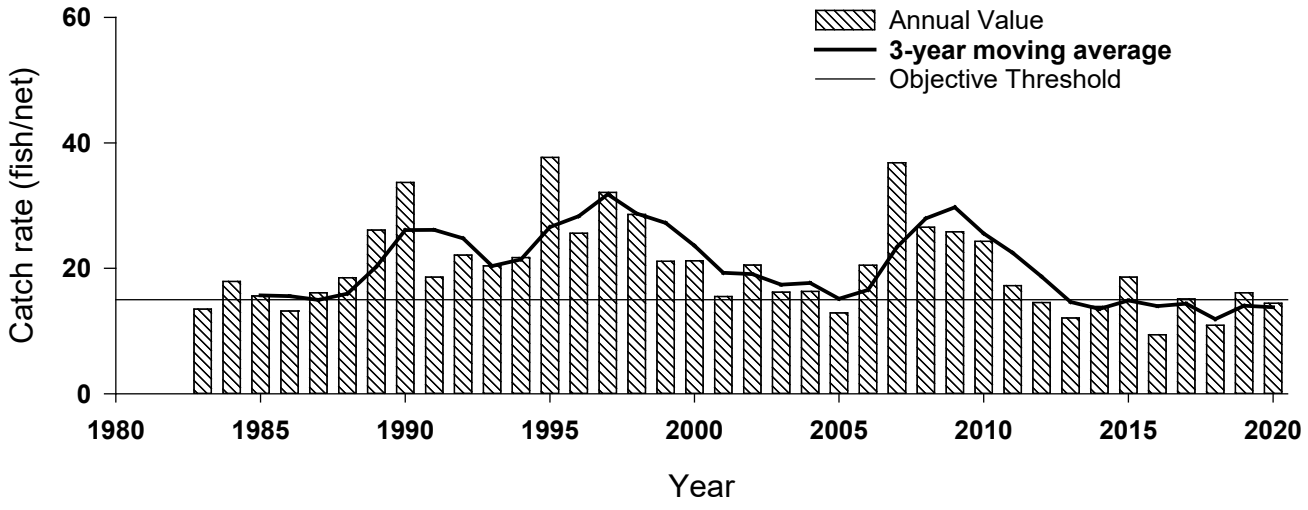

Figure 8. Gill net catch rates (fish/net) of Yellow Perch in Leech Lake, 1983-2020. The horizontal line represents the 25th percentile. The darker line represents the 3-year moving average.

Size Structure. *The percentage of Yellow Perch sampled in gill nets (3-year moving average) ≥8 inches should exceed 30% (currently 25th percentile).*

Summer and winter anglers start consistently harvesting Yellow Perch on Leech Lake at 8 inches. It is important to maintain a certain percentage of the Yellow Perch population that is of a size anglers elect to harvest. Acknowledging that Yellow Perch are managed as both a primarily prey species and as a species for angler harvest, the 25th percentile (30%) from the 1983-2014 time series was originally established as the management objective, this is the same as the 25th percentile for the entire 1983-2020 time series of 30%.

The percentage of Yellow Perch sampled in gill nets ≥8 inches has ranged from 17% (2020) to 49% (1999) from 1983-2020. The size structure objective under the 2011-2015 management plan stated that the percentage of Yellow Perch sampled in gill nets ≥8 inches (PSD-8) and ≥10 inches (RSD-10) exceed the 25th percentile thresholds for the 1983-2009 time series, which were 30% and 7%, respectively (Murphy and Willis 1996). Although the previous objectives did quantify length-frequency data and the portion of the population that was sexually mature and large enough for anglers to catch, the method was complex so this simpler metric was chosen.

The time periods where the metric fell below the 30% threshold for multiple years included the early to mid-2000s and two of the three years from 2012-2014. Reductions in the early to mid-2000s were attributed to elevated cormorant predation of juvenile Yellow Perch, which resulted in lower numbers of fish reaching harvestable sizes. Reductions in recent years are suspected to be attributed to elevated Walleye predation of juvenile Yellow Perch and elevated winter angler harvest of adults.

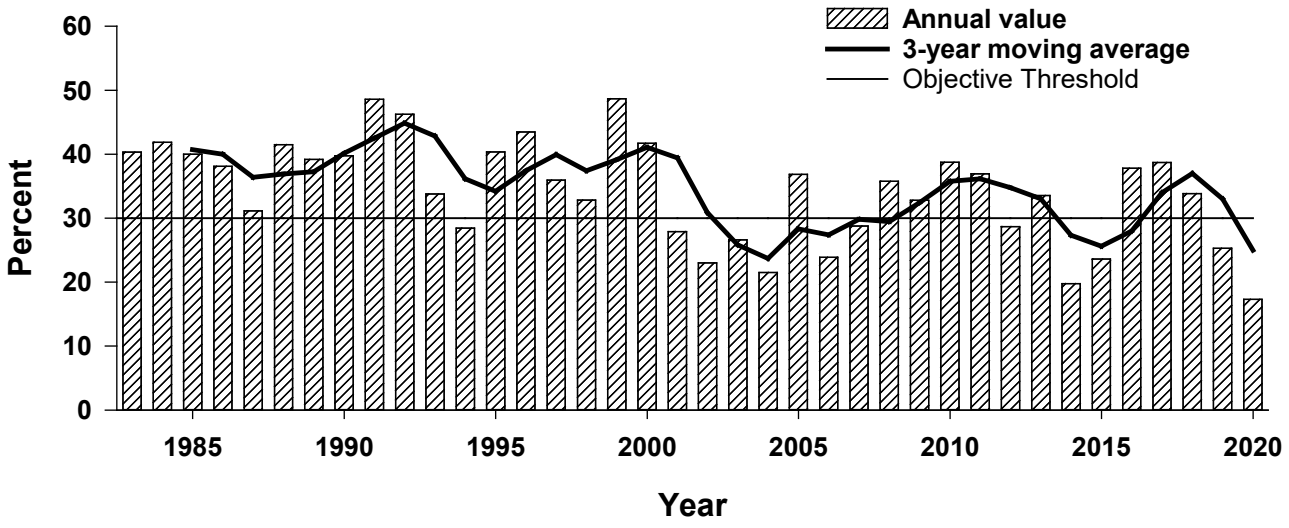

Figure 9. The percentage of Yellow Perch in gill nets ≥8 inches in Leech Lake, 1983-2020. The horizontal line represents the 25th percentile. The darker line represents the 3-year moving average.

Recruitment. *Maintain gill net catch rate (3-year moving average) of age-4 Yellow Perch ≥3.3 fish/net (currently 25th percentile).*

Maintaining stable Yellow Perch recruitment ensures fish are both available for consumption by sportfish and angler harvest. Monitoring Yellow Perch recruitment is important as it is a metric that indicates increased mortality of juvenile Yellow Perch or declines in production. Although young-of-the-year and age-1 Yellow Perch are annually sampled via seine in mid-July and bottom trawl in mid-August, there are no statistical relationships between the relative abundance of juvenile Yellow Perch sampled with standardized gears at standardized locations and the number of individuals sampled in gill nets. Likely reasons include the numerous bottlenecks present between juvenile life stages and maturity or gear type and sampling locations. These include, but are not limited to climate shifts, consumption by predators, and abundance of alternative prey such as Tullibee (Cisco) for predators. Age-4 Yellow Perch are a size (approximately 7 inches on Leech Lake) at which all individuals in a year class are large enough to be sampled in a gill net yet are smaller than most anglers elect to harvest. Therefore, age-4 gill net catch rates are a good index of recruitment.

Yellow Perch gill net catch rates for age-4 individuals have ranged from 1.3 (2018) to 9.0 (2007) from 2001-2020. Yellow Perch were aged with scales prior to 2001 and sample sizes were small and not distributed around the lake; consequently, the data set used to calculate this metric is limited to 2001 and later. The threshold of 3.3 fish/net refers to the 25th percentile of the 3 year moving average. Suspected reasons for the precipitous decline in recruitment since 2007 include increased predation pressure by Walleye in response to aggressive Walleye management actions in previous plans, i.e. stocking and Walleye protected slot limits. The impacts of increased Walleye biomass in the lake certainly may be having an impact on the Yellow Perch population. The removal of the PSL in 2019 was in part done to create a heathier predator prey balance between Walleye and perch in the lake with the ultimate goal being better survival of both species.

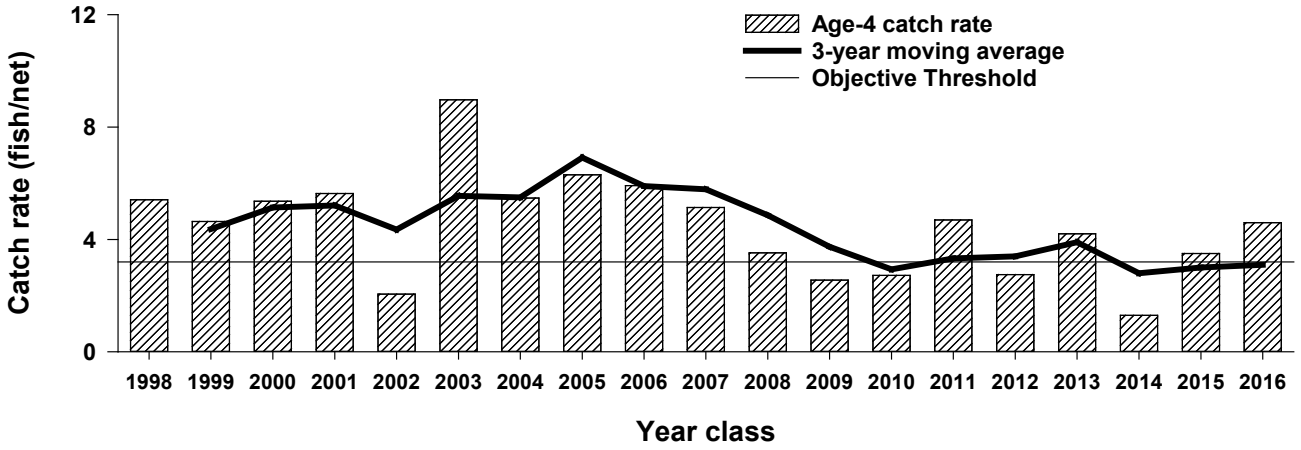

Figure 10. Gill net catch rates (fish/net) of age-4 Yellow Perch by year class in Leech Lake, 1998-2020. Year class indicates the year the fish was born. The horizontal line represents the 25th percentile. The darker line represents the 3-year moving average.

Angler Harvest. *The annual total Yellow Perch harvest should be less than 98,000 pounds.*

An angler oriented objective focused on Yellow Perch harvest is important, as it is a measure of fish returned to the angler. Yellow Perch are the most targeted species certain times of the year like September and March but are sought by anglers year round. The total annual pounds harvested (summer + following winter) have ranged from 28,909 (2004) to 160,217 (2010) between 1965 and 2019 with not all years being sampled in that range. Recently winter harvest has exceeded summer harvest especially on years where there is favorable on ice travel conditions in March.

The threshold of 98,000 pounds first used in the 2016-2020 management plan represents harvest levels below which angling quality is protected or enhanced (DNR 1997). If the annual pounds harvested exceeds the threshold on an infrequent basis, changes to population metrics (e.g. abundance, growth, age at maturity, etc.) will not likely be observed. Although the threshold can be exceeded in an individual year, sustained exceedance may result in changes to population metrics. For example, if annual total harvest consistently and significantly exceeds the objective, then growth rates may increase and maturity rates may decrease in response to elevated mortality. If harvest is driving this effect, then a noticeable decline in Yellow Perch ≥8.0 inches should also occur. Therefore, if annual harvest routinely exceeds the threshold and changes to population metrics similar to those described above are observed, the weight of evidence approach should be used to determine if regulation modifications are appropriate. There was not an angler harvest objective for Yellow Perch in the 2011-2015 management plan.

Lower angler harvest in the mid-2000s corresponded with the declines in angler pressure at that time. Reductions in angler pressure and harvest in the mid-2000s was attributed to declines in Walleye and Yellow Perch abundance resulting from high cormorant abundance. Increases in angler pressure and harvest over the past ten years, specifically in the winter, have resulted in unprecedented winter harvest of Yellow Perch. As a result, harvest and other population metrics (e.g. abundance, growth, and length at maturity, size structure) will be closely monitored during the life of this plan. The removal of the Walleye PSL in 2019 is expected to provide benefits to the perch population. If after several years of the new Walleye regulation, perch numbers remain low, a specific perch regulation will be considered.

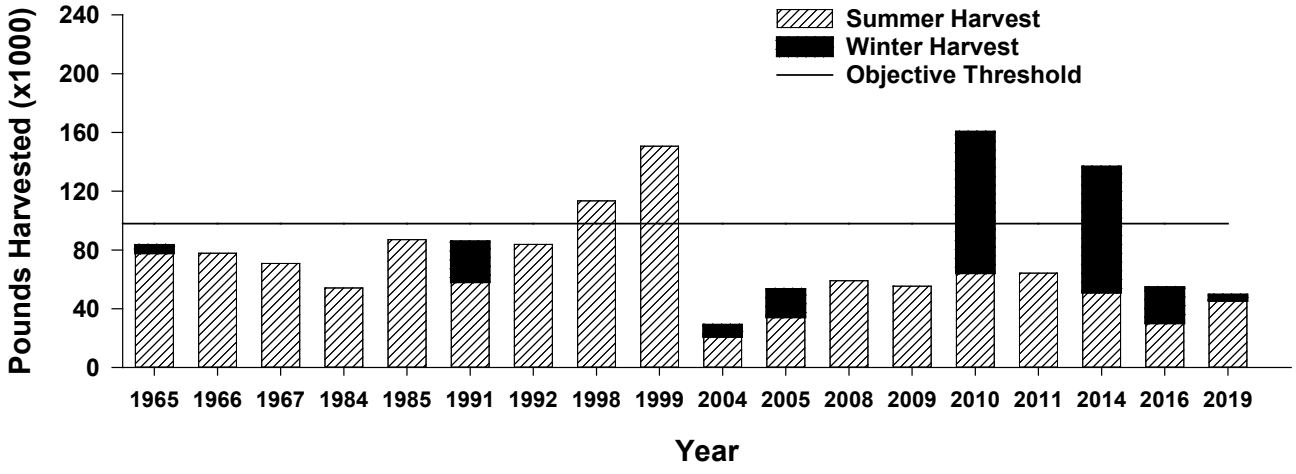

Figure 11. Total harvest (pounds x 1,000) of Yellow Perch by Leech Lake anglers throughout summer and winter seasons, 1965-2019. The horizontal line represents the harvest level below which angling quality is protected or enhanced (DNR 1997).

Maturity. *Female length at 50% maturity exceeds 5.5 inches.*

The length at which individuals become sexually mature is one of several metrics that can indicate overharvest or, more precisely, increased mortality. As mortality increases, populations respond by shifting more energy to reproduction than growth, resulting in maturation at shorter lengths. Changes in growth rate and recruitment patterns are two additional metrics that can indicate increased mortality.

Female length at 50% maturity refers to the length at which females have a 50% chance of being mature. That length was 6.1 inches in 2019. Therefore, individuals less than 6.1 inches had less than a 50% chance of being mature, while individuals greater than 6.1 inches had greater than a 50% chance of being mature. Prior to 2000, maturity observations were not recorded for Yellow Perch. Two distinct time periods exist within this time series, 2000-2005 and 2007-2019. From 2000-2005 when cormorant predation was excessive, female length at 50% maturity never exceeded 5.4 inches. Specifically, in 2002, 2004, and 2005, less than four immature individuals were sampled in gill nets, while no immature fish were sampled in 2006. However, from 2007 through 2019 the length at 50% maturity had an average of 6.3 inches (range 6.1-6.5)

The differences in these metrics across the two respective time periods indicates the expected population responses by Yellow Perch to changes in mortality as cormorant abundance increased and was then reduced and maintained by control efforts (Schultz 2013). There was not a maturity objective for Yellow Perch in the 2011-2015 management plan.

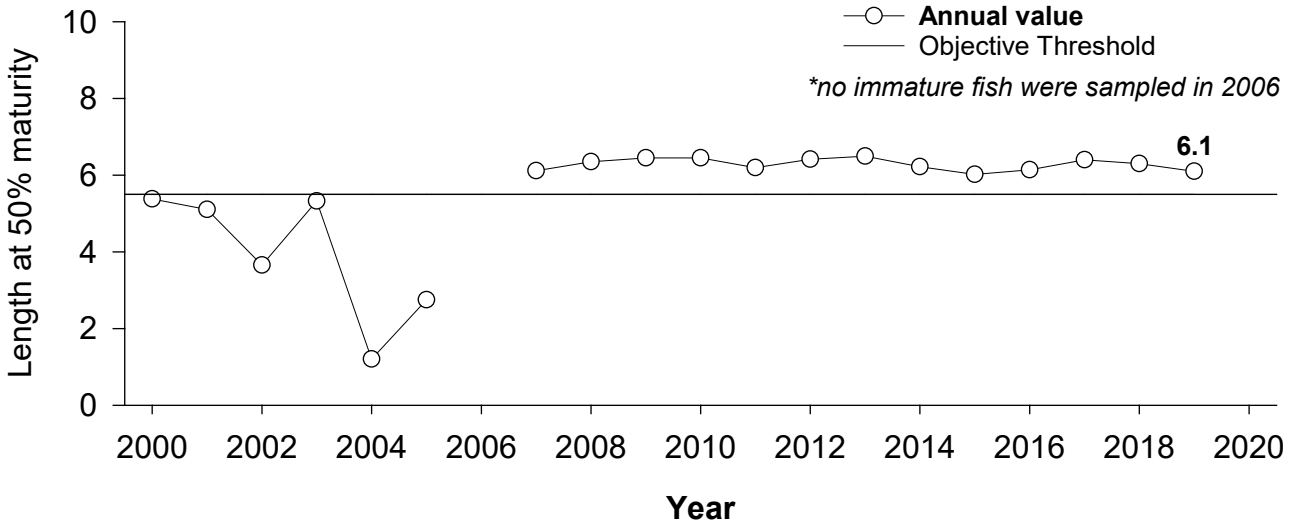

Figure 12. Total length of female Yellow Perch at 50% maturity in gill nets in Leech Lake, 2000-2019. The horizontal line represents the mortality threshold below which Yellow Perch matured at shorter lengths.

Northern Pike Goal:

Support a self-sustaining Northern Pike population that balances harvest opportunity with catch quality.

Northern Pike Objectives:

Abundance. *Maintain a gill net catch rate (3-year moving average) between 4.1 - 5.3 fish/net (currently 25th and 75th percentiles).*

Maintaining a stable abundance of Northern Pike is important as they are the 2nd most harvested species (pounds) annually and comprise 5-10% of angling trips. Overall, gill net catch rates have varied little since 1983, ranging from 3.6 fish/net (1993) to 6.2 fish/net (1995) during 1983-2020. The objective range of 4.1 to 5.3 fish/net that represents the 25th and 75th percentiles, respectively, was developed during the 2016-2020 management plan process. The abundance objective under the 2011-2015 management plan was to maintain a gill net catch rate of 4.1 fish/net or higher, the 25th percentile for the 1983-2009 time series. Although catch rates exceeded the 25th percentile most of the time, having a threshold at the 25th percentile did not account for statewide concerns of increasing pike abundance. Therefore a range instead of a threshold is more appropriate. It is still unsure how much Leech Lake will benefit from the zone Northern Pike regulations that were implemented in 2018. If gill net catch rates above the 75th percentile are sustained for consecutive years, then the weight of evidence approach should be used to determine if alternative regulations are appropriate. It is important to note that any changes from the new northwest zone regulation will take time (e.g. 10-15 years). Growth and maturity rates, recruitment, and harvest statistics are additional metrics to monitor for determining the appropriateness of regulation changes.

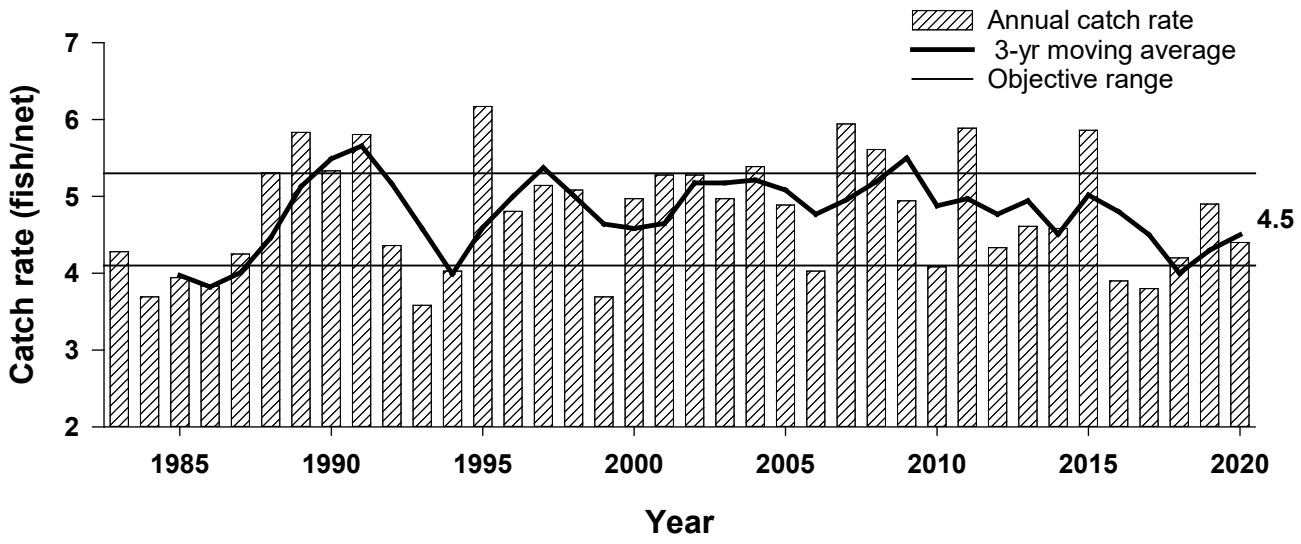

Figure 13. Gill net catch rates (fish/net) of Northern Pike in Leech Lake, 1983-2020. Horizontal lines represent the 25th and 75th percentiles. The darker line represents the 3-year moving average.

Size Structure. *The percentage of Northern Pike sampled in gill nets (3-year moving average) ≥22 inches should exceed 31% (currently 25th percentile).*

Increases in the abundance of small Northern Pike can result in slow growth, increases in consumption of prey (Yellow Perch and Walleye), lower harvest potential and fewer trophy sized pike. Therefore, maintaining a balanced size structure of Northern Pike reduces the likelihood these conditions will occur and maintains the catch quality and harvest potential for anglers.

Anglers on Leech Lake consistently begin harvesting Northern Pike at lengths of 22 inches. It is important to maintain a certain percentage of the Northern Pike population that is of a size anglers elect to harvest. The percentage of Northern Pike sampled in gill nets ≥22 inches has ranged from 22% (2001) to 62% (2007) from 1983-2019. The threshold of 31% represents the 25th percentile throughout the time series, and provides perspective on mid-size and larger individuals. The 25th percentile as the objective was established during the 2016-2020 management plan process. The size structure objective under the 2011-2015 management plan stated the percentage of Northern Pike sampled in gill nets ≥21 inches (PSD-21) and ≥28 inches (RSD-28) exceed the 25th percentiles for the 1983-2009 time series, which were 43% and 5% respectively (Murphy and Willis 1996). Although the previous objectives did quantify length-frequency data and the portion of the population that was sexually mature and large enough for anglers to catch, the metric was overly complex.

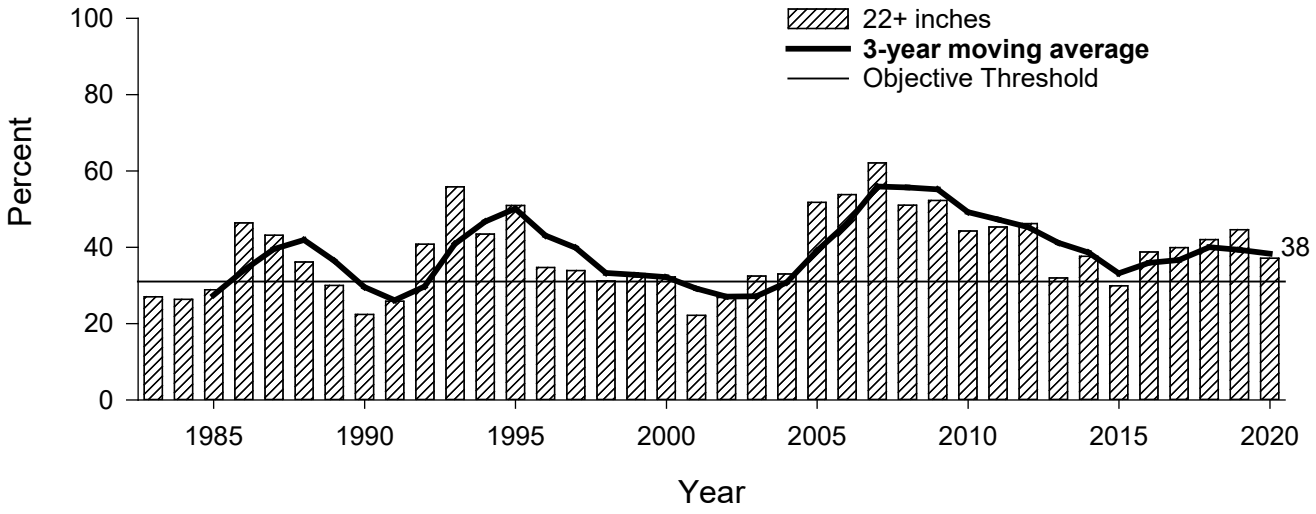

Figure 14. The percentage of Northern Pike in gill nets ≥22 inches in Leech Lake, 1983-2020. The horizontal line represents the 25th percentile. The darker line represents the 3-year moving average.

Recruitment. *Maintain gill net catch rate of age-3 Northern Pike (3-year moving average) between 1.0 - 1.7 fish/net (currently 25th and 75th percentiles).*

Maintaining a stable number of juvenile Northern Pike recruiting to the fishery ensures there are both fish available for anglers and sexually mature individuals continually entering the spawning population. Most Northern Pike concerns center on the elevated abundances of small pike and this objective provides perspective on smaller sized individuals. Age-3 Northern Pike are a size (approximately 18-19 inches) at which all individuals in a year class are large enough to be sampled by gill nets, yet are smaller than most anglers elect to harvest. Therefore, age-3 gill net catch rates are a good index of recruitment.

Northern Pike gill net catch rates for age-3 individuals have ranged from 0.4 (1993) to 2.4 (2004) from 1990-2020. Northern Pike were aged with scales prior to 1990; consequently, the data set is limited to when cleithera have been used as the aging structure. The ranges of 1.0 and 1.7 refer to the 25th and 75th percentiles, respectively. Maintaining gill net catch rates between 1.0 and 1.7 fish/net indicates stable lakewide recruitment. There was not a recruitment objective for Northern Pike in the 2011-2015 management plan and this criteria was developed during the 2016-2020 process.

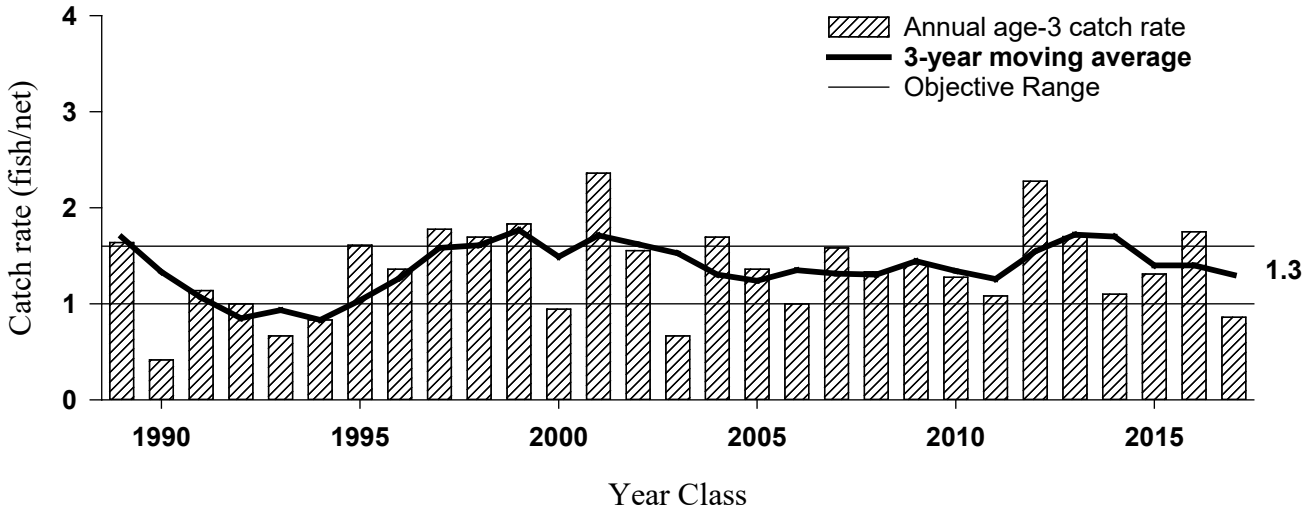

Figure 15. Gill net catch rates (fish/net) of age-3 Northern Pike by year class in Leech Lake, 1998-2020. Horizontal lines represent the 25th and 75th percentiles. The darker line represents the 3-year moving average.

MANAGEMENT ACTIONS

Fisheries Assessments

Annual Large Lake surveys
Annual surveys will continue to include water quality sampling and seining in mid-July, trawling in mid-August, electrofishing in mid-September, gill netting in mid-September, water temperature loggers (recording hourly year round), and monthly zooplankton sampling (mid-May through mid-October).

Creel surveys
Summer and winter creel surveys will be conducted every four years. An unplanned creel survey was conducted in 2019 and winter 2019-2020 to evaluate impacts of the removal of the slot limit. The regularly scheduled 2020 survey was canceled due to concerns over the COVID-19 outbreak and lack of staffing. The next scheduled creel surveys on Leech Lake are for the summer of 2024 and the winters of 2024-2025. Angler satisfaction will continue to be incorporated into future creel surveys at the request of the Leech Lake Fisheries Input Group.

Fall Electrofishing for YOY Walleye
To date, a combination of trawl and gill net catch rates at age-0 have been used to predict year class strength. The estimated year class strength at age-1, age-2, and age-3 is determined based solely on gill net catch rates. Age-3 Walleye are considered fully recruited to the fishery and harvest on a year class generally starts during fall of age-3. The multivariate (multiple years) method for predicting age-0 year class strength has greater precision over the trawl-only prediction model (Schultz 2007), though both are subject to the high uncertainty surrounding young-of-year catch rates and first-year survival. These methods will continue to be refined as additional years and new gears are assessed. Electrofishing in mid-September was initiated in 2007 and appears to be a more accurate predictor of age-0 Walleye year class strength. If this relationship continues to show an improvement over trawling-related methods and models, consideration will be given to changing from trawling to electrofishing as the primary predictor of year-class strength. Additionally in Lake Winnibigoshish trawl fouling from Zebra mussels has caused this gear to be unreliable which is a possibility in Leech Lake. This may further the need to utilize fall electrofishing as the primary source for year class predictions,

Bluegill, Black Crappie, Largemouth Bass, and Smallmouth Bass Sampling
Conduct lakewide Bluegill, Black Crappie and Largemouth Bass assessments every four years, following standardize sampling methodology, locations, and timing developed in 2018. Originally the plan was to sample every 3 years but this was adjusted to every 4 years to avoid conflicts with Muskellunge spawn take every 4 years. The next scheduled survey is in 2022. Smallmouth Bass are difficult to target but will be tracked using standard gill net sampling and additional directed electrofishing when possible.

Muskellunge Sampling
The 2016-2020 management plan included a section concerning Muskellunge tagging. After careful evaluation by Walker Fisheries office staff and the statewide Muskellunge Technical Committee it was determined that tagging fish handled during spawning and tagging the 600 fish that are stocked into Leech every 4 years would not provide any scientifically viable data due to low probability of recapturing marked fish in a 112,000 acre lake sampled infrequently. Subsequently, no Muskellunge will be tagged as part of spawn-take operations or stocking moving forward.

Tullibee (Cisco) and Whitefish Sampling
Coordinate with the Leech Lake Band of Ojibwe, Division of Resource Management to collect additional Tullibee (Cisco) and Lake Whitefish data from the commercial fishery when possible.

Burbot Sampling
The 2016-2020 management plan included annually collecting data from a subsample of Burbot registered at the Leech Lake Eelpout Festival. Very poor ice conditions and changes to the format of the Eelpout tournament made sampling very difficult. Burbot are a cold-water sensitive species that are poorly understood. Interest in Burbot has increased in recent years and Burbot were removed from the list of rough fish in Minnesota statute and are now listed as an underutilized fish. A formal rulemaking process will need to take place to establish

possession limits for this species. Sampling to collect biological information to better understand population characteristics and dynamics is recommended, but if the annual Eelpout Festival is cancelled indefinitely this information may difficult to obtain.

Stocking & related activities

Walleye Fry Stocking

The DNR recognizes stocking is a valuable management tool when used to meet specific management objectives if natural reproduction is limited. In general, stocking has not been necessary for maintenance of Walleye populations in Minnesota's large natural Walleye lakes and it has been determined that stocking on top of adequate natural reproduction can be detrimental to Walleye fisheries.

Stocking OTC-marked Walleye fry (i.e. oxytetracycline-marked) was one of four tools used to increase Walleye abundance in Leech Lake following a decline in the fishery 2005 to 2014. The use of variable densities of marked fry facilitated a thorough evaluation of total fry density effects on first-year growth and eventual recruitment to the fishery (Appendix 2, Figures 1-7). Annual fry stocking densities during those years ranged from 7.5 to 22.5 million fry and total fry density (wild + stocked) ranged from 237 to 908.

These analyses have determined that:

- During periods of extremely low spawner stock abundance (e.g. 2005), supplemental stocking could be beneficial.
- Higher fry stocking rates have not resulted in more Walleye surviving to catchable sizes.
- Higher fry stocking rates have resulted in slower growth rates for young-of-the-year Walleye.
- Slower growth rates of young-of-the-year Walleye resulted in fewer Walleye surviving to catchable sizes.
- Higher Walleye fry densities have increased predatory demand for young-of-the-year Yellow Perch and has statistically corresponded with lower abundances of Yellow Perch surviving to age-4 produced the same year.
- Yellow Perch are the primary prey of Walleye, years with lower abundance of Yellow Perch have resulted in below average adult Walleye condition (plumpness; see Walleye condition Figure 7).

Although annual stocking of Walleye fry at the time of the development of this management plan is not necessary on Leech Lake, it is important to outline circumstances when it may be an appropriate and/or an informative management action appropriately balanced with potential short- or long-term risk imposed on the fishery. Most recruitment concerns center on consecutive years where the year class strength index (i.e. the relative abundance of Walleye produced in an individual year) is below the 25th percentile. The 25th percentile is a threshold below which year class strength is defined as poor, and the most recent occurrence of this was during the early 2000s when cormorant predation was later determined to be excessive (Schultz et al. 2013). Cormorant control, Walleye stocking, and restrictive Walleye harvest regulations were all simultaneously implemented in 2005 to improve the Walleye population. Research indicates the current level of cormorant control is appropriate, and the stocking evaluation indicates current wild fry production is sufficient to maintain a robust Walleye population. Discontinuation of walleye stocking as an annual management action in 2015 was based on strong empirical evidence indicating negative impacts of supplemental fry stocking not once but for multiple year classes of Walleye and Yellow Perch. Thus, the state of the Walleye population in 2020 has proven the validity of the current cormorant control target in the absence of Walleye fry stocking and given the current level of natural reproduction. Continued monitoring of Walleye recruitment in the absence of fry stocking should continue to fully evaluate the fishery.

This plan includes two scenarios when Walleye fry will be stocked that were developed in the 2016-2020 management plan process. The first is directly related to the Walleye Recruitment objective (figure 4). The action states that if the 3-year moving average (of year class strength index values) falls below the 25th percentile (for the 1983-2019 time series) 7.5 million Walleye fry will be stocked the following year. This stocking density has performed similarly to higher densities and minimizes the potential for negative effects on first-year Walleye growth, survival, and recruitment to the fishery as well as minimizing predation pressure on the Yellow Perch.

The second scenario when Walleye fry stocking action would be implemented would be for research purposes to expand on the range of total fry density observations (currently 237-908 fry/littoral acre) when yearly mature

female density is below 1.25 pounds/acre or above 2.75 pounds per acre. The action states if the mature female density estimate observed in a single year is below 1.25 or above 2.75 pounds/acre, a low-density fry stocking will be considered the following year. A weight of evidence approach will be used to determine if implementing this action will pose low risk to Walleye or other sportfish populations, particularly Yellow Perch. The stocking density will be determined based on statistical needs to meet the target objective (i.e. achievable sample size requirements for recapture rates with a reasonable expectation to meet the target density).

Any stocked Walleye fry will originate from the Boy River (Cass County) and will be marked with OTC prior to stocking. This genetic stocking strategy is based on recommendations from the University of Minnesota which determined that the Boy River strain is the most similar and appropriate strain to use in Leech Lake (Miller 2007). Other recommended strategies for reducing the risk for adverse population impacts at the genetic level include stocking early life stages (fry instead of fingerlings), stocking fewer fish, stocking less often, and not stocking from multiple sources (e.g. other strains).

Muskellunge Spawn Take and Fingerling Stocking

Conduct Muskellunge spawn take operation every four years in Miller's Bay to maintain genetic diversity in brood stock lakes. To compensate for removing gametes during the Muskellunge spawn take operation, approximately 600 fingerlings will be returned to Leech Lake under the traditional DNR put-back policy on systems with spawn take operations. The next scheduled spawn take is in 2021.

Regulations

Walleye regulations

An 18-26 inch Walleye PSL, 4 fish possession limit was implemented in 2005 to protect and increase spawner biomass; the regulation was relaxed to a 20-26 inch PSL in 2014 after management objectives were exceeded. In 2019 the regulations were further relaxed to a 1 over 20 inch limit with a possession limit of 4 fish. Spawner biomass has continued to remain high despite a more liberal harvest regulation, however the new regulation has only been in effect for one complete angling season. The 2016-2020 management plan outline for further relaxation of the regulation led to this new regulation being implemented. If spawner biomass drops below management objectives (three year moving average) reinstatement of a protected slot limit will be considered.

Whitefish and Tullibee (Cisco) regulations

The existing bag limits (25 daily and 50 in possession) on Tullibee (Cisco) and Lake Whitefish within the Leech Lake Indian Reservation will be continued. The current statewide proposal matches this regulation.

Potential Sunfish and Black Crappie regulations

A crappie possession limit of 5 and Sunfish possession limit of 5 were proposed in 2020 with likely implementation in 2021 as part of a statewide Quality Bluegill Initiative. This regulation will be evaluated utilizing future creel surveys and targeted spring sampling. The proposed regulations are intended to reduce exploitation and maintain and/or improve size structure and abundance of both species. Strong concerns have been expressed by lakeshore owners, area guides, fishing industry personalities and Leech Lake Fisheries Input Group members concerning harvest impacts to the exceptional size quality of both species.

Other species managed with statewide regulations

If changes to statewide regulations occur, implement regulations consistent with statewide recommendations and evaluate angler and fish population responses through standardized creel and gill net surveys.

Habitat

Protection

Many of the proposed habitat management actions will require additional funding and/or staff, or rely heavily on partner agencies or non-governmental organizations (NGOs) and will only be possible when specific opportunities present themselves (Appendix C). DNR Fisheries will make recommendations or support actions

with other non-governmental organizations and/or government agencies as appropriate to protect the aquatic resource.

The DNR will continue to cooperate with the Leech Lake Band of Ojibwe, Division of Resource Management and partner with NGOs to identify and acquire critical shoreland habitat through fee title and conservation easements. Five Mile Point and Miller's Bay (Whipholt) were identified as high priority areas for acquisition because they are Muskellunge spawning areas and potentially sensitive to anthropogenic disturbance and have been partially protected. Prioritizing additional areas for acquisition can be accomplished using findings from the Cass County Sensitive Shorelands project, Minnesota Pollution Control Agency's WRAPS program (Watershed Restoration and Protection Strategy), DNR sampling information, and other habitat-oriented evaluations.

The DNR will continue to thoroughly review project proposals requiring a permit within the context of short- and long-term environmental impact.

Nearshore Habitat Inventory

A Score the Shore inventory of Leech Lake was completed in 2018. Score The Shore is a natural resources survey used to estimate the amount of habitat in three lakeshore zones, The Shoreland Zone is the portion of land which is most likely to be developed and approximates the required minimum setback distance for shoreland structures. The Shoreline Zone is the portion of land between the Shoreland and Aquatic Zones. It begins at the water's edge and extends landward to the bank. This zone may be narrow or broad, depending on the slope. The Aquatic Zone begins at the land-water interface and extends lakeward 50 feet. It includes shallow water where rooted aquatic plants may grow; this is also the zone of a lake most likely to be utilized and impacted by riparian residents.

Aquatic Vegetation Inventory

Emergent Vegetation Mapping was implemented in 2019 with the goal to have all emergent vegetation mapped on the lake by 2023. Emergent vegetation is the aquatic vegetation that emerges from the water and can be seen above the surface of the water. Wild Rice, Waterlilies and Bulrush are the primary species of emergent vegetation found in Leech Lake but there are others present.

Muskellunge Spawning Habitat Assessment

Explore options for performing a telemetry study to identify additional Muskellunge spawning locations and other critical habitats to guide future priorities for shoreland protection.

Aquatic Invasive Species (AIS) management & education

Continue to coordinate with DNR Ecological and Water Resources staff and Cass County Environmental Services to assist with aquatic invasive species prevention, education, and management efforts by DNR Ecological and Water Resources Division and other agencies.

Other Considerations

Double-crested cormorant control & evaluation

The Leech Lake Band of Ojibwe, Division of Resource Management (DRM) has jurisdiction over the double-crested cormorant control policy on tribal lands and waters on Leech Lake. The DRM conducted studies from 2004 to 2006, 2010 and 2017 to 2019 in order to evaluate the effects of cormorant predation on fish populations in Leech Lake. Based on findings in these studies along with standard fisheries survey results the DNR will continue to support maintaining the cormorant population at 500 reproducing pairs which equates to a total fall population at or below 2,000 birds. The annual removal of most birds earlier in the year will continue to be encouraged as this reduces total fish predation and was included under the previous federal Public Resource Depredation Order. The DNR will continue to support DRM's efforts to secure funding sources and provide technical assistance for continued cormorant control and research evaluating cormorant impacts on Leech Lake sportfish populations as requested by DRM and pursue long-term permitting of control. DNR staff are currently

engaged on a national effort to characterize cormorant effects on fish populations and model prescriptive management actions via a recently funded study based at Michigan State University.

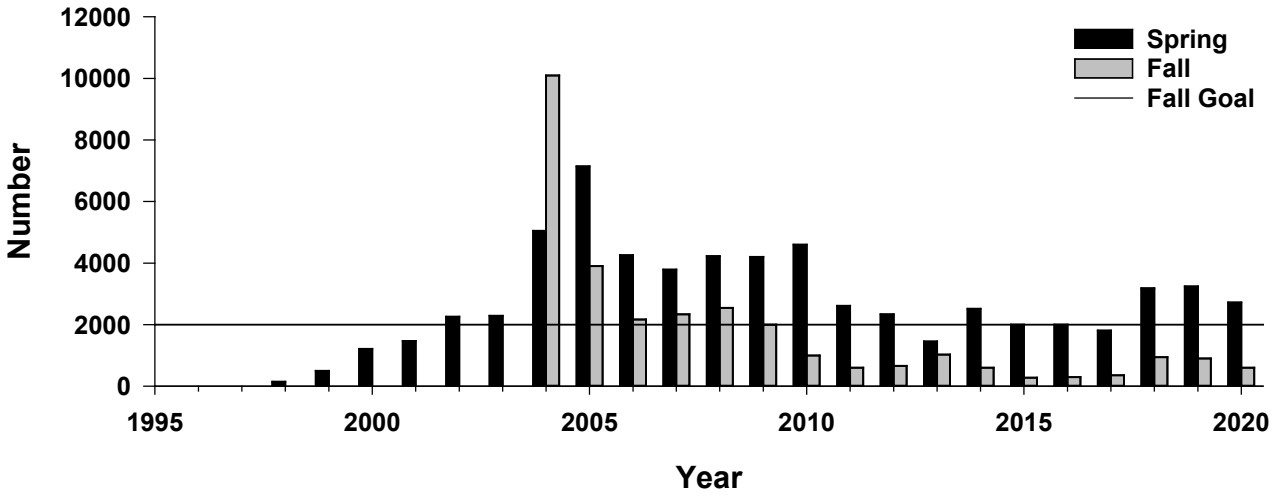

Figure 16. Spring and fall Double-Crested Cormorant numbers on Leech Lake, 1998-2020. The horizontal line depicts the current fall population goal of 2,000 birds ([500 nesting pairs x 2 adults] + 2 offspring/nest). (S. Mortensen, Division of Resource Management, Leech Lake Band of Ojibwe, personal communication).

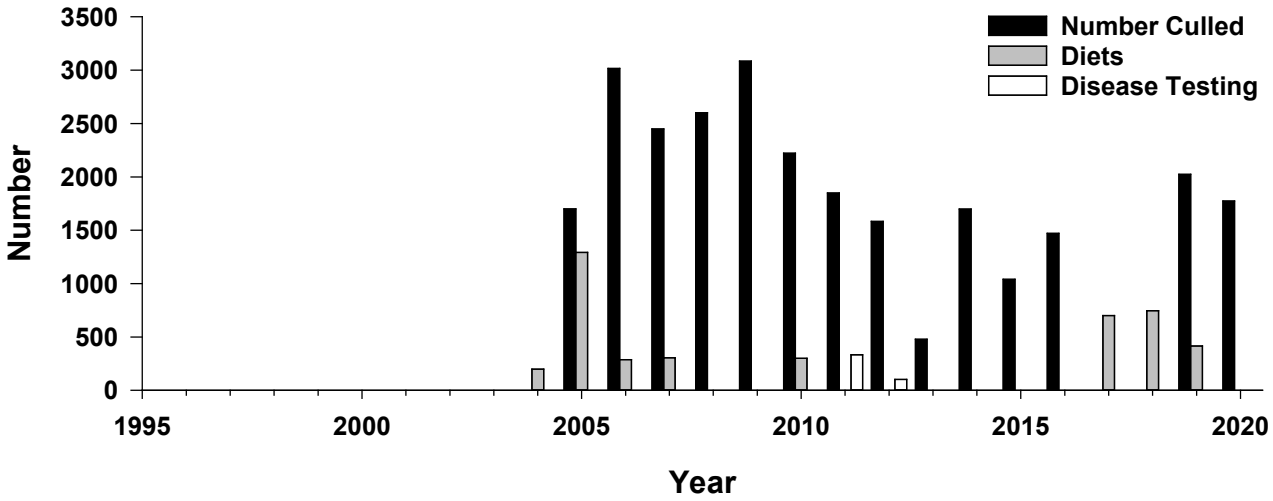

Figure 17. The number of Double-Crested Cormorants culled on Leech Lake, 2000-2020. The number of additional birds culled for diet and disease testing is also indicated. (S. Mortensen, Division of Resource Management, Leech Lake Band of Ojibwe, personal communication).

Climate effects on Walleye populations

Continue to evaluate climate effects on Walleye recruitment, specifically length and intensity of the growing season (i.e. growing degree days; GDD_{50}=GDD ≥50°F). Annual GDD_{50} values were calculated using water temperature data from loggers deployed in Leech Lake by the DNR. Growing season length and intensity have a strong influence on Walleye first-year growth and eventual recruitment (Appendix 2 Figures 5 and 6).

Muskellunge Tournament Data

Creel data has been collected from a minimum of 3 Muskellunge tournaments each year since 2015, with the exception of 2020 when COVID-19 impacts allowed for creel data collection at only 1 tournament. Continue to collect data from participants during various Muskellunge tournaments in an effort to build a long-term dataset. Other options to consider include using social media or mobile phone applications to monitor catch rates, size structure, etc.

Fishing Tournaments

Encourage CPR (Catch Photo Release) formats for tournaments to the extent possible.

Annual stakeholder meetings

Annual update meetings with the LLFIG will occur in March. The purpose of these meetings will be to share current data and information with the LLFIG and other interested stakeholders. Management objectives and actions delineated in this document are intended to provide the framework for management for the next five years. Most management objectives and actions outlined here are directed at fish populations. Consequently, time is required for these populations to respond via metrics, such as recruitment, growth, and maturity rates, to the effects any management actions may be having. While adaptive management relies upon "learning by doing", appropriate timelines are needed to ensure the outcomes of management actions can be accurately assessed and lessons learned can be applied to future decision-making processes.

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APPENDIX A.

A comparison of the 2005-2010, 2011-2015, and 2016-2020 and 2021-2025 Fisheries Management Plan objectives for Leech Lake.

	Management Plan				
Walleye	*2005 – 2010*	*2011 – 2015*	*2016 – 2020*	*2021-2025*	Change Justification
Abundance (fish/gillnet)	≥7.4 (60th percentile)	≥ 8.5 (75th percentile)	3-year running average between 7-10 (40th - 90th percentiles)	3-year running average between 7-10 (29th - 85th percentiles)	Updated Percentiles
Female spawner abundance (pounds/acre)	1.25 – 1.75 (50th - 80th percentiles)	1.5 – 2.0 (60th - 90th percentiles)	3-year running average between 1.5 – 2.0 (50th - 80th percentiles)	3-year running average between 1.5 – 2.0 (40th - 77th percentiles)	Updated Percentiles
Gillnet size structure	50% < 15" (40th percentile)	45 – 65% ≤ 15" (25th - 75th percentiles)	3-year running average between 10-20% ≥20" (50th - 80th percentiles)	3-year running average between 10-20% ≥20" (39th - 70th percentiles)	Updated Percentiles
Year class strength (recruitment)	Two strong year classes by 2009 (≥75th percentile)	Average or stronger year classes produced 2 out of 4 years (50th percentile)	3-year running average >1.1* (>25th percentile)	3-year running average >0.80* (>25th percentile)	*Standarizded formula used to calcualte YCS in 2015
Age 1 abundance	Age-1 trawl catch rate 45 fish/hour (50th percentile)	None	None	None	
Angler catch (fish/hour)	None	None	Targeting angler summer catch rate ≥0.30 (50th percentile)	Targeting angler summer catch rate ≥0.30 (60th percentile)	Updated Percentiles
Angler harvest	None	Targeting angler summer harvest rate 0.25 (fish/hour) (90th percentile)	Annual pounds harvested between 130,000 and 190,000 (50th and 80th percentiles)	Annual pounds harvested between 130,000 and 190,000 (53th and 78th percentiles)	Updated Percentiles
Natural reproduction	None	Natural reproduction alone can maintain population	None	None	
Condition	None	None	3-year running average between 82 and 86 (25th and 75th percentiles)	3-year running average between 81 and 85 (25th and 75th percentiles)	Updated Percentiles

Yellow Perch

Abundance (fish/net)	None	≥16.3 (25^{th} percentile)	3-year running average ≥16 (25^{th} percentile)	3-year running average ≥15 (25^{th} percentile)	
Gillnet size distribution	None	Proportion ≥8 inches (PSD-8) and ≥10 inches (RSD-10) (25^{th} percentiles)	3-year running average ≥8 inches exceeds 30% (25^{th} percentile)	3-year running average ≥8 inches exceeds 30% (25^{th} percentile)	
Year class strength (fish/net; recruitment)	None	None	3-year running average age-4 perch ≥3.2 (25^{th} percentile)	3-year running average age-4 perch ≥3.3 (25^{th} percentile)	Updated Percentiles
Angler harvest	None	None	Harvest should be ≤98,000 pounds annually[1]	Harvest should be ≤98,000 pounds annually[1]	
Maturity	None	None	Female length at 50% maturity >5.5"	Female length at 50% maturity >5.5"	

Northern Pike

Abundance (fish/net)	None	≥4.1 (25^{th} percentile)	3-year running average between 4.2 and 5.3 (25^{th} and 75^{th} percentiles)	3-year running average between 4.1 and 5.3 (25^{th} and 75^{th} percentiles)	Updated Percentiles
Gillnet size distribution	None	Proportion ≥8 inches (PSD-21) and ≥10 inches (RSD-28) (25^{th} percentiles)	3-year running average ≥22 inches exceeds 30% (25^{th} percentile)	3-year running average ≥22 inches exceeds 31% (25^{th} percentile)	Updated Percentiles
Year class strength (fish/net; recruitment)	None	None	3-year running average age-3 catch rate between 1.0 and 1.6 (25^{th} and 75^{th} percentiles)	3-year running average age-3 catch rate between 1.0 and 1.7 (25^{th} and 75^{th} percentiles)	Updated Percentiles

[1]Threshold established in MNDNR 1997; Special Publication 151

APPENDIX B.

Relationships observed through the evaluation of total Walleye fry density effects on first-year growth and eventual recruitment to the fishery.

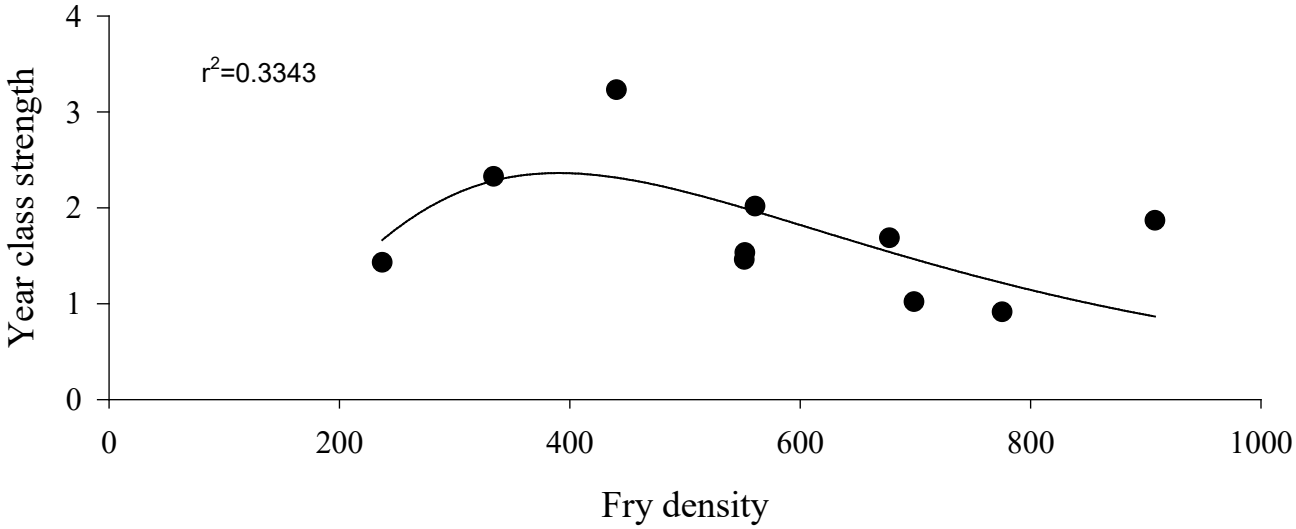

Figure B1. Estimated total Walleye fry density (fry/littoral acre, i.e. depths ≤15 feet) and the resulting strength of stocked year classes, 2005-2014. Year classes are considered fully recruited at age-3.

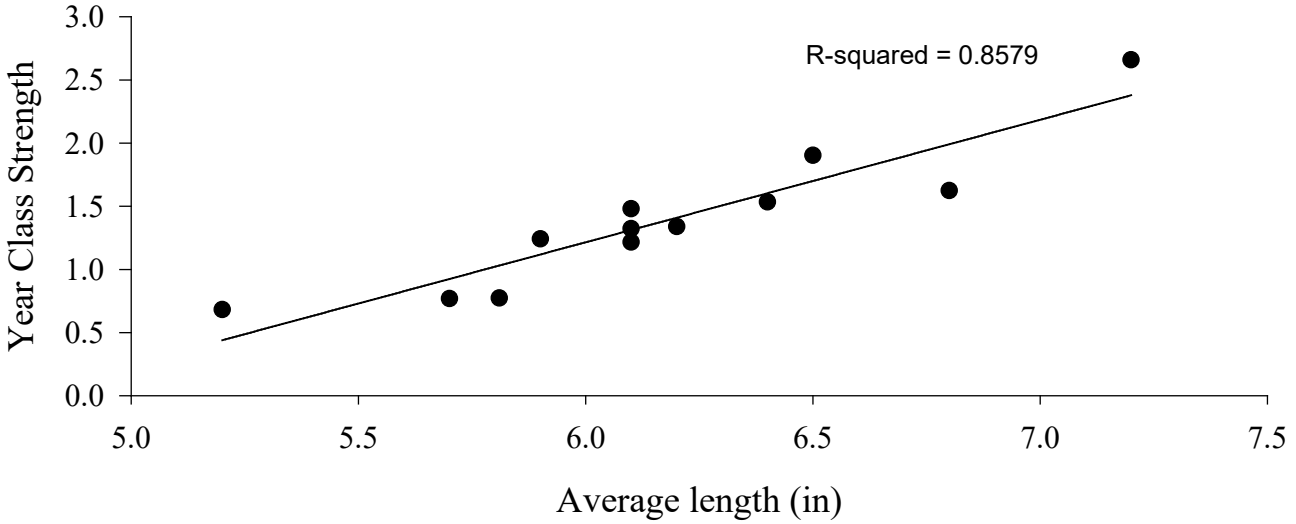

Figure B2. Estimated Walleye year class strength and the average length (inches) of young-of-the-year Walleye sampled by electrofishing in mid-September, 2005-2019.

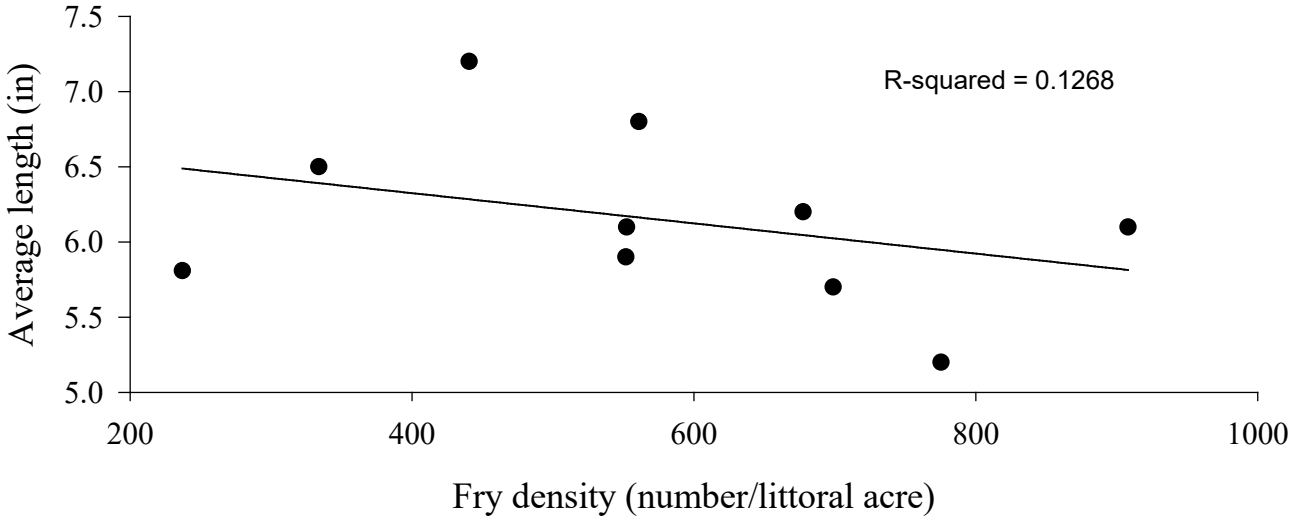

Figure B3. The average length (inches) of young-of-the-year Walleye sampled in mid-September and the resulting strength of stocked year classes, 2005-2014. Year classes are considered fully recruited at age-3.

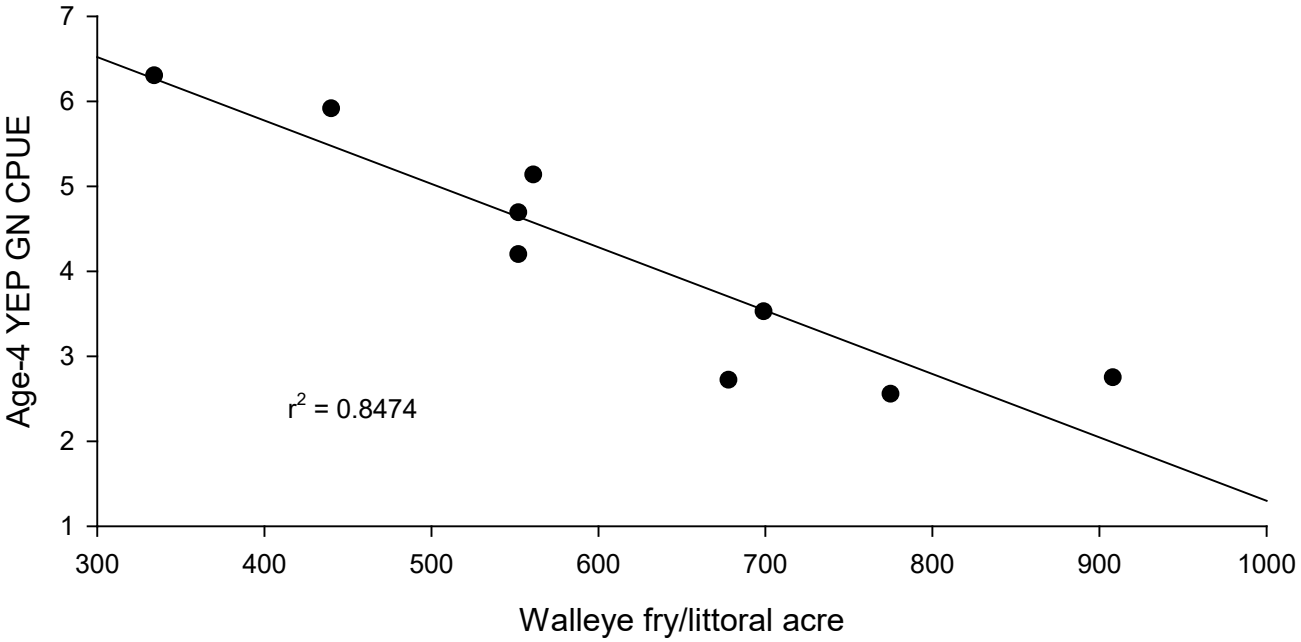

Figure B4. Estimated total Walleye fry density (fry/littoral acre, i.e. depths ≤15 feet) and the resulting strength of Yellow Perch year classes (age-4 gill net catch rate) produced the same year, 2005-2014.

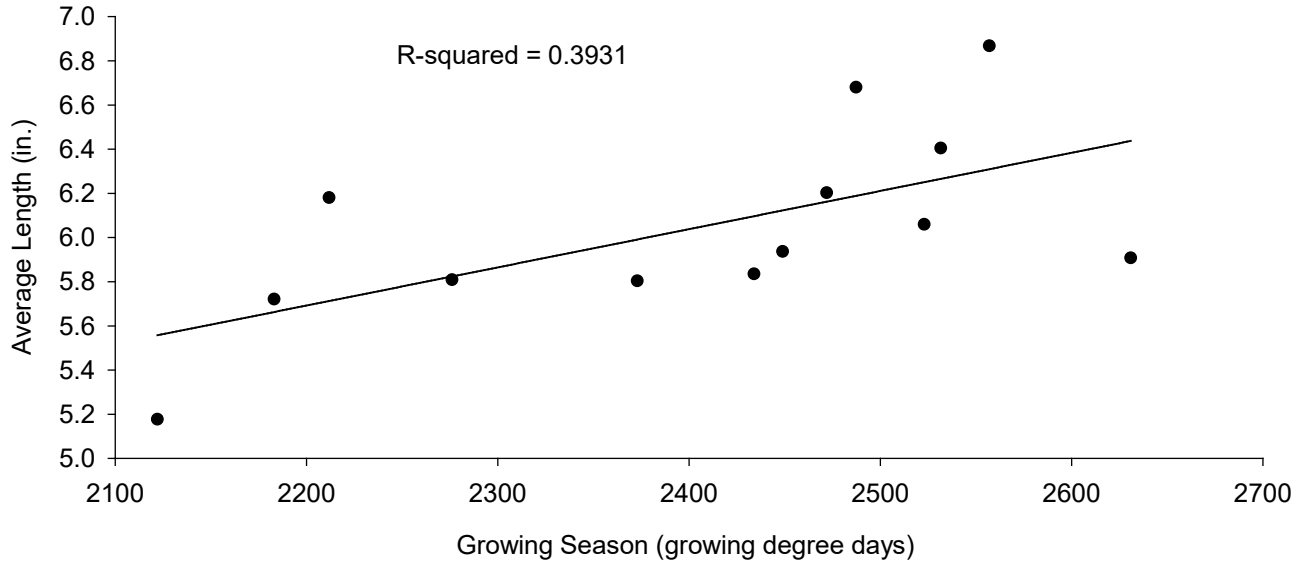

Figure B5. Growing degree days (GDD_{50}) and the average length (in) of young-of-year Walleye sampled by electrofishing in mid-September, 2005-2019.

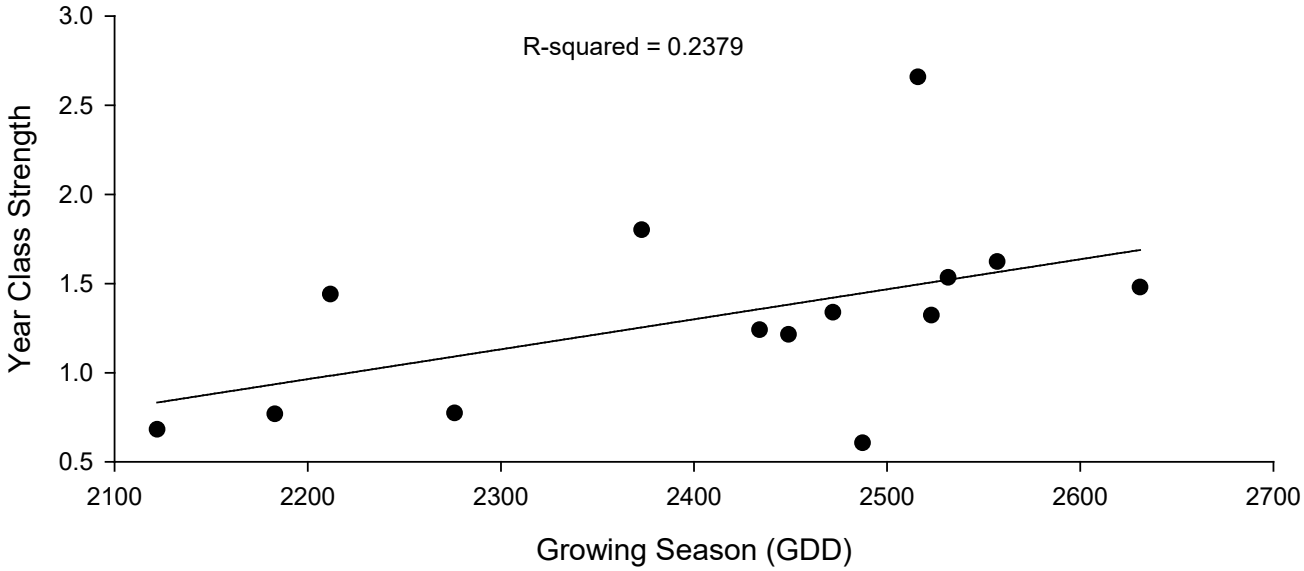

Figure B6. Growing degree days (GDD_{50}) experienced by young Walleye during their first growing season and the resulting strength of stocked year classes, 2005-2019.

APPENDIX C.

Habitat and aquatic invasive species initiatives outlined by the LLFIG to pursue throughout the life of the 2016-2020 fisheries management plan with updates as of 2020. Some of these recommendations are enveloped under annual DNR operating responsibilities and associated budgets. In other instances, staff and funding limitations necessitate that much of this work will only be accomplished with supplemental funding and collaboration among the many partners interested in a healthy ecosystem.

Habitat	Related Recommendations	Lead Agency/Partners	Relative Priority (1 = high, 2 = moderate, 3 = low)	Funding	Status as of 2020
1	Inventory nearshore aquatic habitat	FAW[1], partners	2	External funding	Completed 2018
2	Lakewide inventory of aquatic vegetation	FAW, partners	2	External funding	Ongoing
3	Inventory and evaluate spawning areas	FAW, partners	2	External funding	Not completed
4	Continue Environmental Review	FAW, EWR[2], COE[3], ESDCC[4]	1	Agency base funding	Ongiong
5	Protect vegetation beds including wild rice	EWR, ESDCC	1	Agency base funding	Ongoing
6	Enforce shoreland rules, vegetation removal, and invasive species	DOE, EWR, ESDCC	1	Agency base funding	Ongoing
7	Acquire important shoreland	FAW, LLAWF[6], LLA[7], partners	1	External funding	Ongoing
8	Continue shoreland development rulemaking	EWR, ESDCC	1	Agency base funding	Ongoing
9	Continue invasive species prevention and treatment	EWR, ESDCC, partners	1	Agency base funding	Ongoing
10	Continue tournament watercraft inspections, enforcemnt and education	EWR, ESDCC, partners	1	Agency base funding	Ongoing
11	Continue invasive species and vegetation management education and outreach for guides, resorts, law enforcement and industries	EWR, ESDCC, partners	1	Agency base funding	Ongoing

FAW[1] DNR Division of Fish and Wildlife

EWR[2] DNR Division of Ecological and Water Resources

COE[3] Army Corps of Engeneers

ESDCC[4] Environmental Services Division, Cass County

DOE[5] DNR Division of Enforcement

LLAWF[6] Leech Lake Area Watershed Foundation

LLA[7] Leech Lake Association