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Management Plan for Northern Pike in Michigan

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Introduction and Background

This plan focuses on the ecology and management of Northern Pike *Esox lucius* from the family Esocidae. Esocidae includes two of the more popular game fishes in the Midwest, the Northern Pike and Muskellunge *Esox masquinongy*, as well as one rarely caught and irregularly distributed esocid, the Grass Pickerel *Esox americanus*. All three of these species share some biological characteristics, yet have unique features of their ecology that affect fishery management. Of the three species, Northern Pike are by far the most common in terms of both their distribution and their abundance in Michigan. The purpose of this document is to review the biology and ecology of Northern Pike, and then to use this information in understanding the fisheries, recreational management of these fisheries and the potential impact recreational fishing has on those resources.

The State of Michigan recognizes several treaties between the United States government and Tribes residing in Michigan. Tribal governments' signatory to the 1836 and 1842 treaties retained hunting, fishing, and gathering rights for Tribal members. Tribal governments are sovereign nations, have their own regulations for fishing matters, and may view the management of Northern Pike differently than the state. This plan does not pertain to Tribal fishing rights under the 1836 and 1842 treaties; however it does describe the management of Northern Pike for state-licensed anglers.

Biology

Northern Pike is one of the most common species of game fish throughout the State of Michigan. They are present in virtually all watersheds within the state and common in most inland lakes. They

provide an important amount of fishing activity within the state, particularly for winter ice fisheries. In 2006, an estimated 226,000 anglers (resident and nonresident) fished 2,909,000 days for Northern Pike and Muskellunge in Michigan (USFWS 2008). Their populations naturally occurred throughout most of Michigan, although introductions to isolated lakes and streams have occurred sporadically as well. While Northern Pike sometimes provide a significant fishery in large rivers and streams, abundant populations and associated fisheries more frequently occur in inland lakes. Northern Pike are also common in embayments of the Great Lakes and the connecting waters (St. Marys River, St. Clair River, and Detroit River). While some genetic differences may exist among various Northern Pike populations in Michigan, for management purposes there are no recognized subspecies or varieties.

Northern Pike are primarily piscivorous and tend to be more opportunistic than selective. Most research has shown that esocids will tend to use the most abundant prey species present in a body of water. As such, they provide a unique ecological function as a top predator in many lakes. Fish communities occurring in the presence of Northern Pike often differ significantly from those occurring in their absence (Ryder and Kerr 1978). While Northern Pike forage predominantly on Yellow Perch *Perca flavescens* and various minnows (Seaburg and Moyle 1964, Diana 1979), the distribution of many minnow species is commonly limited by Northern Pike abundance (Tonn and Magnuson 1982). Northern Pike begin foraging on other fishes at only a couple of weeks of age and depend mainly on fishes throughout their life history. As they mature and grow, their forage shifts to larger prey species, and often the size and abundance of available prey species may limit their growth (Diana 1979). The characteristics of lake systems that contain many large-sized Northern Pike include abundant deep water habitat and intermediate-size prey species, such as small Ciscoes *Coregonus artedii*, White Suckers *Catostomus commersonii*, or other fishes of an appropriate size (Chapman and Mackay 1984, Jacobson 1993). Such lakes are quite different from lakes that maintain large abundances of smaller Northern Pike and have extensive spawning and rearing habitat to allow for high levels of reproduction (Jacobson 1993). In such lakes with smaller sized fish, often shallow and weedy with no temperature stratification, Northern Pike populations become overabundant with poor growth.

Habitat is a key factor in determining Northern Pike population dynamics in inland waters, and ultimately the status of the fisheries those populations can support. Since lands surrounding most of our lakes, particularly in the southeastern part of the state, are developed, loss of wetlands adjacent to the lake and loss of spawning grounds on lakeshores have changed the historical geographic distribution and status of Northern Pike. Settlement of the southern Lower Peninsula of Michigan brought development that transformed fish populations with most of the biomass of current fish assemblages in many lakes not consisting of the primary food for Northern Pike that existed prior to extensive settlement of the area. Ditching, draining, filling, and blocking of marshlands occurred on large numbers of lakes and lakeshores have been subjected to intensive development. The result has been a regional, human-driven, ecosystem shift with altered aquatic habitats and fish communities with lower capacity for supporting Northern Pike populations across wide areas of the Southern Lower Peninsula. This pattern of habitat alteration has been spreading northward over the past four decades threatening the sustainability of Northern Pike populations in the Northern Lower and Upper Peninsula as well. Preservation of remaining critical habitats will be a key component of future management of Northern Pike in Michigan.

Temperature is an important environmental factor affecting growth and mortality of this coolwater fish (Casselman 1978; Craig 2008). The maximum average temperature tolerance of Northern Pike is 82°F. The distribution of Northern Pike in Michigan is limited to those waters where physiological stress is low and temperatures are favorable for growth and survival. At the onset of summer thermal stratification, fish move from inshore to offshore locations that are frequently associated with macrophytes or bottom structures such as submerged logs. Dissolved oxygen concentrations can also affect the activity and vertical distribution of Northern Pike within a lake. When lake surface temperatures exceed 77°F, fish are found in the coolest available water with dissolved oxygen concentrations of at least 3.0

mg/L, and they are restricted to this stratum for two to three months (Headrick and Carline 1993). If water temperatures are low, Northern Pike can survive periods of dissolved oxygen concentrations as low as 0.5 mg/L (Casselman 1978). Habitat for Northern Pike within a lake is constricted when water temperatures increase and dissolved oxygen concentrations decrease to suboptimal conditions.

Margenau et al. (1998) examined 19 small Wisconsin lakes and identified multiple factors as potentially limiting Northern Pike growth and size structure. Growth was negatively related to density, water transparency, and abundance of small bluegills. Extensive littoral areas, water temperatures greater than 70°F during the growing season, and low dissolved oxygen levels in both summer and winter also limited Northern Pike growth and size structure in those small northern lakes. Pierce and Tomcko (2005) examined 16 lakes of diverse morphometric and biotic characteristics. Lake morphometry was identified as a key factor in determining Northern Pike density, which has important effects on growth rates, production, and population size structure. Greater numbers and mass of Northern Pike larger than 14 inches were found in lakes with more littoral habitat area and higher optimal thermal habitat. Percent littoral area was the most important variable explaining density differences, exceeding the effects of other ecological factors such as water productivity, exploitation, or prey fish abundance. Densities of large Northern Pike (>20 inches) were higher in lakes with larger total area and shoreline length.

Northern Pike spawn early in the spring at water temperatures from 46 to 54 °F, in shallow vegetated areas, or in rivers or floodings adjacent to a lake. The fish may show significant migrations to spawning areas, and males tend to predominate in the early spawning migration and remain within the spawning habitat for a much longer time than females. Northern Pike broadcast their eggs over shallow vegetation, and the eggs, which are sticky, remain attached to the vegetation and out of the sediments (Diana 1995). These eggs develop quickly over a couple of weeks and hatch early in the spring. The fish progress rapidly from foraging on invertebrates to other fishes, but tend to remain in shallow vegetated habitat throughout their first year of life. Surveys of Northern Pike populations often have difficulty collecting young-of-year Northern Pike compared to older age classes, indicating that younger Northern Pike use different habitats and are probably behaviorally different from adult fish. Spawning success can be excessive, resulting in overabundant Northern Pike populations in extremely shallow and weedy lakes. In lakes with lesser amounts of submergent and emergent vegetation, spawning may only occur in certain habitats, and limit the overall production and abundance of Northern Pike in a lake. For many locations, particularly in southern Michigan, shoreline development, coupled with filling or draining of nearshore wetland areas and removal of vegetation, have resulted in limited spawning habitat of Northern Pike and often dramatically reduced Northern Pike populations. In many of these lakes, Northern Pike have only managed to persist by stocking of fish periodically to replenish the adult population. These human-induced changes, including removal of vegetation, as well as removal of access to flooded areas near water bodies, are a major problem in maintaining Northern Pike populations in areas with extensive development.

Northern Pike is considered a long-lived species in the northern portion of its natural range. Recent standardized sampling of inland lakes in Michigan has revealed the average life span of Northern Pike to be six to eight years with 10 to 12 age classes observed rarely (Michigan Department of Natural Resources, unpublished data). Information from other studies on Northern Pike age structure appears similar (Margenau et al. 1998). Variation in longevity is not clear but recent information suggests that high natural mortality resulting in low survival of older fish, high exploitation of larger individuals and environmental and habitat factors might be reasons that explain the shorter life span observed in current Michigan populations compared to populations of Northern Pike reported in northern Canadian populations.

Maturity often occurs at age 3–4 for males, and age 4–5 for females, depending on local conditions (Diana 1983). However, in situations with high exploitation rates and high natural mortality rates, males mature at age 2, and females at age 3. This change in maturation is believed to be due to selective pressure by angling and removal of large Northern Pike, resulting in the change in the reproductive life

history of the fish. In this situation, fast-growing and early-maturing Northern Pike are more common in the population (Diana 1995). A similar early maturation condition occurs in overpopulated lakes, except that growth rate in these lakes is very limited. Often in overpopulated lakes, the fish may mature at the end of their first or second year of life, in spite of their very small size. This shift in reproductive status is believed to be a result of the low likelihood of survival to an older age (similar to the mechanism for high exploitation by anglers) selectively favoring a fish that matures early (Diana 1995). Earlier maturation results in energy being shunted from growth into reproduction, so that ultimate growth is reduced by early age at maturation (Diana 1987).

Northern Pike have a relatively high natural mortality rate, which is also related to fish size. Small fish are vulnerable not only to more predators, but also to cannibalism by adult Northern Pike. In fact, Grimm (1981) and LeCren (1987) suggest that the numbers of small Northern Pike are regulated by numbers of large individuals through cannibalism. If this is the case in a lake, then the abundance of large Northern Pike can influence population size structure and, in turn, can be influenced by fishing. Causes of overpopulation and poor size structure are not entirely clear, but include warm temperatures during the growing season, lack of appropriate-sized prey, overproduction of young fish, and possibly harvest of large fish (Diana 1987).

Northern Pike abundance and size at age appear to be influenced by local lake conditions as much as regional differences like geology and climate. In fact, a common biological characteristic in many Michigan lakes is large numbers of small, slow-growing Northern Pike. These populations, from a fisheries management viewpoint, are difficult to alter because they arise from some combination of overharvest of large fish, a lack of appropriate-sized prey fish, and habitat characteristics that are not suitable for good growth. Maintaining an appropriate balance of large Northern Pike, with increasing fishing pressure, may be a key problem for managing Northern Pike populations as the natural habitat characteristics that have been found to directly influence these growth rates cannot be altered.

In Minnesota, densities of large Northern Pike are low, with fish over 24 inches averaging only about 0.6 individuals per acre compared to densities averaging 9.3 individuals per acre for fish 14 inches and larger (Pierce and Tomcko 2005). The productive capacity from this study showed that large fish can easily be overexploited. This is because the productive capacity of Northern Pike declines rapidly as they get to larger sizes and older ages, yet recreational fishing by all methods tends to select for larger Northern Pike that are the least productive part of the population. Pierce and Tomcko (2003) found that in north-central Minnesota lakes, production of fish age six and older was estimated to average only 0.1 pounds per acre per year.

In Michigan, average densities of Northern Pike in large inland lakes have ranged from 0.5 to 2.9 adults per acre (Hanchin, Michigan Department of Natural Resources, unpublished data), whereas small and medium sized lakes have average densities ranging from 1.6 to 4.7 individuals per acre for fish 14 inches and larger (Michigan Department of Natural Resources, unpublished data). Comparison of densities between states are difficult because of the different types of gear used to catch Northern Pike. However, general trends suggest that lower overall densities of Northern Pike exist in Michigan compared to Minnesota. Therefore, large fish can be easily overexploited as was found in studies conducted in Minnesota.

Fishing Regulations

Fishing regulations for Northern Pike have changed dramatically over time. In the late 1800s the state fish commissioners in Michigan advocated a “policy of extermination” for Northern Pike, referring to them as the “freshwater devil fish” (Williams 1952). There was no minimum size limit and no possession limit from 1865 to 1915. As angler’s views on Northern Pike changed and they became targeted by anglers, special regulations were developed (Diana and Smith 2008). From 1916 to 1929,

there was a ten-inch minimum size limit and a ten-fish daily possession limit. From 1930 to 1958, there was a 14-inch minimum size limit and a five-fish daily possession limit. From 1959–1993, there was a 20-inch minimum size limit and a five-fish daily possession limit. Latta (1971) reported that an increase in the size limit from 20 inches to 22 inches would result in a decrease in yield with a further gain in number of spawners. Latta further found that a decrease in the size limit to 16 inches would result in the highest yield, but would reduce the spawning stock below the status necessary to maintain the population. From 1993 to 2001, the size limit was raised to 24 inches with a daily possession limit of five fish. During this time it was believed that an increase in the size limit would provide a general improvement in the Northern Pike population size structure, the regulation would produce more fish of quality size (≥ 21 inches, Gabelhouse 1984), and provide more numbers of fish predators to control their prey. J. Schneider (Michigan Department of Natural Resources personal communication) compared growth indices between slow, average, and fast growth Northern Pike populations. Preliminary results from this analysis suggested that the 24-inch minimum size limit increased the percentage of fish larger than 24 inches within the fast growth lakes, but not in the slow or average growth populations. In 2002, the daily possession limit was further reduced to a maximum of two Northern Pike within a combined total five fish limit including black bass *Micropterus* spp. and Walleye *Sander vitreus*. Finally in 2015, Northern Pike were removed from the collective daily possession limit and were governed by their own stand-alone daily possession limit. These changes in size and possession limits indicated concerns about the sustainability of some Northern Pike populations, especially where angling pressure had increased dramatically during these time periods.

In addition to these statewide limits, fisheries managers agreed to liberalize catch and keep regulations for waters that have abundant populations of small Northern Pike. In 2002, Fisheries Division allowed anglers to keep five fish with no minimum size limit on lakes with Northern Pike growing below state average. Opportunities for catching large Northern Pike were also developed by allowing for a slightly higher size limit on select lakes that have a known capability of growing large Northern Pike. This regulation allowed anglers to keep two fish with a 30-inch minimum size limit. These special regulations were implemented because research and computer modeling provided insight that changing size limits has been the most effective tool to achieve an improvement in the fishery.

Management efforts for Northern Pike are usually focused on sustaining a harvestable population. Recently, some stakeholders and fisheries managers have expressed an interest in Northern Pike management to redistribute exploitation rates, increase growth rates, and improve production of larger fish to provide for a quality fishery in certain key lakes. Yet, in some situations Northern Pike management is still geared toward allowing for a sustainable harvest.

In recent years, Minnesota and Wisconsin fish managers have evaluated changes in Northern Pike sport fishing regulations in those states. In Minnesota, a long-term evaluation of regulation changes that included increased minimum size limits, maximum size limits, and protected-slot limits suggested an overall improvement in the size structure of Northern Pike populations, but no consistent trend in relative abundance (Pierce 2010). In Wisconsin, the results from minimum size limit changes implemented in 1995 were equivocal (Margeneau et al. 2008) and researchers promoted the need for monitoring and standardized sampling protocols.

Status of the Fisheries

Northern Pike were historically an important commercial fish, but contributed only a small percentage of the total commercial harvest according to Michigan's early records (MDOC, 5th Biennial Report). The total commercial harvest of "Grass Pike" in Michigan waters of the Great Lakes in 1928 was 39,775 lbs. for \$4,773, which represents a value of 12 cents per pound. In 1929 the harvest was 68,408 lbs. for \$8,208.96. These values correspond to annual values ranging from \$59,232 to \$101,871

when converted to 2009 dollars. According to Michigan Department of Conservation (MDOC) records the total commercial harvest in 1930 and 1931 increased from the previous two years, but the value decreased to only 10 cents per pound in 1930 and 9 cents per pound in 1931 (MDOC, 6th Biennial Report). Currently, there is a recreational fishery and a Tribal subsistence fishery and there is no legal commercial harvest of Northern Pike by non-Tribal members in Michigan.

Several treaties exist between the United States government and Tribes residing in Michigan. Tribal governments' signatory to the treaties of 1836 and 1842 retained fishing rights for Tribal members and the Tribes may view management of Northern Pike differently than the state. Tribal governments are sovereign nations and operate their fisheries pursuant to their own regulatory and management systems. The Treaty of Washington, signed in 1836, covers the eastern Upper Peninsula and the northern Lower Peninsula of Michigan and in 2007, the State of Michigan, the Little River Band of Ottawa Indians, the Grand Traverse Band of Ottawa and Chippewa Indians, the Little Traverse Bay Bands of Odawa Indians, the Sault Tribe of Chippewa Indians, the Bay Mills Indian Community and the United States government signed a Consent Decree which defines the extent of the Tribes' inland treaty rights in the 1836 ceded territory. The Treaty of La Pointe, signed in 1842, covers the western Upper Peninsula and a portion of northern Wisconsin. Currently, there is no formal agreement in place between the Tribes' and the State of Michigan to define the extent of the Tribes' reserved fishing rights there. However, the 1842 Treaty rights have been adjudicated in Wisconsin. The Tribes of the Voigt Intertribal Task Force conduct inter-Tribal coordination and manage the Tribal fisheries within the portion of the 1842 ceded territory located within the State of Michigan pursuant to their own regulatory and management systems. A Tribally regulated spring subsistence fishery is present in the western portion of the Upper Peninsula within the 1842 Treaty area. The Tribes do not currently exercise their 1842 treaty reserved right to commercially harvest Northern Pike in Michigan.

Within the 1836 Treaty area, Tribes residing in Michigan prohibit or restrict spearing of Northern Pike in a manner that is no less restrictive than 2006 state spearing restrictions. The Tribes also regulate their members' fishing activities through the use of daily possession limits, size limits, and season limits in accordance with Paragraph 11.2 and 11.3 of the 2007 Consent Decree, including Northern Pike. Except when waters are targeted for complete fish eradication, there is no legal commercial harvest of Northern Pike by 1836 Tribal members in Michigan.

Michigan recreational anglers seek Northern Pike for both their hard fighting qualities on hook and line and also for food. The recreational fishery is diverse; open-water angling techniques include casting and trolling lures, still fishing with live baits, and fly fishing. During the winter considerable effort occurs with hook and line, spears, and tip-ups, even on southern Michigan lakes where winter ice conditions can be limited. In northern Michigan, Northern Pike are targeted during both the open-water and ice season, but effort and harvest is likely greater for the ice fishery than for the open-water fishery on many northern lakes. Clark et al. (2004) reported the ice fishery accounted for 82% of the Northern Pike harvested from Houghton Lake. Wisconsin researchers have documented higher catch rates and live release during open-water fishing, and higher harvest rates for Northern Pike during the winter, as well as some evidence that larger fish are caught during winter months (Margenau et al. 2008).

Recreational fishing in Michigan has had historical influences on Northern Pike populations. Recreational fishing is highly selective for large Northern Pike. Creel surveys from large inland lakes in Michigan have shown fish over 24 inches are seldom released and comprise a large proportion of the harvest. These surveys also indicate that some people harvest Northern Pike as small as 16 inches, but 20 inches is typically the minimum size that most people will harvest. An intensive survey of seven north-central Minnesota lakes showed that annual exploitation rates are as high as 46% of the Northern Pike longer than 20 inches (Pierce and Tomcko 2003). Creel surveys from Minnesota also show that people harvested Northern Pike as small as nine inches, although 14 inches was typically considered the minimum size that anglers harvested. Pierce and Cook (2000) reported that large (>24 inches) Northern Pike are heavily exploited and that both angling and spearing are responsible. They also reported that

darkhouse anglers harvest large Northern Pike at a rate similar to summer and winter anglers who target Northern Pike. A result of this size selectivity and the continual increase in size regulations is that sizes of fish have suffered from historical increases in fishing effort and fewer memorable size Northern Pike are caught today.

In general, Michigan sport fishing regulations for Northern Pike have become increasingly restrictive over the last 20 years. This trend reflects management efforts to decrease fishing mortality and increase production of larger Northern Pike, thus increasing top-down predatory control of nongame fish and sucker populations. Northern Pike fisheries in Michigan are regulated with a combination of seasons, size limits, and daily possession limits with some regional differences (Table 1). In addition to the general regulations, the 2015 Fishing Guide lists special Northern Pike regulations on selected inland waters, and these include: waters with no size limit and daily harvest limit of five fish, including not more than one fish over 24 inches (149 water bodies); waters with 24–34-inch protected slot limit (7 water bodies); waters with Northern Pike season from the last Saturday in April to November 30 (3 water bodies); waters closed to spearing (29 water bodies); and one water body with no size limit or possession limit. Northern Pike fishing in the Sylvania Wilderness Area Lakes in Gogebic County is regulated with a season open from the last Saturday in April to October 31, a 30-inch minimum size limit, and a one fish daily harvest limit (32 water bodies). The Northern Pike fishery of Lake St. Clair, St. Clair River, and Detroit River allows anglers to possess five Northern Pike 24 inches or greater in the daily possession limit. The Big Island Complex lakes in Schoolcraft County are covered by a Northern Pike season that runs from May 15 to November 30, along with a 42-inch minimum size limit and one fish daily harvest limit (10 water bodies). Finally, the Michigan-Wisconsin boundary waters have a Northern Pike season that runs from the first Saturday in May to March 1, with no minimum size limit and a five fish daily harvest limit (25 water bodies). In total, 257 waters (including both lakes and rivers) across the state have special regulations in place for Northern Pike fishing.

Table 1.—General recreational fishing regulations for Northern Pike in Michigan, 2015.

Gear	Region	Season	Minimum size (in)	Daily limit
Hook/line	U.P. Great Lakes and inland waters, and St. Marys R.	May 15 to March 15	24	2
Hook/line	Lower Peninsula inland waters	Last Sat. in April to March 15	24	2
Hook/line	Lower Peninsula Great Lakes, L. St. Clair, St. Clair R., and Detroit R.	Open all year	24	2 ^a
Spear	Statewide	December 1 to March 15	24	2 ^a

^a The daily possession limit is five Northern Pike on Lake St. Clair, St. Clair River, and Detroit River.

Embayments of the Great Lakes also support Northern Pike fisheries. Saginaw Bay once supported a modest population of Northern Pike, but is currently well below carrying capacity despite the habitat to support a healthy population. The Les Cheneaux Islands presently supports one of the most dense Northern Pike populations in the Michigan waters of Lake Huron. Catch rates in the fishery are high due to cormorant management, low angling effort, and increasing water levels in Lake Huron that are inundating spawning habitat. Northern Pike populations in the Michigan waters of Green Bay support an economically important fishery and have contributed to broodstock egg collections for the State of Michigan. Connecting waters of the Great Lakes such as the St. Mary’s River support a popular

recreational fishery around Sugar Island and Potagannissing Bay. Lake St. Clair supports a Northern Pike fishery that is characterized by fast growth rates with a high proportion of legal-sized fish.

The potential health effects of eating large predatory fish such as Northern Pike may be a factor in an angler's decision to practice harvest or catch-and-release fishing for Northern Pike in Michigan. The Michigan Department of Community Health (MDCH) issues advisories for consumption of sport-caught fish (MDCH 2010). At the time of publication, a statewide advisory for consumption of Northern Pike, based on elevated levels of mercury, recommends that women of childbearing age and children eat no more than one meal of Northern Pike per month, while the rest of the human population should restrict consumption to one meal per week. Additional advisories recommending restricted consumption of Northern Pike, due to PCB or Dioxin contamination, exist for certain specific waters in the State of Michigan (MDCH 2010).

Michigan's Northern Pike Management Plan

The purpose of this management plan is to improve the quality of Northern Pike recreational fishing opportunities by protecting and enhancing existing stocks and the environmental conditions upon which they depend, and by improving technical information and outreach, in full partnership with the anglers of the state.

In order to make objectives specific and measurable, we propose the use of numerical, biological reference points (BRPs). According to Hutchings (2009), BRPs specify levels of stock biomass and fishing mortality that managers aim either to achieve or maintain ("target" reference points) or to not exceed ("limit" reference points). They are usually defined in terms of relative abundance (catch-per-unit-of-effort or CPUE) by gear type, mean length at age, size structures, or some other numerical measure. Given their availability, we used relative abundance and mean length at age data from Northern Pike populations across the state to develop target reference points (TRPs). As more data becomes available for density, exploitation, and annual mortality we may develop additional TRPs for Northern Pike.

We used TRPs to identify the typical ranges for various Northern Pike population types in Michigan, basing them on the upper and lower quartiles from data across the state. We used ranges because we recognize that precise measurement and control of a fishery is difficult. We then identified regulation options that would be suitable for each population type. Our regulations were designed to address angler comments received during public review of the draft management plan that demonstrated angler preferences for higher quality fishing. The regulations also serve fish community requirements such as predator-prey balance. Metrics falling outside of the range for a population type may trigger more detailed evaluation or management action such as a regulation change; however, managers will have considerable discretion as to whether or not to take action.

The majority of Northern Pike sampled by Fisheries Division are caught in entrapment nets (fyke or trap) and gill nets. Although Northern Pike are widely distributed, catch rates are often lower in small shallow lakes and some Great Lakes waters. The range of typical growth conditions for Northern Pike varies by sex, region, lake size and depth; however, mean length at age data from across Michigan indicates that Northern Pike typically reach the current minimum size of 24 inches between age 4 and 5 (Table 2). Analysis was based on a query of surveys completed from 1990 through 2015. Only surveys conducted during March, April, or May were used. Data were limited to ages determined from dorsal fin rays. The statistical unit was mean length at one age group from one survey. Each mean was given equal weight in determining the statewide mean length at age. A minimum of five fish were aged for each statistical unit. These criteria resulted in 7,726 Northern Pike aged from 109 lakes resulting in 308 mean lengths at age.

Table 2.—Statewide mean length at age for Northern Pike ages 1 to 10 and calculated growth metrics based on length quartiles for ages 3 to 5. Mean lengths based on fin ray data. Means calculated from 109 populations sampled during March–May, 1990 to 2015.

Age	Mean (in)	SD	N	25th percentile (in)	Median (in)	75th percentile (in)
1	12.0	1.9	31			
2	17.3	2.3	85			
3	20.7	2.4	109	19.1	20.6	22.2
4	22.7	2.4	109	20.9	22.7	24.5
5	24.6	2.6	90	22.8	24.4	26.2
6	26.3	2.9	59			
7	28.2	2.9	32			
8	31.9	4.2	16			
9	34.9	3.7	8			
10	36.6	1.8	2			

Selection of recreational fishing regulations for Northern Pike depends on correct assessment of recruitment and population dynamics. Because we do not have direct measures of recruitment or absolute abundance for Northern Pike for most waters in the state, abundance is often expressed as gill-net or fyke-net catch rates offering measures of relative abundance (Table 3). Hanchin (2016) reported that adult Northern Pike density was positively correlated with both fyke-net and trap-net spring CPUE for large lakes in Michigan; thus, there is evidence that CPUE may serve as an index of relative abundance. Summer gill-net catch rates associated with low recruitment are often fewer than two fish/net. Michigan lakes with moderate recruitment had gill-net catch rates of 2–4 fish/net and high recruitment would be greater than the upper quartile range. Low recruitment typically results in good growth rates if natural mortality is also low. The size distribution of Northern Pike caught in fyke nets, gill nets, or trap nets varied in details of the shape of their distribution with the mean length being lowest in gill nets, followed by fyke nets and the largest size fish caught in trap nets. Michigan lakes with a low density of Northern Pike have average lengths in fyke net catches of 22 inches or greater. Moderate density lakes have average lengths of 18–20 inches with less than 40% proportional stock densities or “PSD” (Gabelhouse 1984; PSD is the ratio of numbers of quality size to stock size fish). Fisheries managers should consider these criteria to assess where an individual Northern Pike population falls in the range of performance for our state.

Table 3.—Statewide Northern Pike metrics for catch per unit effort (CPUE) by gear type.

Gear type	CPUE			
	25th percentile	Median	75th percentile	Maximum
Fyke net	0.4	0.8-1.5	3.3	13.0
Gill net	1.0	2.0-4.0	5.4	14.5

Many of Michigan’s Northern Pike populations are characterized by high density (upper quartile limit CPUE) and slow growth (lower quartile limit length at age). Northern Pike populations exhibiting these characteristics are often labeled as being overpopulated. Lakes with these Northern Pike characteristics are often small lakes with a high percentage of littoral zone and abundant aquatic plants. Regulations for these populations are generally tailored to improve size structure and growth through increases in exploitation. The majority of individuals in these populations are less than 18 inches in length and because of the gear selectivity and general lack of interest by anglers, exploitation of fish smaller than 18 inches is very limited. However, harvest of fish greater than 23 inches may have a negative effect on size structure, so we recommend limiting exploitation of larger Northern Pike in these populations to improve size structure. These populations are typically found in the lower quartile for mean length at age (Table 2). If a population is found to be below the lower quartile metric for growth and above the upper quartile for relative abundance we recommend using a no minimum size limit regulation with a liberal daily possession limit and a restricted bag limit for Northern Pike over 24 inches (Table 4).

Table 4.–Statewide growth metric, population characteristics, regulation options, and management goal for Northern Pike in Michigan. See Table 3 for gear-specific catch rate metrics. MSL denotes minimum size limit; PSL denotes protected slot limit, with no harvest within length range.

Age	Statewide growth metric	Population characteristics	Suggested regulation options	Management goal
3-5	Mean length exceeds 75 th percentile	Above average growth, low density	24 in MSL, possession limit 2 or PSL 24–34 in, possession limit 2	Maintain population size structure, encourage above average growth of younger fish, maximize reproductive potential, and allow for harvest of memorable- or trophy-size fish
3-5	Mean length between 75 th and 25 th percentile	Average growth, moderate density	24 in MSL, possession limit 2 or PSL 24–34 in, possession limit 2	Maintain average abundance and size structure or Improve size structure
3-5	Mean length less than 25 th percentile	Below average growth, high density	No MSL, possession limit 5 ^a	Reduce over abundance, improve growth rate, maximize sustainable harvest

^a Five-fish limit includes no more than one Northern Pike greater than or equal to 24 inches in total length.

Northern Pike populations characterized by moderate densities (SW Median CPUE) and moderate growth rates (SW Median length at age) near the state average length at age have been managed through conservative regulations. These lakes are often considered the normal condition with a moderate amount of littoral zone habitat and intact wetlands for spawning. These lakes have historically been managed with the statewide minimum size and daily possession limits to provide fishing opportunities for Northern Pike as food, yet some of these lakes could be managed to improve quality sized fish. Populations with metrics between the upper and lower quartile ranges (Table 2) should be managed with the statewide minimum size and daily possession limits or the protected slot limit to provide for additional quality fisheries (Table 4).

Large inland lakes and some Great Lakes populations are characterized by moderate to low densities and average to high growth rates (upper quartile ranges). These waters have minimal amount of littoral zone with extensive shoreline length and are typically managed as the popular fisheries for quality sized Northern Pike production. Metrics for these populations are mean lengths at age in the

upper quartile range (Table 2) and relative abundances at two fish per gill-net lift (Table 3). We suggest using minimum size limit or protected slot limit regulations with a conservative daily possession limit for these populations (Table 4).

Goals, Issues, and Objectives

Our goal is to improve recreational angling opportunities of Northern Pike. We propose that Northern Pike populations should be managed to provide a stable fishery harvest and to increase population size structure through regulations that redirect exploitation for certain size classes. The recreational management objectives for Northern Pike should reflect the guiding mission statements for both the Michigan Department of Natural Resources (DNR) and Fisheries Division. The DNR is committed to the conservation, protection, management, use, and enjoyment of the state's natural and cultural resources for current and future generations. It is the mission of Fisheries Division to protect and enhance Michigan's aquatic life and habitats for the benefit of current and future generations.

This plan identifies current issues that prevent attainment of the goals and provides suggestions of how to address these issues for future management.

Goal I: Protect, restore, and enhance habitat on Michigan waters

Issues

- Michigan lakes exhibit a high diversity of chemical and physical characteristics across the state. These differences need to be understood to successfully manage and protect Northern Pike populations.
- The simplification or loss of littoral and riparian habitat (e.g., shoreline hardening, loss of large woody cover, conversion of vegetated littoral zones to sandy beaches, etc.), including incompatible aquatic plant management, is a major threat to the state's Northern Pike fisheries.
- Riparian land uses impact fisheries habitat, yet enforcement of existing rules and development of more appropriate measures to protect nearshore habitat is lacking.
- Fisheries Division has no regulatory authority for human activities affecting the littoral and riparian habitat required by self-sustaining Northern Pike spawning habitat.
- For inland waters, Michigan does not have regulatory authority to prevent mechanical aquatic plant harvesting that would alter juvenile Northern Pike habitat and habitat for forage species.
- Education of lakeshore property owners on the importance of habitat to fisheries is not consistent across the state.
- Sedimentation, due largely to nonpoint source runoff, negatively affects many of Michigan's waters.
- Barriers to fish passage, including dams, lake level control structures, poorly designed stream crossings for roads, etc., can restrict Northern Pike spawning movements and reduce available spawning and nursery habitat.

Objectives and Strategies

- Locate, document, and protect existing functional littoral and riparian habitat through joint local, federal, and state efforts.
- Ensure that local concerns for the fishery are incorporated into decisions on proposed habitat alterations. Evaluate the current waterway, wetland, riparian and aquatic plant management permitting procedures and ensure that the fisheries biologists and angling-interests are included in the process.

- Review/develop educational material about the value of aquatic habitats for lake property owner associations and identify opportunities for interaction/input. O'Neal and Soulliere (2006) is an excellent resource that should be useful in this effort.
- Ensure that effective, cost-efficient habitat protection, restoration, and enhancement procedures are documented and used consistently throughout the state.
- Work with the Department of Environmental Quality to ensure that Fisheries Division biologists are given every opportunity to provide comments on proposed habitat alterations and that permitting processes reflect the established Fisheries Division policies for such activities.
- Improve enforcement of existing habitat protection regulations.

Goal II: Ensure that adequate technical information is available about Michigan's Northern Pike fisheries

Issues

- There is often insufficient information on Northern Pike populations and angler use to make informed management decisions.
- Current Status and Trends surveys do not capture sufficient numbers of Northern Pike to assess population parameters.

Objectives and Strategies

- Develop a statewide strategy to ensure sufficient information is available about Northern Pike fisheries.
 - Support the Lake Status and Trends Program for systematic monitoring and assessment of the fish communities in Michigan's inland waters, while recognizing the need for additional sampling to effectively monitor Northern Pike population parameters.
 - Survey Michigan anglers to determine demand for various types of Northern Pike fishing opportunities and evaluate trends in Northern Pike fisheries.
 - Adopt a standard Northern Pike survey protocol for Michigan inland waters starting with the draft protocol found in Appendix A. This protocol should be finalized through the Fisheries Division internal review and approval process and should remain as working guidelines as management improves for Northern Pike populations in Michigan.
 - Support the statewide creel survey program for inland waters and develop targeted effort estimates to evaluate Northern Pike fishing success. Additionally, survey anglers by fishing method so that comparisons in general fishing pressure can be assessed (e.g. winter spear fishing, tip-up fishing, and hook-and-line fishing).
- Maintain a standing Esocid Committee within Fisheries Division to foster continued attention to Esocid management issues.

Goal III: Protect and maintain Michigan's self-sustained recreational Northern Pike fisheries and associated fish assemblages and aquatic communities

Issues

- Limited stocking of Northern Pike is conducted by Fisheries Division, mainly for the reestablishment of populations lost to fish kills, rehabilitation, low reproduction, loss of spawning habitat, etc.
- Northern Pike are a large native predator species that should be preserved as part of a balanced fish community.

Objectives and Strategies

- Maintain and optimize Michigan's existing self-sustained Northern Pike populations. Natural reproduction is not a limiting factor in many lakes, but there are a few lakes where habitat has been destroyed and stocking could be used for maintaining Northern Pike populations. The DNR, Fisheries Division Northern Pike stocking guidelines should also be considered when supplemental stocking is necessary (Dexter and O'Neal 2004).
- Prevent excessive harvest of large Northern Pike to the point where adequate spawning numbers or biomass, reproduction, and recruitment to larger sizes (>26 inches) cannot be sustained.
- Determine the risks for disease transmission from trap and transfer and stocking operations, and determine disease influences on population levels.

Goal IV: Communicate with anglers and promote the recreational value of Michigan's Northern Pike fisheries

Issues

- The public is sometimes poorly informed of the reasons behind management actions.
- Ecological differences between water bodies necessitate having a variety of management options available for appropriately managing the Northern Pike fisheries in individual water bodies.
- Stakeholder groups and individual anglers can have conflicting values for Northern Pike fisheries.
- Identification of Northern Pike and Muskellunge can be problematic for some anglers.
- Anglers may not recognize the relative rarity of large Northern Pike in Michigan waters and the negative effect that even low levels of exploitation can have on the size structure of Northern Pike populations.

Objectives and Strategies

- Work through the Warmwater Resources Steering Committee to accomplish the following:
 - Increase awareness of the importance of large Northern Pike to maintaining balance in many aquatic systems.
 - Obtain information about the economic value of Northern Pike fisheries to increase public awareness of the importance of quality Northern Pike fisheries to Michigan's economy.
 - Educate anglers on the differing potential of Michigan lake types for supporting Northern Pike populations.
 - Increase education efforts on the identification, biology, and management of Northern Pike in Michigan.
 - Provide communication between anglers of the state and staff within Fisheries Division.
 - Provide a forum to discuss regulatory decisions and nonregulatory issues affecting fisheries in the state.

Goal V: Provide a variety of Northern Pike fishing opportunities within a science-based management system

Issues

- Large fish can easily be over-exploited in high fishing pressure waters.
- Many inland waters are not achieving their potential for producing large Northern Pike.
- Anglers commented that fishing regulations are getting too complicated and there are too many exceptions to statewide regulations.

- Conflicts exist between various user groups.
- It is impractical to obtain sufficient information to manage every Northern Pike fishery on a lake-by-lake basis.

Objectives and Strategies

- Assess a variety of regulations and develop a group of standard regulations for managers to choose from for addressing management goals specific to water body (Table 4).
- Conservatively manage our most popular Northern Pike fisheries to maintain quality size structures by protecting them from over-exploitation.
- Northern Pike populations that fail to exhibit a healthy size structure including quality-sized fish, should be managed to promote or achieve such a size structure based on biological reference points (Table 4).
- Manage some Northern Pike populations to provide a stable fishery yield (by numbers), where growth rates achieve state averages.
- Manage some Northern Pike populations to limit their influence in the management of other fish species such as trout.

Summary and Action Items

This document provides a review of the biology and ecology of Northern Pike, compiles the available knowledge of the Northern Pike fisheries in Michigan, and proposes a strategy for the future management of Northern Pike in Michigan. We propose that Northern Pike populations should be managed to improve angling opportunities for large Northern Pike through regulations that redirect exploitation of certain size classes, while still providing a stable fishery harvest. Goals addressing the areas of habitat, technical knowledge, fish populations, and stakeholders are presented in this plan. Issues representing impediments to the achievement of those goals are identified and objectives and strategies to address those issues are included. Strategies and options identified by this plan are summarized here as action items:

- Maintain a standing Esocid Committee within Fisheries Division to foster continued attention to Northern Pike management issues (Goal II – Technical Information).
- Use growth rate and density metrics calculated from Michigan Northern Pike data to group Northern Pike populations for management based on biological reference points (Goal II – Technical Information).
- Assess a variety of regulations and develop a group of standard regulations for managers to choose from for addressing the management goals (Table 4, Goal V – Fishing Opportunities).
- Adopt a standard Northern Pike survey protocol for Michigan inland waters. This protocol should be vetted and finalized through the Fisheries Division internal review and approval process and updated periodically as knowledge of Northern Pike populations in Michigan increases. The draft protocol found in Appendix A is suggested as a starting point for this effort (Goal II – Technical Information).
- Survey Michigan anglers to determine demand for various types of fishing opportunities for Northern Pike. This survey could be part of a statewide angler survey with specific questions targeting Northern Pike anglers (Goal II – Technical Information).
- Support the statewide inland waters creel survey program and explore options for improving the estimates of Northern Pike fishery targeted effort, harvest, and catch when Northern Pike waters are creel surveyed (Goal II – Technical Information).

- Facilitate communication between interest groups with various values for Northern Pike fisheries in Michigan (spearing interest versus no-kill proponents for example; Goal IV – Communicate with anglers).
- Ensure that local concerns for the fishery are incorporated into decisions on proposed habitat alterations. Evaluate the current waterway, wetland, riparian, and aquatic plant management permitting procedures and ensure that fisheries biologists and angling-interests are included in the process (Goal I – Habitat).
- Implement fishery-specific Northern Pike management across three objectives: (1) to maintain populations and their fisheries where size structure and abundance targets are already deemed adequate; (2) manage some Northern Pike populations on the basis of only abundance, striving either for high catch rates or to reduce/eliminate Northern Pike where detrimental to other fishery management objectives; and (3) manage for trophy Northern Pike fishing opportunities in select waters where such potential exists (Goal V – Fishing Opportunities).

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Appendix A

Draft-Sampling Protocol and Population Assessment

Management opportunities are often limited by the inconsistent collection of data for detailed population dynamics. The ability to sample populations needs to be improved so that management can be based on quantitative analysis. Baseline assessment and monitoring for pike has not been implemented in Michigan. Recently developed Lake Status and Trends Program sampling protocols, employed during late spring and early summer, generally assess fish composition statewide where information on Northern Pike may be collected, but catch of Northern Pike can be highly variable and may not provide enough information to estimate population characteristics. Existing survey methodologies need to be examined or modified to evaluate newly-proposed quantitative objectives for management and to estimate the parameters of proposed biological reference points. This section outlines techniques for assessment and a call for future research and evaluation.

Standard fisheries sampling techniques and monitoring methods need to provide adequate information on Northern Pike population characteristics, primarily population abundance, catch at age, growth, and size structure. Early spring impoundment gear assessments are regionally accepted as the primary means of collecting population information. Enough nets should be set to collect fish from spawning habitat and most of the available habitat within the lake. Data should be recorded separately for each net set. Spring population densities of Northern Pike should be estimated by use of Chapman's modification of the Peterson estimator for single recapture runs, and the modified Schnabel estimator for multiple recapture runs in closed systems (Ricker 1975).

Early spring surveys of Northern Pike are critical in developing biological information because during this period, sex can be determined, sexual dimorphism is large in this species, and therefore appropriate biological analysis can be calculated from these surveys. Available information within the statewide database indicates that trap nets and large-mesh fyke nets with similar selectivity (generally with conventional 1.5-inch mesh pots) are efficient at capturing adult Northern Pike and Muskellunge age 3 and older. Northern Pike inch groups between 16 and 24 inches are the highest proportion of sizes captured by these types of gear.

Early summer gill-net surveys are encouraged to be used to recapture marked fish in the population, but should not be used during the marking period to prevent violating assumptions of population estimates. We recommend standardizing experimental gill-net efforts by the following lake sizes: lakes 100 to 300 acres would get 9 overnight net sets; lakes 300 to 600 acres would get 12 overnight net sets; lakes 600 to 1,000 acres would get 16 net sets; and lakes over 1,000 acres would follow protocols for the large lake survey.

Electrofishing methods employed in large, slow-flowing rivers may be another useful method to assess pike populations. Multiple mark and recapture runs during spring should be conducted to complete mark-recapture sampling. Electrofishing catch rates should be estimated from the number of fish captured during the last run. Electrofishing in lakes should be conducted during spring months to estimate population density from electrofishing catch rates. Electrofishing catch rates were linearly related to population density in spring for Northern Pike (Schoenebeck and Hansen 2005). Electrofishing to obtain a relative abundance determination for young-of-year (YOY) and yearling fish has been developed and proposed as a possible method (Ziegler and Schneider 2000). Adoption of electrofishing surveys should be included with general surveys and should exclude a standard gear used for assessment by itself. This technique, however, may be useful in monitoring recruitment (YOY catch rates) of populations where natural reproduction occurs because variation in year classes might be more accurately detected. Coverage of the water to be sampled should be separated by random selection of segments developed by the total area of the water. Segments should be chosen at equally

spaced intervals and data recorded separately by each effort within that segment. Research is needed to evaluate spring and fall survey techniques for Northern Pike in Michigan.

Because of the longevity of Northern Pike, the use of PIT tags to identify fish is reasonable, but half finclips, elastomer marks, or metal jaw tags should also be considered for short-term surveys. The objective should be to approximately mark/tag 10% of the estimated population. If this information is not available prior to the survey, then approximately 0.5 Northern Pike per acre should be captured and marked. Marking more fish may improve the accuracy of the population estimate, but longer sampling effort may be inefficient. Age determination of Esocids by cleithrum bones or dorsal fin rays are the most reliable structures and surveys should be standardized using this method for statewide comparisons. A subsample (>12) of adult fish (6 of each sex) that are believed to be representative of that population's size structure can be used for growth determination derived from cleithra, and subsequently limiting the number of mortalities. Dorsal fin rays should be collected from enough fish to establish accurate estimates of age and growth information. This number may include collecting dorsal fin rays from 20 fish per inch group with no fewer than 10 of each sex within that inch group.

Standardized sampling of Northern Pike should be adopted to evaluate the management objectives and status of the fisheries in Michigan. A stratified random selection of fixed waters should be selected based on growth potential, stocked and natural waters, and other sampling logistics. These waters can be used to monitor abundance, mortality, recruitment, growth evaluation, and length distribution for adult Northern Pike. Currently Northern Pike regulations are based on ecological groupings and these groupings can be used to establish similar waters to monitor within these groupings.

Tasks

- Use existing Northern Pike assessment data in the Fish Collection System database to describe Northern Pike population characteristics.
- Collaborate with and coordinate research studies to assess recruitment, survival, survey techniques, etc.
- Develop Northern Pike monitoring protocol and survey design.
 - Establish long-term trend waters where adult population estimates can be conducted every 5–10 years.
 - Conduct and coordinate regular creel surveys between management units.

Goals/objectives

- Monitoring
 - Establish a series of indicator lakes that can represent long-term trends of Northern Pike abundance, size-structure, annual mortality, exploitation, and relative abundance of the associated fish community. These waters should be surveyed more frequently if not annually.
 - Conduct frequent mail surveys to track angler attitudes and to evaluate program goals. Pilot an angler diary program for possible local coverage.
 - Variation among lakes and the wide distribution of the species dictate that Northern Pike populations be monitored for extended periods, and that indicator waters also be monitored to aid interpretation of data and development of meaningful management recommendations.
- Evaluation
 - Compare new surveys of Northern Pike populations to statewide metrics presented in Tables 3 and 4 of the Northern Pike Management Plan (e.g., CPUE fyke net, CPUE gill net, mean size at age 3, mean size at age 4, mean size at age 5, etc.).
 - Periodically review quantitative criteria to better define biological reference points.

- Implement a comprehensive angler survey that represents public performance objectives for fishing regulations that have been evaluated and exploitation rates that have been estimated correctly on select waters. Develop seasonal sample indexes for statewide evaluation and analysis.