Minnesota Department of Natural Resources

Division of Fish and Wildlife

Long Range Plan for Muskellunge and Large Northern Pike Management Through 2020

Final Draft
Adopted August 2008

Minnesota
DEPARTMENT OF
NATURAL RESOURCES

DEPARTMENT MISSION AND GOALS

Minnesota Department of Natural Resources Mission Statement

Our mission 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.

Section of Fisheries Management Mission Statement

To conserve and manage Minnesota's aquatic resources and associated fish communities for their intrinsic values and long term ecological, commercial, and recreational benefits to the people of Minnesota.

Section of Fisheries Management Goals

To make recreational fishing as good as it can be in the state of Minnesota for the present and future.
To maintain, enhance, or restore the health of Minnesota ecosystems so that they can continue to serve environmental, social, and economic purposes.
To foster an ethic of natural resource stewardship among all Minnesotans.

Muskellunge Long Range Plan Goal

To provide unique, high quality angling opportunities for trophy muskellunge.

Northern Pike Long Range Plan Goals

To provide high quality angling opportunities for large northern pike.
To provide opportunities for spearing northern pike.

Muskellunge Stocking Committee and Northern Pike Workgroup
Minnesota Department of Natural Resources
Fisheries Management Section

Marc Bacigalupi, Assistant Area Supervisor, Waterville
Gary Barnard, Area Supervisor, Bemidji
Dean Beck, Area Supervisor, Glenwood
Rick Brusewitz, Area Supervisor, Aitkin
Paul Diedrich, Area Supervisor, Montrose
Chris Foster, Fisheries Specialist, Hutchinson
Dave Friedl, Area Supervisor, Detroit Lakes
Roy Johannes, Program Consultant, St. Paul
Doug Kingsley, Area Supervisor, Park Rapids
David McCormack, Assistant Regional Manager, St. Paul
Steve Mero, Fisheries Specialist, Grand Rapids
Jason Moeckel, Fisheries Operations Support Supervisor, St. Paul
Rod Pierce, Research Biologist, Grand Rapids
Bruce Pittman, Fisheries Specialist, Waterville
David Weitzel, Assistant Area Supervisor, Grand Rapids
Jerry Younk, Research Biologist, Bemidji

Esocid Workshop Participants

While the participants did not reach consensus agreement on some of the specific elements of the draft plan, we are including the list of names that participated to acknowledge their individual contribution and to maintain an open and transparent process.

Bob Halvorson
Bob Johnson
Brett Duenow
Burton Scripture
Carl Peterson
Dale Lyon
Don Haller
Erv Halstead
George Selcke
John Underhill
Jon Wogen
Kirk Schnitker
Rob Carper
Rob Kimm
Robby Pollreis
Roger Goeschel
Ron Berglin
Shawn Kellet

Steve Hoskins

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EXECUTIVE SUMMARY

The purpose of this plan is to guide fisheries management of muskellunge and northern pike in Minnesota for the next 12 years. Our management goals are to improve opportunities for trophy muskellunge and large northern pike, while also providing opportunities to harvest northern pike. This plan builds on the foundation of previous long range plans (MNDNR 1986, 1994) and incorporates the latest research and management experience.

Fisheries management of Minnesota's lakes, rivers, and streams is based on public input as well as an understanding of fish communities and the best available science. While this plan emphasizes muskellunge and northern pike management, the Section of Fisheries Management's mission statement is "to conserve and manage Minnesota's aquatic resources and associated fish communities for their intrinsic values and long term ecological, commercial, and recreational benefits to the people of Minnesota." The long range plan does not identify specific waters for muskellunge expansion or changes in northern pike regulations, and therefore does not address specific concerns for individual lakes. The plan describes reasonable goals and objectives, provides detailed information on the biology and management of these species, and describes a process for obtaining further public input and internal review for specific changes in management.

The plan was developed with input from angling interests, including six workshops, two roundtables, and public comment through the Department of Natural Resources (DNR) website. This plan includes specific goals, objectives, strategies and actions for managing trophy muskellunge populations (including tiger muskellunge), improving opportunities for large northern pike on select waters, and improving northern pike fishing statewide, while also maintaining opportunities for harvest and spearing of northern pike. However, the desire by anglers to harvest medium and large northern pike conflicts with improving the opportunities to catch large northern pike. Similarly, the desire by anglers to expand the number of waters managed for muskellunge conflicts with those who oppose expanding.

There continues to be strong interest in large northern pike and a growing interest in muskellunge angling. A recent survey estimated that 14% of resident, licensed anglers target muskellunge when angling (Schroeder et al. 2007), with another 18% of non-muskellunge anglers moderately or very interested in fishing for muskellunge. While the interest in muskellunge angling appears to be growing, the opportunities are limited. Currently 116 waters (including Lake of the Woods) are managed for muskellunge and hybrid (tiger) muskellunge totaling about 790,000 acres (Appendix A), which represents about 35% of accessible lake acreage in Minnesota. Of these, 95 are managed as pure strain waters, and 21 waters are managed with hybrid muskellunge in the Twin Cities Metropolitan Area. The 95 pure strain waters include 44 lakes or lake systems and 8 rivers that are considered native waters and 43

waters where muskellunge were introduced and maintained through stocking (Figures 2-4 and Appendix A).

Northern pike populations are found in 3,351 waters throughout the state, including border waters. This represents about 2.17 million acres (MNDNR Lake Survey Data) or about 95% of accessible lake acreage in Minnesota. Currently 106 waters, totaling about 675,111 acres (about 29.5% of the total) are managed with experimental or special regulations intended to improve northern pike size structure and improve the opportunity to catch large pike (Figure 5, and Appendix D). These include four of Minnesota's 10 large lakes, which comprise about 520,000 of the 675,111 acres.

The following summarizes the recommendations. The supporting information, analysis, and operational needs are described in the long-range plan.

Recommendations for Muskellunge

- Increase pure strain muskellunge opportunities by up to eight additional waters for a total of 103 pure strain waters (does not include hybrid muskellunge), by the year 2020. Candidate lakes will be geographically distributed, approximately two per DNR administrative region based on described ecological criteria, trophy potential and social considerations developed through a public participation process.
- Manage muskellunge populations for "trophy" angling opportunities through stocking, size regulations, season closures, existing spearing bans, and promoting voluntary catch and release.
- Conduct spring population assessments that include mark and recapture population estimates to evaluate stocking effectiveness and population status.
- Continue to monitor and evaluate muskellunge management and the associated fish communities through standard lake surveys and special sampling, and communicate results of evaluations with the public.
- Evaluate the capacity of public and private production to meet management needs. Identify additional capacity if necessary to maintain program objectives.
- Evaluate the number of lakes managed with tiger muskellunge and potential to discontinue their management or substitute pure strain muskellunge in select metro area lakes.
- Increase public awareness of the role the muskellunge within fish communities.

Recommendations for Northern Pike

- Improve angling opportunities and population size structure through regulations to reduce the annual harvest of large pike.

- Continue to monitor and evaluate the effectiveness of the current experimental and special regulations, currently 106 waters, through netting and creel surveys, and communicate results of evaluations with the public.
- Consider managing up to 125 lakes statewide with regulations intended to improve size structure.
- Conduct research to evaluate management and inform future decisions.
- Increase public awareness of importance of large pike to fish communities.

Recommendations for Spearing

- Continue to provide opportunities to spear northern pike.

Long Range Plan for Muskellunge and Large Northern Pike Management Through 2020

INTRODUCTION

Background

The purpose of this plan is to guide fisheries management of muskellunge and northern pike in Minnesota for the next 12 years. Our management goals are to improve opportunities for trophy muskellunge and large northern pike, while also providing opportunities to harvest northern pike. This plan builds on the foundation of previous long range plans (MNDNR 1986 and 1994) and incorporates the latest research, management experience, and input from angling interests.

The Department of Natural Resources (DNR), like many organizations, periodically develops plans to guide its management decisions. Recently developed plans include: Fisheries Management Plan for the Minnesota Waters of Lake Superior (2006) and the Long Range Plan for Trout Streams in Southeastern Minnesota (2004). Each of these plans is unique to meet the specific needs at that time, while also looking forward to future management efforts and decisions, including a combination of near term and long term strategies and actions to implement management changes, collect information, monitor changes, and obtain public input. These plans should be viewed as guides for making decisions, not as decisions in of themselves.

This plan includes specific goals, objectives, strategies, and actions for managing trophy muskellunge populations (including tiger muskellunge), improving opportunities for large northern pike on select waters, improving northern pike fishing statewide, while also maintaining opportunities for harvest and spearing of northern pike. The plan is organized by species, summarizing the history of management, latest research and information, criteria to consider, and guide management proposals. Criteria include: biological and physical characteristics, social considerations, and the process for obtaining public input and participation in management planning. We anticipate revising objectives, strategies, and actions as we collect new information and obtain additional input.

Fisheries management of Minnesota's lakes, rivers, and streams is based on public input as well as an understanding of fish communities and the best available science. While this plan emphasizes muskellunge and northern pike management, the Section of Fisheries Management's mission statement is "to conserve and manage Minnesota's aquatic resources and associated fish communities for their intrinsic values and long term ecological, commercial, and recreational benefits to the people of Minnesota." This plan is consistent with the DNR mission statement and the Section of Fisheries Management mission and goals described on page 2.

The goals and objectives can be viewed as long term targets, while the strategies and actions are carried out through the development and implementation of operational and spending plans as a means of reaching those targets. The agency considers a variety of long range plans in its development of annual budget proposals.

Public Input

The DNR involves the public in decision making using a variety of public participation forums and techniques that range from informing (e.g. news releases, websites, news stories, and publications), consulting (e.g. public meetings, phone calls, and surveys), involving (e.g. workshops and roundtables), and collaborating (e.g. advisory committees). In the fall of 2006, the Section of Fisheries Management invited representatives from northern pike, spearing, and muskellunge interests to participate in discussions about issues related to managing northern pike and muskellunge and help advise the agency in our planning process. Attendees at the Esocid Workshops included members of Muskies Inc., Northerns Inc., Minnesota Darkhouse Association, Minnesotans for Responsible Muskie Management, and several non-affiliated anglers. A commitment to develop this long range plan was an outcome of early discussions with workshop participants.

To inform plan development, the department hosted a total of six workshops between 2006 and 2008, sought additional feedback at the 2007 and 2008 Fisheries Roundtable, contributed to several newspaper articles locally and statewide, and solicited comments on a draft version of the plan through the DNR website. The workshop discussions included information related to managing northern pike and muskellunge as recreational fisheries, feedback on that information, and exploring alternatives and solutions to resolve concerns and improve angling opportunities. The DNR's intent was to use a collaborative process to incorporate participants' advice and recommendations to the extent possible.

The Department posted a draft version of the plan on its website asking interested stakeholders to comment on the plan from January 3, 2008 through February 15, 2008. During this comment period, 573 individual comments were received, with a total length of 135 pages of text. Respondents were not limited as to the subject or length of comments. Some were very brief while some went into great detail on specific elements in the plan. To help organize and understand the comments, the DNR completed a qualitative analysis using software program Nvivo 7,which organizes information by grouping words or phrases to find similarities and differences. In most cases, comments suggested specific actions that the DNR should do as part of the plan or its management, along with reasons supporting or opposing those action items. Some of the comments identified specific issues or concerns in the plan; others requested additional information, while others suggested reorganizing or revising portions of the plan. The following generally summarize comments received:

- Regardless of support or opposition to specific issues, both workshop participants and website respondents emphasized the importance of an open and transparent process, in which the public has an opportunity to influence the decisions that affect them.
- Comments indicate support for more intensive efforts for both northern pike and muskellunge to increase trophy opportunities and decrease pike stunting (i.e. improve growth).

- There is also support for increasing the number of waters managed for muskellunge to relieve crowding and improve the accessibility for anglers around the state. The limited opportunities in some geographic areas of the state are also an area of major interest to muskellunge anglers.
- Many respondents indicate that Minnesota has a nation-wide image as a muskellunge destination, and that there is much value in retaining and expanding that image. Given the amount of time to develop a trophy fishery (~12-15 years), muskellunge anglers urge the Department to expand the opportunities sooner than later.
- There is some opposition to adding new waters to muskellunge management. Concerns over threats of muskellunge populations affecting other fish, such as walleye, bass, perch, and panfish are mentioned, along with concerns that stocking will lead to spearing bans on stocked lakes.
- Some respondents expressly support increasing the number of lakes with special regulations for northern pike to reduce stunting (i.e improve growth) and increase "trophy" angling opportunities.
- Frequently, comments suggest adding a ban, or restrictions, on spearing (either on select lakes or statewide) to protect large pike and muskellunge. In these comments, there is clearly a perception that spearing takes too many large fish.
- Defense of spearing is also argued as a reason to oppose special regulations for northern pike, as length/slot limits are difficult to follow when estimating fish length through a spearing hole.
- Some respondents do not like special regulations because of reduced opportunity to harvest fish for meals or trophies. These comments often included mention of depriving individuals or families the right to catch enough fish to eat.

General comments of support for, or opposition to, the DNR or the plan were considered, but not included in analysis, as they did not specify a desired action.

The summary of comments above reflects the general lack of consensus among anglers for how to manage recreational fisheries in Minnesota. The desire by anglers to harvest medium and large northern pike conflicts with improving the opportunities to catch large northern pike. Similarly, the desire by anglers to expand muskellunge opportunities conflicts with the concerns of anglers who opposed expansion. Workshop participants recognized these tensions and ultimately acknowledged that consensus agreement on the "right" balance would be difficult if not impossible to achieve. Local and regional perspectives strongly influenced perceptions about the acceptability of different solutions.

The revised plan addresses to the extent practicable many of the specific concerns or suggestions. We included additional information that was requested, and revised many of the objectives, strategies, and actions to address several of the concerns expressed. Concerns about

specific lakes aren't addressed in plan. However, the plan does describe how the Department will obtain further public input as specific waters are proposed for changes in management (Social Considerations and Appendices E and F).

Plan Overview and Direction

A review of long term creel studies, dating back to the 1930s, documented an increase in fishing pressure while the mean size of harvested fish has declined (Cook and Younk 1998). Exploitation directed at large fish was cited as a dominating force affecting Minnesota fisheries. Analysis of creel data including fish caught and released as well as fish caught and harvested suggests that anglers do not widely practice catch and release; rather, the size of released fish reflects angler preference for keeping large fish and releasing small ones (Cook and Younk 1998). Pierce et al. (1995) described angler exploitation of northern pike in a study of seven north-central Minnesota lakes that showed annual exploitation rates can be as high as 46% of the fish longer than 20 inches. Olson and Cunningham (1989) reported a downward trend in the number of "trophy" fish entered into fishing contest in the Park Rapids area of northern Minnesota.

Long term declines in fishing quality along with increasing fishing effort being directed at large northern pike and muskellunge have heightened anglers' interest in changes to regulations and a move to individual lake management to improve angling quality. Since the early 1990s and the first gathering of the Fisheries Roundtables there has been a strong and growing interest in managing for large northern pike and trophy muskellunge. In the mid-1990's fisheries managers began experimenting with different regulations intended to improve the size structure of northern pike and the opportunity to catch a trophy muskellunge. The results of those early experiments, which included both successes and failures, have been incorporated into the latest thinking about managing these recreational fisheries. Specifically, the importance of conserving large pike to maintain size structure and preferred state of fish communities is becoming increasingly clear. If a lake is going to be managed for the opportunity to catch large northern pike, harvest of medium and large pike will have to be reduced (Cook and Younk 1998).

Future management of muskellunge and northern pike is highly dependent on conservation of the fishes' habitats. Draining and filling of wetlands, and development along shorelines and within the watersheds of lakes and streams can reduce water quality, remove important vegetation, reduce spawning and nursery habitat, and can affect dissolved oxygen levels in the water. The impending impacts of global climate change are also likely to affect muskellunge and northern pike conservation efforts in the future. Earlier stratification in the spring contributing to warmer upper water layers during summer, plus potentially higher nutrient loading from more intense storm systems, may significantly increase biological oxygen demand (BOD) and reduce dissolved oxygen. This compound effect may reduce availability of thermally preferred habitats; including indirect affects on the abundance of important forage species. Predicted impacts of climate change include reductions of this type of sensitive habitat, a habitat that also supports prey fish species such as cisco.

At this point, some of the predicted issues include greater variability in spring run-off during spawning and nursery periods, prolonged dry periods, and reductions in cool-water habitat from higher summer water temperatures. In particular, some research suggests that large northern pike thrive best in lakes where deeper, cool-water habitats have enough dissolved oxygen to support the fish during the heat of summer. Although less is known about the thermal preferences of large muskellunge, some research suggests higher water temperatures for optimal growth. However, increased BOD can result in lethal conditions even near the surface as indicated in a partial fish kill in 2007 on Lake Rebecca a muskellunge brood lake.

The Department of Natural Resources has initiated a long-term research program called *Sustaining Lakes in a Changing Environment* (SLICE) that is designed to help better understand and predict the outcomes of change on lake habitats and fish populations. Beginning in 2008, the first four years will include an intensive research and monitoring program to enhance understanding of environmental stressors (e.g. landuse, climate, sediment and nutrients) and the effect of these stressors on lake habitats and fish communities. The results of this intensive 4-year effort will be used to design a long term monitoring program. A desired outcome is the ability to forecast changes and evaluate actions to mitigate, restore or adapt to changes.

Muskellunge Overview

Muskellunge was one of the first sport fishes in Minnesota to be affected by over-exploitation as described by the numerous outdoors writers of the late 1800s and early 1900s. Evidence of increased exploitation coupled with changes in population size structure was documented for muskellunge in north-central Minnesota over a 58-year period starting in the 1930s (Olson and Cunningham 1989). Early attempts by fisheries managers to correct this issue by supplemental stocking had limited success, and may actually have been counterproductive. Little was known at that time about fish genetics. Unfortunately, the most readily available brood source (Shoepack strain) was later found to have inferior growth potential relative to other native genetic strains. Lakes receiving supplemental stocking with Shoepack strain were held in low esteem by muskellunge anglers because they were not providing the desired trophy opportunities. Breakthrough research in genetic strain evaluation and developing dependable sources for the preferred genetic strain revolutionized muskellunge management in Minnesota. By developing and implementing a cooperative Fisheries Research and Management effort that incorporated genetics, proper stocking, and progressive regulation changes, the Section of Fisheries Management was able to restore high quality trophy-fishing opportunities for Minnesota anglers (Wingate and Younk 2007). Since muskellunge exist in low density populations, both natural and introduced, it is essential that harvest rates be very low if a trophy fishery is to be maintained.

In a recent survey, muskellunge anglers expressed an above average satisfaction with the size and numbers of muskellunges they have encountered (Schroeder et al. 2007), with about 80% satisfied or very satisfied with their overall fishing experience. In contrast, they were less satisfied with the number of muskellunge fishing opportunities. Schroeder et al. (2007) estimated that 14% of licensed anglers target muskellunge when angling, with another 18% of non-

muskellunge anglers moderately or very interested in fishing for muskellunge in the future. While the interest in muskellunge angling appears to be growing, the opportunities are limited. The growing interest is creating concerns about crowding and long term sustainability of muskellunge fisheries. Compared to other gamefish species in Minnesota waters, muskellunge are managed in a relatively small percentage of waters. Not including Lake Superior, the Section of Fisheries Management samples and conducts other management activities on about 4,285 waters totaling 2,285,978 acres (Figure 1). Currently 116 waters (including Lake of the Woods) are managed for muskellunge and hybrid (tiger) muskellunge totaling about 790,000 acres, which represents 35% of available lake acreage (Appendix A). These include 6 of Minnesota's 10 large lakes, which comprise about 648,000 of the 790,000 acres.

Of the 116 waters, 95 are managed as pure strain muskellunge, and 21 are managed with hybrid muskellunge in the Twin Cities Metropolitan Area. The 95 pure strain waters include 44 waters (lakes or lake systems) and 8 rivers that are considered native waters and 43 waters where muskellunge were introduced and maintained through stocking (this number includes three waters managed with Shoepack strain) (Figures 2-4 and Appendix A). Muskellunge have been sampled in small numbers in another 54 waters, but these are not actively managed for muskellunge and the likelihood of catching a muskie is very low. Many of these waters are small-connected waters that do not support fishable populations, and some are waters that were discontinued in the muskellunge program due to a lack of success achieving the management goals. Appendix B lists waters that are connected to muskellunge managed waters for purposes of regulation enforcement.

Future muskellunge management will focus on "trophy" (48 inches and longer) management of existing waters, evaluation and research, habitat protection, increasing the opportunities for muskellunge angling, and a review of tiger muskellunge management in the Twin Cities Metropolitan Area. The support for a statewide 48 inch minimum size limit (Schroeder et al. 2007) coupled with an increasing catch and release ethic for muskellunge are consistent with maximizing opportunities into the future.

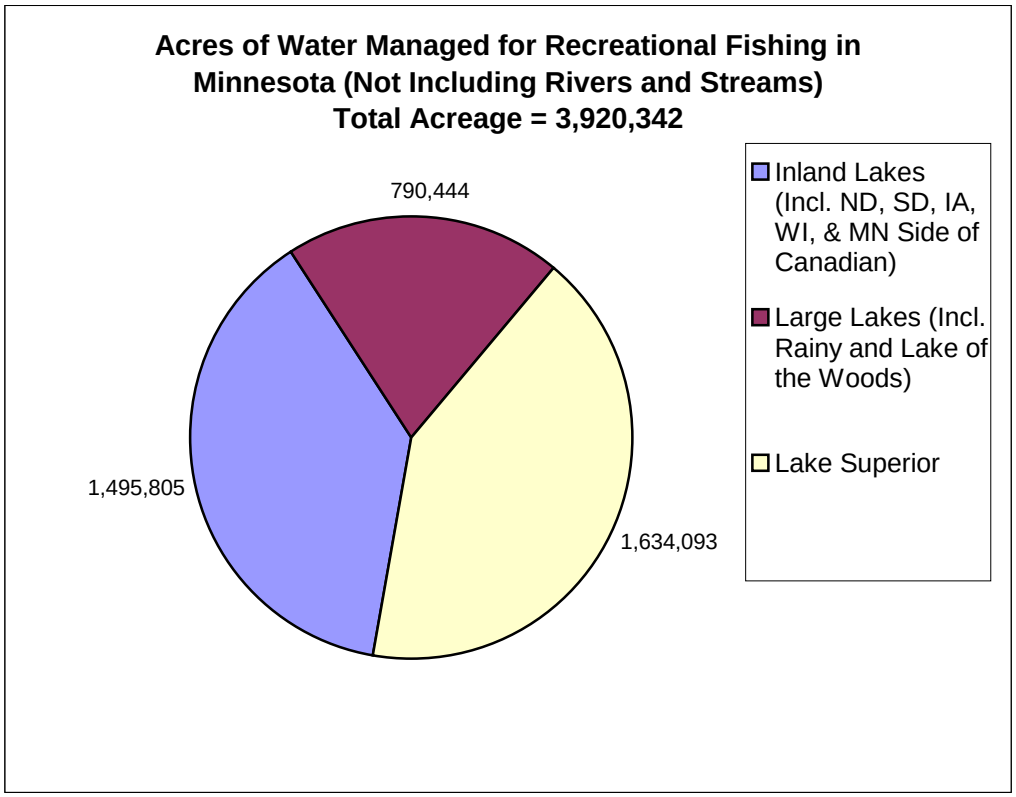

Figure 1 Acres of water managed for recreational fishing is limited only to those lakes that are surveyed by DNR Fisheries, these include border waters that are available to Minnesota anglers without a separate angling license.

Northern Pike Overview

Monitoring of angler harvest and fish communities over time has led fisheries managers to conclude that over-harvest of medium and large pike (for example, fish greater than 24 inches) has been a major factor leading to many pike populations having high densities of smaller fish with fewer fish above 24 inches. Therefore, opportunities to catch large pike have been reduced. Moreover, the opportunities to catch "trophy" size pike (over 44 inches) are rare. The consensus of fisheries managers is that shifts toward high densities of small pike have also affected most fish communities in lakes through excessive predation on perch, potentially increasing numbers and slowing growth of bluegills, reducing survival of young walleye, and limiting fishery management options. While the type of lakes, fish habitat, fish communities, and productivity of lakes vary significantly from southwest to northeast within Minnesota (Schupp 1992) these changes in northern pike population size structure and fish communities are particularly evident in central and north-central Minnesota.

The DNR Section of Fisheries Management has sampled northern pike populations in 3,351 waters throughout the state, including border waters (MNDNR Lake Survey Data). This represents about 2.17 million acres. Currently 106 waters, totaling about 675,111 acres (about

29.5%) are managed with experimental or special regulations intended to improve northern pike size structure and improve the opportunity to catch large pike (Figure 5, and Appendix D). These include four of Minnesota's 10 large lakes, which comprise about 520,000 of the 675,111 acres.

A statewide initiative during 2002-2003 greatly increased the number of waters with size limits designed to protect medium to large northern pike, particularly those over 24 inches. The current emphasis for northern pike management is to evaluate existing special and experimental regulations, and to modify, drop, or add waters based on public interest and management success. In some waters where northern pike habitat has been degraded, particularly in southern Minnesota, broader watershed and shore-land conservation efforts are needed to reduce our reliance on stocking to maintain northern pike. While the practice of catch and release fishing seems to be growing, there is also a clear demand from many people interested in harvesting northern pike. The majority of northern pike waters in Minnesota will continue to be managed for harvesting fish.

Note: The distinction between lake and water is purposeful. In 1968, the DNR's Division of Waters adopted a numbering system for all lakes over 10 acres. In some instances, "waters" managed for recreational fishing will consist of several connected lakes that have the same DOW number and some that have a separate DOW number. Whether these are considered one water or more is largely based on size, similarity and likelihood that fish and other organisms are moving freely throughout the system. Navigability is also a consideration. The list of lakes managed with special and experimental regulations for northern pike includes 106 waters (Appendix D). Some of these represent situations where a small lake typically <100 acres, with a unique DOW is connected to a larger lake (e.g Little Woman (36 acres) and Woman Lake (4,736 acres) in Cass County, or where two similar lakes are so well connected that it's impractical to manage them separately (e.g. Mink and Somers in Wright County). These smaller waters (<100 acres) are inconsequential in the total number of acres statewide. Often, they are included to avoid confusion for enforcement of special and experimental regulations. Conversely, Farm (1,292 acres), South Farm (564 acres), White Iron (3,238) and Garden (653 acres) are well connected as part of the Garden Lake Reservoir but listed as four separate waters in Appendix D.

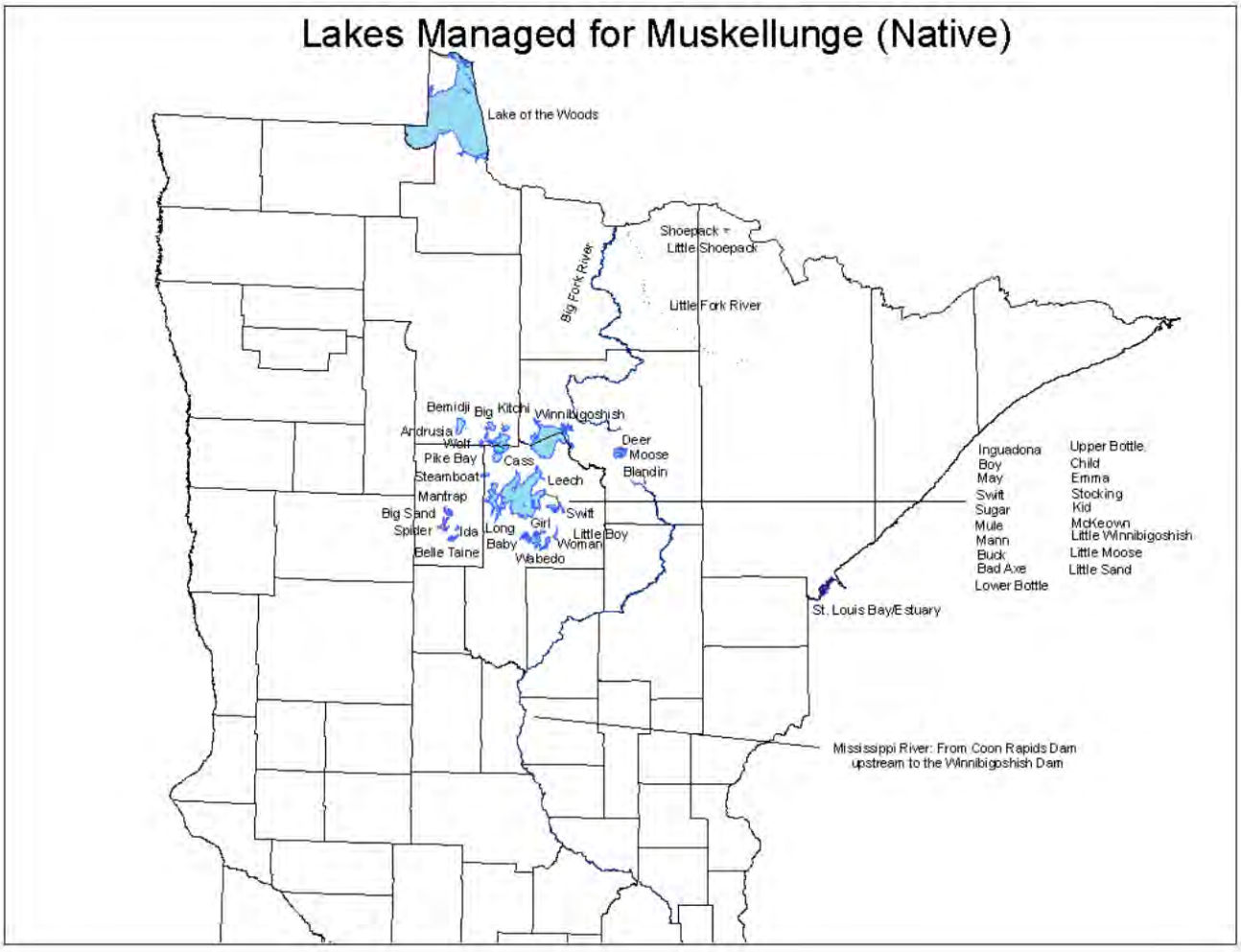

Figure 2 Distribution of native muskellunge waters in Minnesota.

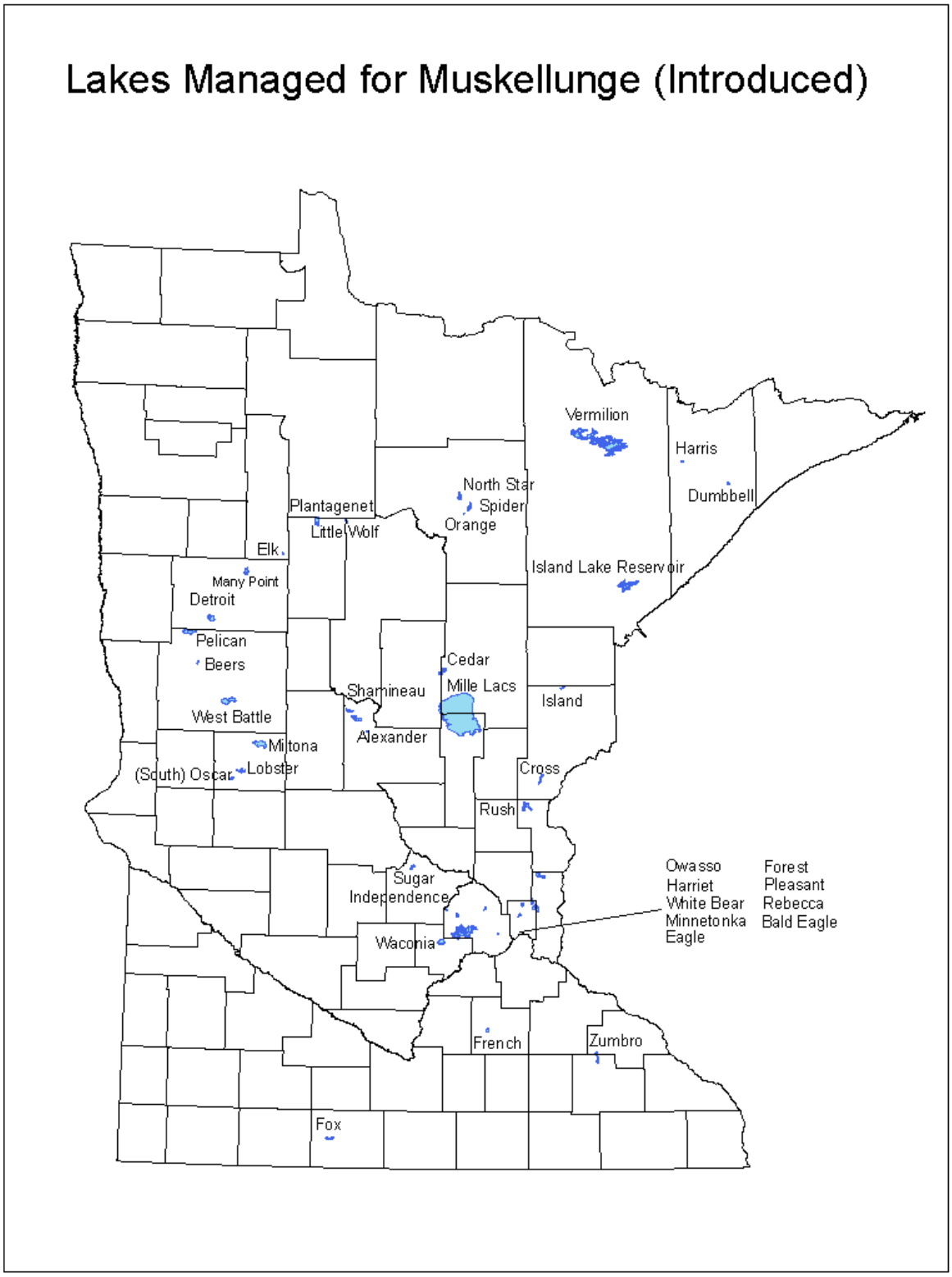

Figure 3 Distribution of introduced muskellunge waters.

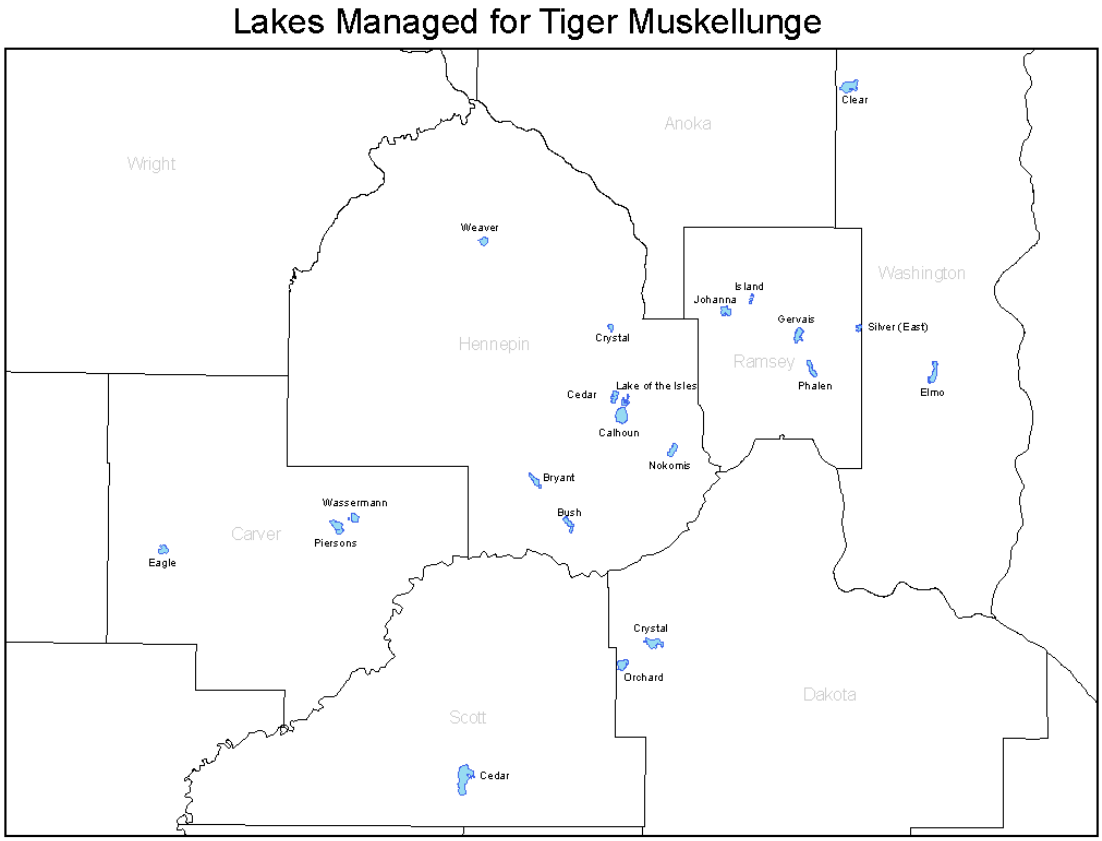

Figure 4 Distribution of lakes managed for tiger muskellunge.

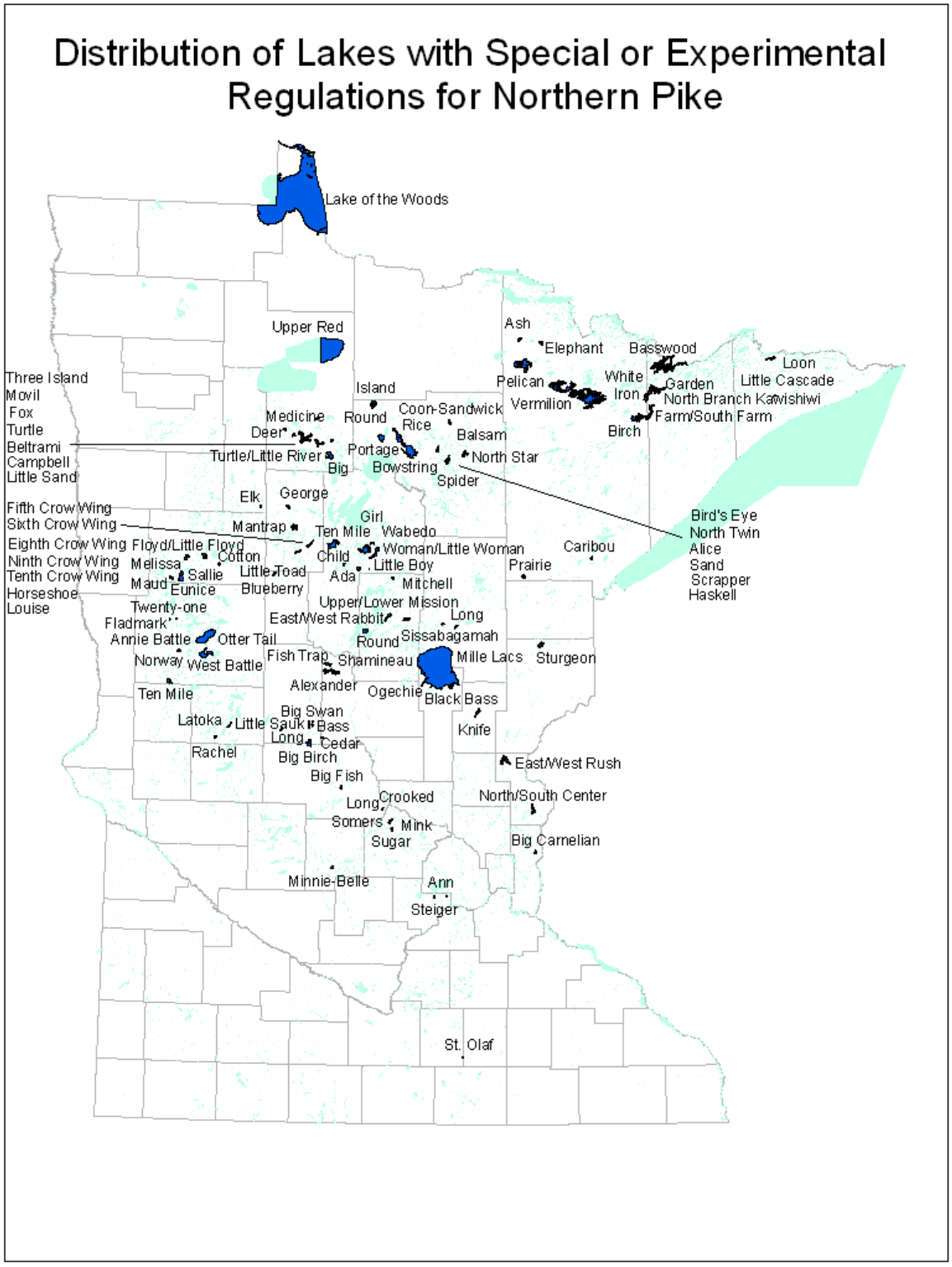

Figure 5 Distribution of lakes managed for northern pike with special and experimental

regulations as of 2008. These correspond to the list in Appendix D.

OBJECTIVES/STRATEGIES/ACTIONS

Objective 1: Manage for pure strain "trophy muskellunge" angling opportunities in up to 103 waters throughout Minnesota (does not include hybrid muskellunge).

Strategy 1.1: Maximize trophy angling opportunities within existing waters.

Action 1.1.1 Implement new stocking guidelines when revising existing Fisheries Management Plans (FMP). Prioritize distribution of muskellunge based on the new stocking guidelines.

Action 1.1.2 Manage for trophy angling opportunities through size regulations, season closures, existing spearing bans, and promoting voluntary catch and release.

Strategy 1.2: Increase trophy muskellunge angling opportunities by adding new waters.

Action 1.2.1 Add up to eight additional muskellunge waters over the next 12 years. Add approximately two per DNR administrative region to provide unique angling opportunities for muskellunge within reasonable proximity (20 to 30 miles) of most major population centers (minimum 5,000 population). Waters will be selected based on physical and ecological criteria described in the long range plan and where public interest, support, and acceptance exists.

Action 1.2.2 Utilize the Fisheries Management Plan (FMP) process to develop new proposals for new muskellunge management, and evaluate suitability using the new criteria described in the plan.

Action 1.2.3 Engage in enhanced public participation to inform stakeholders, disseminate information, and incorporate social concerns and preferences into the selection and approval process.

Strategy 1.3: Maintain critical habitat so that natural and introduced muskellunge populations are preserved.

Action 1.3.1 Begin to identify and quantify critical muskellunge spawning and nursery habitat coupled with existing or proposed shoreline development sites using GPS, GIS, and aerial photo technology.

Action 1.3.2 Protect muskellunge spawning and nursery habitats by purchasing aquatic management areas on muskellunge waters statewide. Native waters or stocked waters with documented natural reproduction would receive the highest priority.

Strategy 1.4: Ensure that public and private fish production capacity is capable of meeting muskellunge management needs.

Action 1.4.1 Continue to manage muskellunge brood lakes with suitable year classes available to produce 750,000 to 1.2 million eggs annually.

Action 1.4.2 Ensure genetic diversity in the brood stock waters by introducing fish from Leech lake every four years. The next scheduled stocking from Leech Lake will be 2009.

Action 1.4.3 Add up to four new drainable ponds (or reinstate drainable ponds previously used) for muskellunge fingerling production and reduce the use of natural ponds. (There are ten drainable ponds currently in use at this time.)

Action 1.4.4 Improve the outlet structures at all drainable ponds by installing manifold barrier outlets and implement the screen box trapping methods to reduce fingerling harvest mortality in the fall.

Action 1.4.5 Implement recommendations from the Viral Hemorrhagic Septicemia (VHS) plan (MNDNR 2007) to move the location of white sucker incubation from French River to Spire Valley for either the 2009 or 2010 production season.

Action 1.4.6 Expand use of the dry diet feed program for producing transplant muskellunge if VHS infects various areas of the state. There are two hatcheries with dry diet experience.

Action 1.4.7 Continue testing all production sites for VHS for both muskellunge and white sucker brood waters. Ovarian fluid testing of muskellunge brood stock and complete fish testing of white sucker in Third River Flowage and Mississippi River.

Objective 2: Improved muskellunge angling opportunities in the metro area, primarily those managed for tiger muskellunge.

Strategy 2.1: Provide anglers with opportunities to catch more and larger fish.

Action 2.1.1 Review current status of tiger muskellunge lakes and evaluate their potential to provide trophy fishing and/or significant numbers of fish.

Action 2.1.2 Communicate with interested anglers and solicit their input regarding stocking rates or frequencies in some lakes, dropping stocking in lakes where it is ineffective, and switching some lakes from tiger muskellunge to pure strain muskellunge stocking.

Strategy 2.2: Provide better information on tiger muskellunge population characteristics.

Action 2.2.1 Develop a reliable sampling protocol that will allow improved assessment of tiger muskellunge populations. Include methodology that would allow for population estimates on half the tiger muskellunge lakes.

Action 2.2.2 Consider a tagging study to provide critical information on tiger muskellunge population dynamics.

Action 2.2.3 Measure angling pressure directed at tiger muskellunge on half the stocked lakes.

Objective 3: Enhanced understanding and knowledge that will inform decisions and communicate the state of muskellunge management.

Strategy 3.1: Improve and increase monitoring methods to provide better information on muskellunge population characteristics.

Action 3.1.1 Establish a statewide muskellunge sampling protocol that would include conducting a minimum of 40 spring special assessments coupled with population estimates from 2008 to 2020.

Action 3.1.2 Expand the passive integrated transponder (PIT) tagging study to include additional lakes that will provide critical information on muskellunge population dynamics.

Action 3.1.3 Develop and implement a statewide sampling protocol that would assist in classifying muskellunge waters according to reproductive status (i.e. no natural reproduction, limited natural reproduction, or sustainable natural reproduction).

Action 3.1.4 Conduct genetic evaluation of native muskellunge waters that were stocked with Shoepack strain. Develop management guidelines in response to any identified genetic concerns.

Strategy 3.2: Maintain efforts to monitor fish communities and evaluate management criteria.

Action 3.2.1 Maintain lake survey frequency on muskellunge managed waters.

Action 3.2.2. Evaluate response of fish communities, forage and targeted game fish.

Objective 4: Manage for large northern pike angling opportunities in up to 125 waters throughout Minnesota.

Strategy 4.1: Consider up to 18 additional waters with special or experimental regulations geographically distributed throughout Minnesota.

Action 4.1.1 Utilize the Fisheries Management Plan (FMP) process to develop new proposals for trophy northern pike management.

Action 4.1.2 Identify additional candidate lakes for “trophy” management, and implement 40 inch minimum size limit.

Action 4.1.3 Consider requests from lake associations, local area interests, and angling interests to manage individual lakes for better size structure. Engage in enhanced public participation to inform stakeholders, disseminate information, and incorporate social concerns and preferences into the selection and approval process.

Action 4.1.4 Attend lake association meetings, prepare reports, and post information on DNR website.

Objective 5: Improved northern pike fishing statewide.

Strategy 5.1: Evaluate options for statewide regulation changes to reduce the annual harvest of large pike.

Action 5.1.1 Review creel data for potential effect of different options (e.g. 1 over 24 inches in possession, 1 over per license per year, or other variations including bag limits).

Action 5.1.2 Discuss options for limiting harvest of large northern pike with angling and spearing interests.

Strategy 5.2: Implement changes to statewide regulations that will enhance size structures of pike populations statewide.

Action 5.2.1 Seek public input and support for statewide changes to northern pike regulations.

Strategy 5.3: Identify and protect critical habitat for northern pike.

Action 5.3.1 Establish and acquire Aquatic Management Areas (AMA) to protect key habitats.

Action 5.3.2 Continue implementing Aquatic Plant Management rules and permits to protect aquatic habitats.

Action 5.3.3 Support efforts to strengthen Aquatic Plant Management and Shoreland Rules.

Strategy 5.4: Utilize partnerships to restore critical habitats.

Action 5.4.1 Develop demonstration projects with local units of government or watershed management organizations to maintain or improve hydrology and water quality for northern pike habitat (particularly in the southern part of the state).

Strategy 5.5: Maintain capacity to utilize stocking where necessary to sustain northern pike fisheries.

Action 5.5.1 Stock adult northern pike in urban fisheries, primarily through the Fishing in the Neighborhood (FIN) program.

Action 5.5.2 Stock fry in wetlands adjacent to lakes to maintain fisheries where spawning habitat is limited, primarily in southern Minnesota.

Objective 6: Enhanced understanding and knowledge that will inform future decisions and communicate the state of northern pike management.

Strategy 6.1: Continue monitoring and evaluating existing special and experimental regulations for large northern pike.

Action 6.1.1 Maintain appropriate lake survey frequency to monitor size distribution and evaluate response of the fish community.

Action 6.1.2 Utilize periodic creel surveys to determine angler catch and satisfaction.

Action 6.1.3 Modify or drop ineffective regulations after the evaluation period.

Action 6.1.4 Periodically (every two years as appropriate) communicate results of statewide analysis with interested stakeholders and fisheries professionals.

Strategy 6.2: Expand the number and variety of lakes with age-structured population estimates for better ecological data.

Action 6.2.1 Develop a plan to expand the number of mark and recapture population estimates, utilizing ice-out trap netting and short term gill net sets.

Objective 7: Improved understanding by interested stakeholders of the value and role of large pike and muskellunge in fish communities.

Strategy 7.1: Develop communication plans to reach interested stakeholders.

Action 7.1.1 Utilize MinnAqua Curriculum to developed informed stakeholders.

Action 7.1.2 Revise and update brochures, web content, public presentations, advertising campaigns, and annual fishing opener information.

Action 7.1.3 Work with popular media outlets to inform anglers about the value of large pike and muskellunge to angling and fish communities.

Action 7.1.4 Attend angler and lake association meetings to share results of research and evaluations of muskellunge management and northern pike regulations.

Objective 8: Maintain recreational darkhouse spearing opportunities throughout the state.

Strategy 8.1: Do not implement any new spearing bans as part of expanding trophy muskellunge fishing opportunities.

Strategy 8.2: Consider the geographic availability of spearing opportunities when proposing or reviewing special regulations.

Action 8.2.1 Monitor and record spearing statistics separately during creel surveys.

Action 8.2.2 Utilize winter creels and conservation officer reports to monitor spearing and angler catch of northern pike.

MUSKELLUNGE MANAGEMENT IN MINNESOTA

Background

The previous long range plans for muskellunge (1986 and 1994) identified a number of goals, objectives, and strategies that served as the foundation for gains in muskellunge management. The ensuing research and management changed muskellunge management considerably, resulting in: 1) substantial growth in the number of muskellunge anglers, angling pressure, and angler success; 2) development of more specific management criteria for establishing muskellunge populations; 3) a review of the production program; 4) management plan revisions to incorporate new information; and 5) better understanding of muskellunge angling interests and perspectives.

This plan builds from that foundation by revising and adding new objectives and strategies based on information and experience gained since 1994. Highlights of activities from the previous plan included: better management strategies for muskellunge populations, increased knowledge on muskellunge populations and their ecological role in the fish community, quantitative information on angling harvest of muskellunge, identification of critical habitat for muskellunge, documenting deteriorating water quality, assessing the genetic integrity of the muskellunge program, improving production program capabilities, and upgrading culture facilities and techniques.

A number of substantial improvements to our production program have been implemented in the past couple of decades. Improved spawn taking procedures, incubation methods, and refinement of trough-culture techniques have resulted in increased survival rates at various life stages providing a more consistent source of transplants for rearing ponds. Statewide production reached a high of 54,000 fingerlings in 1994 (Figure 6). This created a situation in which production exceeded approved stocking proposals. Improved efficiency reduced program cost and resulted in defining an annual goal of 30,000 to 35,000 fall fingerlings. Fish managers also revised the criteria established in 1982 for starting new muskellunge waters.

The muskellunge management program added three new waters between 1994 and 2007, removed three waters, and expanded stocking in the Mississippi River. Other program changes included the movement of production activities out of the drainable ponds at New London and Waterville hatcheries beginning in 2003. The rationale was two-fold: one to place more emphasis on the walleye program and second, to prevent escapement of muskellunge into nearby waters. DNR Fisheries also conducted an evaluation of our stocked muskellunge waters in response to rule making in 2003 that dealt with designated waters.

The management of muskellunge, whether it has been in native waters or as a result of introducing muskellunge in new waters of the state, has created a mystique of both a trophy angling opportunity and concern about the potential effect of a large predator on the fish community. Over the past 15 years interest and awareness of muskellunge angling opportunities

in Minnesota have reached new highs (Schroeder et al. 2007). This enthusiasm has brought out more resident and non-resident anglers seeking to catch a muskellunge greater than 50 inches in length. Online chat rooms and media reports help fuel the interest. In 2006, a video to promote and describe muskellunge management on stocked lakes was prepared and distributed as a cooperative venture by Muskies Inc. and Minnnesota DNR. In 2007, the DNR increased the minimum size limit from 40 inches to 48 inches for 55 waters, a progressive approach to manage a trophy muskellunge fishery with the use of regulations (Figure 7).

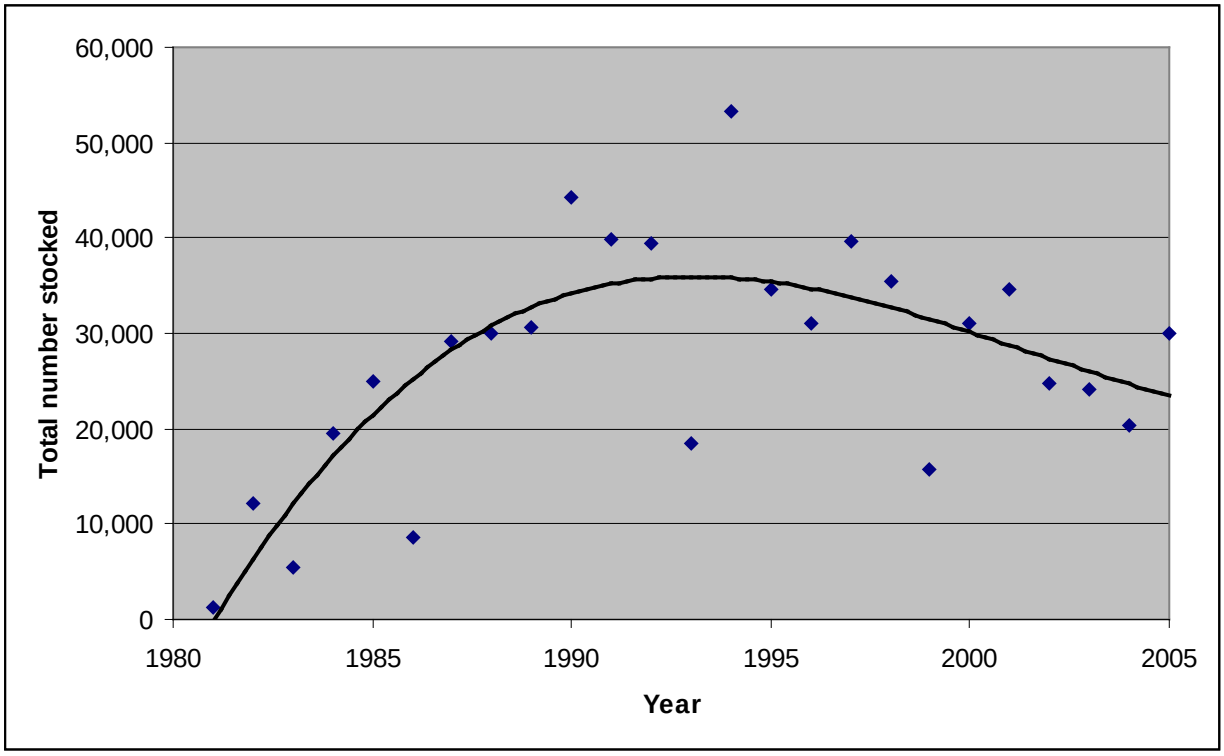

Figure 6 Recent production and stocking history for Mississippi strain muskellunge.

Possession/ Daily Limit	Open Season	Minimum Size Limit	Minimum Size Limit	Minimum Size Limit	Catch & Release	Minimum Size Limit	Catch & Release	Close Season
1956	1982	1983	1990	1993	2004	2007	2007	2008
1	**June**	**36”**	**48”**	**40”**	**Elk**	**48”**	**Miss. R.**	**Dec.**

*Figure 7 A chronology of Minnesota’s muskellunge regulations since 1956. Year indicates when the regulation change (shown in **bold**) was implemented.*

The interest in muskellunge fishing has resulted in additional requests to the DNR to expand the muskellunge program and provide more opportunities for a trophy angling experience, while at the same time other interests have expressed concern about the effects of more muskellunge opportunities on other game fish and spearing opportunities.

In response to these interests and concerns, the DNR is committed to monitor and evaluate lakes that have been managed for muskellunge during the past 25 years and determine short and long term affects of muskellunge management. Continued monitoring and evaluation are essential for adaptive management and facilitates transfer of knowledge to manage other lakes and streams.

In 2006, the Section of Fisheries Management established a Muskellunge Stocking Committee (MSC) consisting of fisheries staff from management, research, and St. Paul central office. The MSC was assigned to:

A) Summarize and evaluate the current muskellunge stocking program, including stocking rates and frequency and production needs;
B) Evaluate and revise criteria used in screening new waters for muskellunge stocking and management;
C) Develop criteria to prioritize stocking requests; and
D) Revise the muskellunge Long Range Plan (LRP).

Interest in Muskellunge Angling

Management of muskellunge in Minnesota has focused on developing high quality trophy fisheries. Younk and Pereira (2007) described trends in Minnesota's muskellunge fishery that included an increase in the number of 40 inch and larger fish and an increase in the proportion of successful anglers following an increase in minimum size regulations. Angler reported catches of 50 inch and larger muskellunge have increased steadily from 1995 through 2004 with 163 such fish reported in 2004 (Muskies Inc. data).

In a recent survey, muskellunge anglers expressed an above average satisfaction with the size and numbers of muskellunges they have encountered (Schroeder et al. 2007), with about 80% satisfied or very satisfied with their overall fishing experience. In contrast, they were less satisfied with the number of muskellunge fishing opportunities. Schroeder et al. (2007) estimated that 14% of licensed anglers target muskellunge when angling, with another 18% of non-muskellunge anglers moderately or very interested in fishing for muskellunge in the future. A previous statewide survey (Schroeder and Fulton 2005) estimated that 9.3% of resident anglers in Minnesota had fished for muskellunge in 2003; suggesting continued growth over the past four years. These estimates corroborate other information that suggests substantial growth in the sport of muskellunge fishing compared to previous estimates by management professionals (Wingate

1986). Creel surveys on Cass Lake (Figure 8) and Lake Bemidji confirm this growing interest: in 1986 2.6 % of the anglers were targeting muskellunge, in 2003, 19.5% of the anglers were targeting muskellunge. On Lake Bemidji the percentage of anglers seeking muskellunge climbed from just a few in 1990 to 18% in 2001. At Sugar Lake 33% of all anglers targeted muskellunge in 1998 versus 1.7% in 1984. Additionally, a previous study of non-resident anglers indicated that approximately 5% had targeted muskellunge while fishing in Minnesota (Currie and Fulton 2001). Based on the number of non-resident licenses sold in 2000 (roughly 250,000), approximately 12,500 non-resident anglers targeted muskellunge. Growth in the sport of muskellunge angling has led many anglers and fisheries professionals to conclude that Minnesota's muskellunge program has been successful.

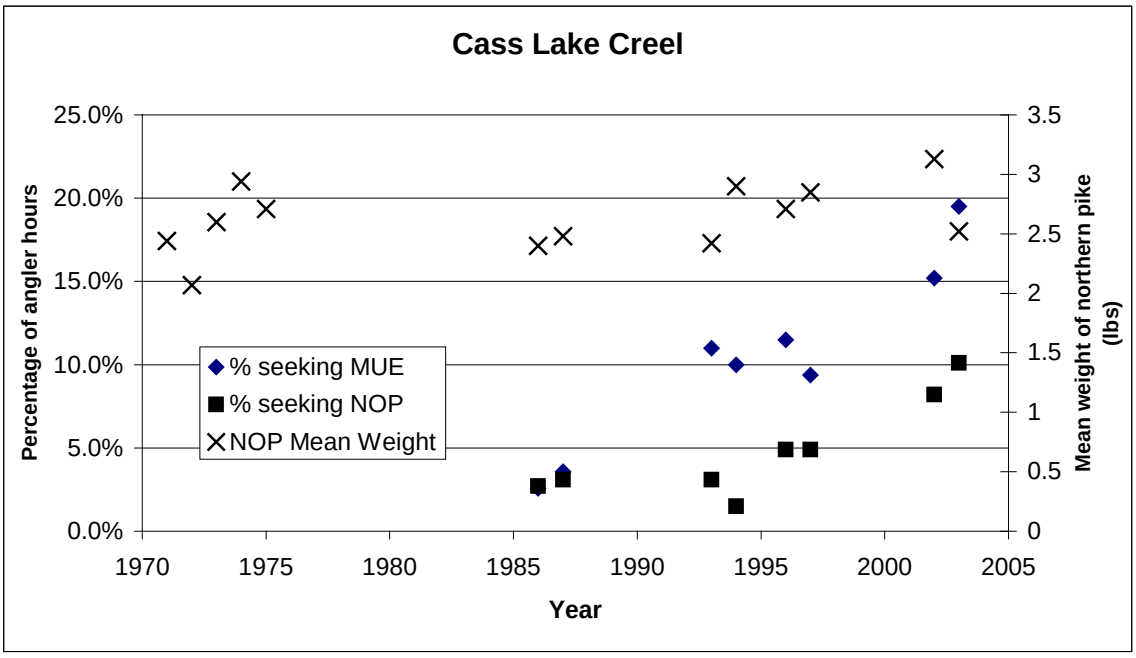

Figure 8 Creel survey data from Cass Lake showing increase in percentage of angler hours targeting muskellunge and northern pike. The mean weight of angler-harvested northern pike has remained relatively steady over the period from 1971 to 2003. Cass Lake is one of 27 lakes where spearing for northern pike is prohibited.

Fish Community Dynamics

The 1994 LRP described the role of muskellunge in fish communities including: their role as a large predator, factors in prey selection such as type and abundance, and potential interactions with other large predators such as walleye and northern pike. Following is an updated reproduction of that section.

Fisheries literature has documented several verified accounts of unusual items found in the stomachs of muskellunge in nature (e.g. frogs, salamanders, ducks, and muskrats); however, these are not everyday occurrences. Muskellunge are primarily piscivorous and tend to be more opportunistic than selective (Parsons 1959; Porter 1977; Hess and Heartwell 1978). Hourston (1952) described muskellunge as general carnivores, preying mainly on fish over 6 inches in length. Most research has shown that esocids (muskellunge and northern pike) will tend to utilize the most abundant prey species present in a body of water. However, other factors that may influence prey selection include critical size and body morphology, habitat, catchability and avoidance behavior, and seasonal behavior or migrations.

Rarely abundant in any lake or river, successful muskellunge populations are most often found in assemblages dominated by percids, coregonids, and catostomids. Various field studies have found prey selection to be dictated by the individual water's species assemblage. Yellow perch was the species selected most frequently by muskellunge examined from western, central, and eastern Canadian waters (Hourston 1952). Stunted perch populations were impacted by the introduction of yearling muskellunge in some Wisconsin lakes (Gammon and Hasler 1965). This study also showed more than a casual relationship between muskellunge growth and yellow perch abundance. It has also been observed that muskellunge were more catchable by anglers during years in which the yellow perch population was low (Inskip and Magnuson 1986). Soft-rayed prey such as suckers, whitefish, and cisco were found to be preferred forage in native Wisconsin muskellunge waters (Oehmcke et al. 1958). Based on a diet study conducted on northern Wisconsin lakes, Bozek et al. (1999) found yellow perch along with white sucker to be the primary food of muskellunge. River and stream muskellunge were also found in association with soft-rayed fish, suckers, redhorse, and cyprinids (Harrison and Hadley 1979; Brewer 1980; Axon and Kornman 1986).

Numerous laboratory studies have confirmed that given a choice of prey, esocids will select soft-rayed fishes over spiny-rayed ones when abundance is nearly equal. This selectivity was more pronounced in hybrid muskellunge and northern pike than in muskellunge (Engstrom-Heg, et al. 1986; Wahl and Stein 1988). However, when soft-rayed and spiny-rayed forage was present in the same size, muskellunge showed no significant selection between the available prey species. Weithman and Anderson (1977) found non-game fish to be more vulnerable to yearling muskellunge predation than game fish.

Targeted prey may change during the life of muskellunge due to changes in prey species abundance, availability, or preferred size. The availability of large prey items is thought to be critical in supporting good growth of top predators (Porter 1977; Diana 1979; Harrison and Hadley 1979). Harrison and Hadley (1979) implied that a lack of suitable prey at all life stages resulted in poor growth in certain riverine populations. It would appear that a stable and diverse forage base would be required to support a well-balanced muskellunge population. To maximize growth and survival, muskellunge should be managed in systems with soft-rayed or fusiform prey rather than in centrarchid-dominated systems (Wahl and Stein 1988).

The prospect of using muskellunge as a predator controlling overabundant panfish populations has solidified the myth that they consume everything in a lake. On the contrary, the role of stocked muskellunge as predators in curbing undesirable or overpopulated forage species is limited in most cases. Although some lake-specific cases have shown positive results, numerous other studies have documented the ineffectiveness of stocking muskellunge for improving the quality of panfish populations (Clark 1964; Oehmcke 1969; Snow 1988). The high reproductive potential of most forage species would more than offset the losses due to predation by low population densities of muskellunge (Porter 1977). Some success in this management practice may be observed when the predator-prey ratio is altered in favor of the predator.

Coexistence of muskellunge and northern pike in the fish community has been the major topic of concern for a number of years. Inverse trends in relative abundance of muskellunge and northern pike have been reported by numerous studies in various lakes, and in each case muskellunge appeared to decrease while northern pike appeared to increase in abundance (Oehmcke 1951; Johnson 1981; Inskip and Magnuson 1986). Predation, competition, and hybridization are possible mechanisms of negative interaction between the two species (Inskip 1986). Earlier spawning in the spring, more aggressive nature and feeding habits, greater food conversion efficiency, shorter generation time, relative abundance, predation by young-of-year (YOY) northern pike on YOY muskellunge, and experience or efficiency as predators gained at a smaller size have all been speculated as possible advantages for northern pike. One study demonstrated the predation of YOY muskellunge by YOY northern pike, whereas the converse did not occur (Caplan 1982). This same type of predation may occur in nature and severely limit muskellunge recruitment. Northern pike also tend to establish stable populations at higher densities than muskellunge.

Dombeck et al. (1986) found that coexistence of the two species is favored in large drainage lakes that have both extensive deep and shallow basins. Ecological separation of spawning habitat and early life stages was also documented for a large lake of the Upper Mississippi River drainage basin (Strand 1986). Separation of the two species with respect to time of spawning, spawning habitat, and location of YOY was documented by Osterberg (1985) in the St. Lawrence River. Differential adaptation to river currents was cited as the most likely factor permitting coexistence of the two species (Harrison and Hadley 1978). The authors found no interaction between YOY muskellunge and YOY northern pike. For both lentic and lotic systems, spawning and nursery habitat types and locations appear to be critical components in permitting a sympatric relationship to prosper. The interaction of muskellunge with other fish species in the community has received limited assessment. Two authors documented negative associations between muskellunge and other species. Siler and Beyerle (1986) found the increase in muskellunge (estimated at 2.2 fish/acre in 1970) and the decrease in populations of black crappie and common suckers to occur concurrently. However, there was also a noticeable increase in the number of pumpkinseeds and yellow perch sampled as the white sucker and black crappie catches decreased. Expansion of a walleye population on top of an existing stable muskellunge population resulted in an increase in mean weight, but a decrease in overall abundance of muskellunge (Mooradian, et al. 1986). This was attributed to decreased survival of stocked muskellunge fingerlings. The presence of both walleye and muskellunge in Chautauqua Lake had little detectable effect on the fish community. Fayram et al. (2005) found muskellunge electrofishing catch per unit effort (CPUE) to be

positively correlated to walleye abundance in 20 northern Wisconsin lakes, suggesting that direct competition or predation was unlikely to occur between the two species. Miller and Menzel (1986) cited competition for food and space, both intra- and interspecific, as potential influences on muskellunge behavior in the fish community. Walleye were present in West Okoboji Lake, but appeared to be spatially segregated from muskellunge. Young-of-the-year muskellunge were found in association with fish assemblages dominated by largemouth bass, pumpkinseeds, and yellow perch (Craig and Black 1986). These nursery areas consisted of wide expanses of varying densities of emergent vegetation. The presence of a diverse aquatic plant community is an essential component-providing habitat for egg deposition and development, newly hatched and YOY fish, and feeding.

Muskellunge also spend parts of their life at the other end of the predator-prey spectrum. Danger of mortality is ever present from egg to adult by other species of the aquatic eco-community. Insects, insect larvae, and small piscivorous and non-piscivorous fish species can destroy large numbers of muskellunge eggs, fry, and fingerlings. Muskellunge fingerlings are especially vulnerable to piscivorous birds during the first 18 months of their life. Other predator fish species will prey on muskellunge that are smaller than them. Cannibalism is also an ever-present threat throughout the various life stages of the muskellunge (Parsons 1959).

At the time of developing the 1994 LRP, limited information was available for lakes in Minnesota, particularly for stocked waters. The management of muskellunge, whether it has been in native waters or as a result of introducing muskellunge in new waters, has created both a trophy angling opportunity and concern about predation on other members of fish communities.

Fisheries managers regularly conduct standard lake netting to track and evaluate managed waters. Knapp et al. (2008) examined information from stocked muskellunge waters in Minnesota to determine if muskellunge have had a noticeable effect on fish communities. They evaluated responses of seven fish species to muskellunge by comparing catch per unit effort (CPUE) before and after muskellunge were stocked in a group of 41 lakes comprised of 12 lake classes. The species examined were: northern pike *Esox lucius*, walleye *Sander vitreus*, yellow perch *Perca flavescens*, black crappie *Pomoxis nigromaculatus*, white sucker *Catostomus commersoni*, and tullibee *Coregonus artedi*. They analyzed data at the individual lake level, pooled over lake classes, and for all muskellunge-stocked lakes combined.

Knapp et al. (2008) also compared each species mean CPUE to the statewide lake class quartiles to determine if the group of lakes displayed trends in CPUE from before to after muskellunge were introduced, as well as to compare post-stocking catch rates to a broader group of non-stocked lakes. They found no significant decreases in mean CPUE among the lakes for any species after muskellunge stocking, either for the stocked lakes as a whole or within lake classes. There was a significant increase in mean CPUE for bluegill over the entire group of lakes and within lake class 24, in addition to an increase in mean CPUE for black crappie sampled by gill nets in lake class 25. The authors reported a lack of strong consistent trends across all species, all lakes and lake classes, and the tendency for most lakes to be within or above the lake class inter-

quartile range suggests the fish species considered in their study have coexisted well with muskellunge in the types of lakes and at the densities the DNR manages for muskellunge.

Population characteristics can include density and mortality estimates, age, growth, and size structure information, and relative catch data. Characteristics describing Minnesota muskellunge populations have been limited to length distribution, average size, and trap net CPUE estimates. However, a number of Area Fisheries offices have begun to incorporate population estimates with the spring trap net assessments. Currently, adult muskellunge densities have been estimated for 10 lakes statewide (Table 1). Densities averaged from 0.13 to 0.35 fish per acre and ranged from 0.06 to 0.39 fish per acre. The Objectives/Strategies/Actions section of the Long Range Plan also addresses this issue by recommending that additional population estimates be conducted over the next 13 years.

Table 1. Summary of estimated densities of adult (30 inch and larger) muskellunge for 10 lakes. Population estimates were calculated by using the modified Schnabel, adjusted Peterson single census, or simply Peterson method.

			Density (fish/ac)	
Lake	Surface area (ac)	Number of estimates	Average	Range
Deer	4,097	6	0.16	0.12-0.21
Moose	1,265	8	0.28	0.14-0.39
North Star	1,059	4	0.22	0.06-0.33
Spider	1,349	6	0.24	0.07-0.36
Alexander	2,763	2	0.19	0.18-0.21
Shamineau	1,626	2	0.28	0.25-0.31
Elk[1]	271	3	0.35	0.33-0.39
Plantaganette[1]	2,529	2	0.13	0.12-0.14
Little Wolf[1]	490	1	0.34	na
Sugar	1,015	1	0.27	na

[1] Brood stock waters

Future Muskellunge Management

In future management of muskellunge waters, Fisheries staff have to consider the challenges of meeting the needs of the program, which include: 1) increasing angler interest; 2) public concerns regarding new introductions; 3) the geographical distribution of existing muskellunge waters; 4) the extensive workload necessary to manage existing waters, including stocking and

evaluation; and 5) habitat issues, including the effects of climate change, which may influence fish communities and production capacity.

Minnesota DNR Fisheries Division initiated a structured individual lake management planning process in 1982 with Special Publication 131, the Lake Management Planning Guide. Section III, Muskellunge Management Planning, listed a number of characteristics to consider when choosing waters for muskellunge management. Those defined characteristics, though general, have been instrumental in shaping Minnesota's current muskellunge program. Good lake selection combined with proper genetics, improvements in production techniques, progressive regulations, and broad acceptance of voluntary catch and release have combined to give Minnesota's muskellunge fishery world class status.

Much has changed since the Lake Management Planning Guide was published 25 years ago. The gains in muskellunge management are most apparent by the definition of a trophy at that time: "*A trophy muskellunge is generally regarded as being over 40 inches long and exceeding 20 pounds*." Now muskellunge over 50 inches and 40 pounds are increasingly common on many of our managed muskellunge waters.

While the Lake Management Planning Guide has become somewhat outdated, the individual lake management plan process has proven to be an invaluable tool for sound management with defined objectives and proper evaluation. It is strongly recommended that the existing lake management plan revision and approval process be adhered to for initiating new lake proposals, recognizing the importance of engaging the public throughout the process. Since stocking new waters affects a statewide production program and prioritization of a limited product, final approval of management plans for new waters should pass an additional step of combined Regions and Central Office approval. Public participation and the process for making decisions are described in more detail later in this document.

The earliest criteria used in considering new muskellunge waters was simple and included lakes that were greater than 500 acres in size, contained low numbers of northern pike, had a preferred forage base consisting of coregonids or catostomids, and typically had public support for muskellunge management. Most of these waters were previously managed with other strains of muskellunge, had previous reports of muskellunge, or were lakes within the Mississippi River watershed. These lakes were stocked directly from Leech Lake or one of the brood waters containing Leech Lake fish. However, a number of lakes that have not met all of the above criteria have resulted in quality muskellunge fisheries. Lakes managed for muskellunge or tiger muskellunge in the Twin Cities were stocked under different criteria and carried forward into the current management program.

Managing a lake for muskellunge requires a considerable investment of staff resources. Adding up to eight additional waters to the program including conducting fish community assessments, monitoring muskellunge stocking effectiveness, implementing the proper strategies to determine muskellunge population density, and having the proper amount of fish for stocking are limiting

factors that have to be considered in expanding the program. At the proposal stage, DNR staff must review lake data, share the information, and solicit input from local interests including: lake associations, interested businesses, and angling groups, and must also consider statewide angling interest. Stocking and subsequent evaluation requires more fieldwork in the spring, a busy time of year for other management operations.

Guidelines for New Muskellunge Proposals

In the early development of a new proposal, the area fisheries manager should begin contacting local stakeholder groups (see Social Considerations and Public Input) to learn about the questions and concerns. The area fisheries manager should provide all relevant information about muskellunge management and the proposed change that will help stakeholders provide meaningful input.

Developing a proposal for muskellunge management requires early and frequent discussions with Regional and Statewide Managers. Written proposals must address the criteria and considerations described in this plan and outlined in Appendix E. New proposals should be submitted for Regional Fisheries Manager review and statewide consideration by December 15 of each calendar year.

A decision to move the proposal forward will initiate a subsequent public input process to ensure that the public has the opportunity to inform the decision making process. That process requires adequate public notice alerting anglers, boaters, and other interests that the lake is being considered for muskellunge management and an open meeting to answer questions and solicit input. Notice can be accomplished through announcements in local and statewide media, posting information on websites, direct mailings, and other appropriate forums.

Advantages of this process are: sufficient time is allotted to develop proposals and determine the interests of stakeholders. Production staff can plan for increases in stocking. The proposal will be consistent with the lake management plan and maintain the tie to individual lake management. Each area is following the same already-familiar guidelines.

In a chapter specific to introduced fishes, Li and Moyle (1999) proposed guidelines when introducing fish species. Among these guidelines they recommend that introductions not be done in places with little or no evidence of human disturbance. In general they suggest Oligotrophic, nutrient poor, or open marine systems are poor sites for introductions. They further suggest that an inventory of the biota and developing a list of species that might be sensitive to the introduction, with special consideration for rare species or species ecologically most similar to the species proposed for introduction. The following sections describe specific criteria to be used for evaluating new muskellunge introductions in Minnesota. New proposals for muskellunge management must address all aspects of the lake background and history, biological and physical

considerations, and social considerations described below. *Note: a checklist in Appendix E is provided to ensure that all criteria and issues have been considered.*

The Muskellunge Stocking Committee examined lake assessment and research data collected from all waters managed for muskellunge populations over the past 25 years. These data were used to refine the criteria used to select muskellunge lakes and are categorized by the following:

A) Lake background and history;
B) Physical and biological considerations;
C) Social considerations;
D) Workload considerations.

Lake Background and History

Waters being considered for muskellunge management are generally high on management area priority lists, resulting in a fairly extensive history of population assessments and management plan revisions. This will provide a rich set of historical data to describe the existing fish community, past management practices, and baseline status for evaluating any changes in community structure.

Muskellunge management does not preclude ongoing management for other primary management species. There are numerous examples of waters where walleye and muskellunge populations are successfully being enhanced through regular maintenance stocking. Special regulations are in place for protection, or quality enhancement, of species other than muskellunge on many muskellunge managed waters. Muskellunge introduction and maintenance stocking is an intensive management activity justifying primary species designation, but should not displace other primary species in management plans.

Waters with a historic presence of muskellunge should be considered excellent candidates for restoration. Records are very limited for documenting presence. DNR Fisheries extensive lake survey database is mostly post 1950, well after early exploitation and possible extirpation of some populations. Standard survey gear would have been ineffective at sampling muskellunge in low density populations. Historical newspaper accounts may provide the only evidence of previously extirpated populations. Waters previously connected to known native populations, now separated by dams, may be other likely candidates for restoration.

Geographic Proximity. The geographic proximity to other muskellunge fishing opportunities is an important consideration. Areas of the state with no muskellunge angling opportunity within 20 to 30 miles of major population centers (minimum 5,000 population) may be given higher priority (Figure 9). Meeting this criterion may require some latitude in some of the other desirable characteristic such as lake size, primary forage, or water clarity.

Trophy Potential. Biologically, lake size and forage availability are viewed as important criteria for maximum size potential. Public support, or minimal acceptance, may be another factor affecting longevity. Since relatively few individual muskellunge survive natural mortality to achieve ultimate size, additional sources of inadvertent or illegal mortality will affect the number of fish reaching trophy potential.

Winterkill Potential. Given the longevity required for muskellunge to reach quality or trophy potential, waters with a history of winterkill should not be considered. Even aerated lakes maintaining quality populations of other species are poor candidates. In the event of system failure or extreme winter conditions, other fish populations can be more quickly restored.

Connected Waters. Proposals for new introductions must also consider any connected waters and describe the physical and biological considerations relative to those waters, likelihood of migration, and any potential concerns or mitigating factors.

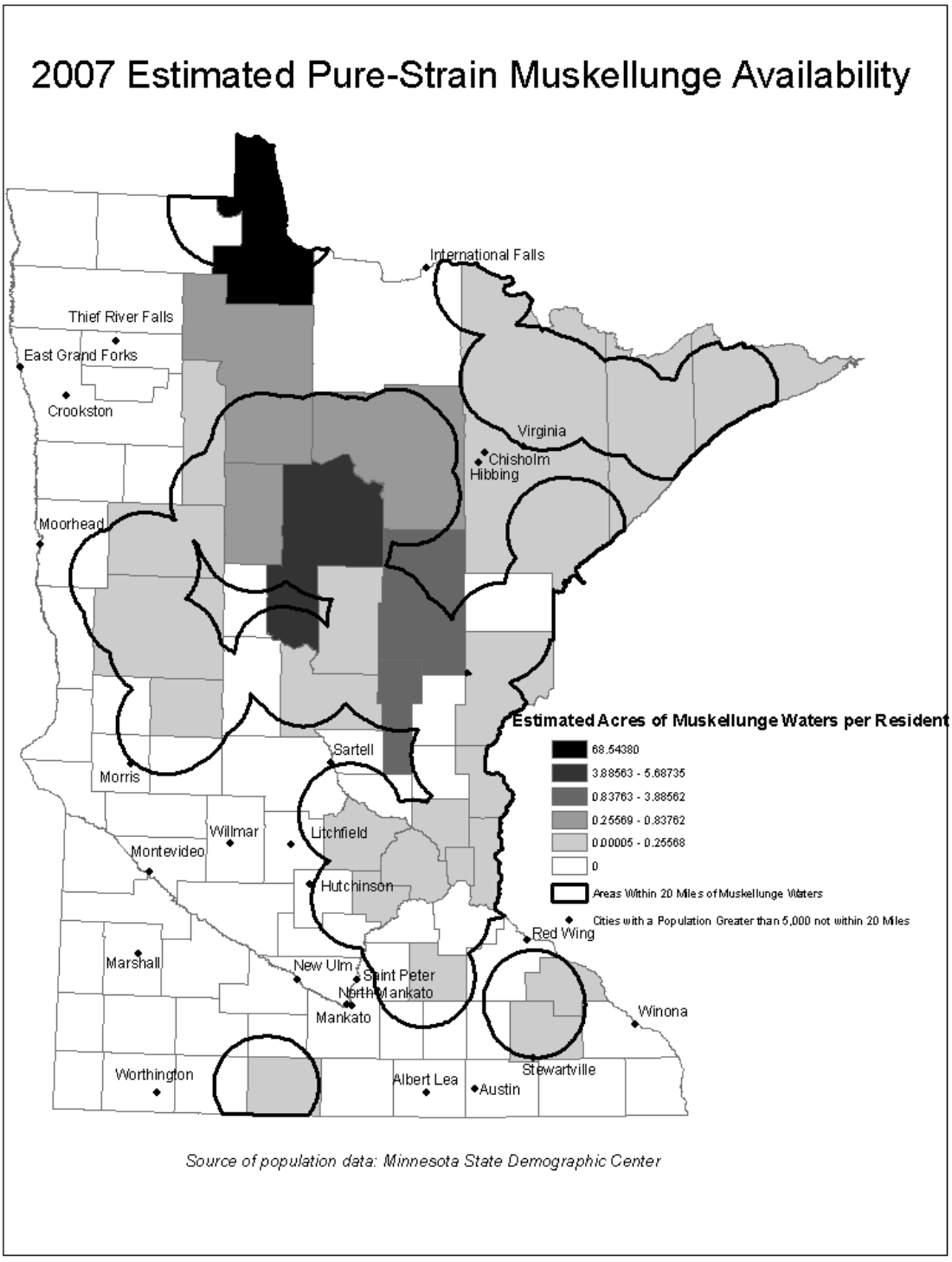

Figure 9 Geographic distribution of muskellunge waters relative to population data for 2005 for each county in Minnesota. Population data were divided by the acres of muskellunge water in that county. These ratios should not be viewed as targets.

Physical and Biological Considerations

Physical and biological information was compiled from both native and successfully introduced muskellunge waters. Application of the older version of lake selection criteria served the Section of Fisheries well as many of the attribute results overlapped between native and introduced waters (Table 2). As a result, we combined information from both native and successfully introduced waters. Summary statistics including inter-quartile ranges were generated for each attribute, which can be used as a benchmark for proposing (areas) and screening (regions) new muskellunge waters (Tables 2 and 3). These attributes were prioritized as acceptable, better, and best. Following is a list of the physical and biological attributes to consider:

Lake size. Although some native muskellunge waters are relatively small, larger is considered better. Muskellunge naturally are found in relatively low density populations. Even populations maintained by regular stocking are generally very low density compared to other top predator species. Large lakes will naturally support more adult fish and provide more opportunity for anglers, as well as being better able to absorb and disperse increased angling pressure. Lake size averaged 5,473 acres (median = 705 acres) and ranged from 56 to 110,527 acres for native muskellunge waters.

Littoral Area. The littoral area can be considered the most productive zone in a lake. These shallow areas extend from the shoreline to the 15 foot contour or the limit of rooted plant growth. The DNR uses the 15 foot contour for all management decisions. Aquatic vegetation, an important component of the littoral area, also plays a key role in all life stages of muskellunge. The littoral area also serves as an interface to open water, another important habitat feature. However, this attribute should be examined in conjunction with lake size, depth, and shoreline development factor (SDF). Native muskellunge lakes average 45% (median = 40%) littoral area (range = 10% to 99%).

Basin Depth. Basin depth varies greatly among waters and can be used as an indicator of winterkill as well as trophy potential. Although deeper waters tend to have cooler water temperatures that tend to support good coregonid populations, shallower waters are more productive overall. Maximum depth averaged 64 feet (median = 56 feet) and ranged from 23 to 150 feet in native waters.

Shoreline Development Factor (SDF). Shoreline development factor (SDF) is defined as an index of the regularity of the shoreline. For example, the SDF for a perfectly circular lake would be unity (1.0). This attribute may serve as an indicator of greater littoral area development and the habitat features and productivity associated with these areas. Higher SDFs could also provide increased angling opportunities along with more diverse angling locations in a lake. SDF averaged 2.0 (median = 1.9) and ranged from 1.0 to 4.4 for native muskellunge waters.

Water Clarity. Esocids are sight feeders and are thought to benefit from good water clarity. Extremely turbid waters could reduce feeding efficiency; however, a recent study (New et al. 2001) suggests that both vision and the lateral line system play an important role in prey capture. Also, the ability to observe fish is an advantage to muskellunge anglers, not necessarily improving catch rate, but adding to the angling experience. Although moderate water clarity is preferred, some native muskellunge waters including riverine systems have relatively low water transparency. Even those water bodies exhibiting lower water transparency have provided quality muskellunge fisheries. Water transparency (based on Secchi disk measurements) for native muskellunge waters averaged 11.0 feet (median = 11.0 feet) and ranged from 2.0 feet to 21.0 feet.

Northern Pike Density (Gill Net CPUE). Low northern pike CPUE is desirable to reduce direct predation on stocked fingerlings, minimize competition with muskellunge for available forage, and avoid the reproductive/recruitment advantage of pike at early life stages. However, both native and stocked muskellunge waters with high northern pike densities have provided quality muskellunge fisheries. Native muskellunge waters averaged 4.7 northern pike/gill net (median CPUE = 4.2) with a range of 0.4 to 11.6 northern pike/gill net. Waters with higher pike density could be considered where pike size structure is poor. This may be an instance where muskellunge would be used to replace a large pike fishery that is already gone, not to be confused with displacing large pike. Larger carry-over yearling or adult muskellunge may be the preferred method for stocking in these instances.

Adequate Forage Base. Muskellunge growth is improved by the availability of larger high protein/fat prey species for efficient foraging and biomass conversion. Presences of healthy coregonid (whitefish and tullibee) and/or catostomid (suckers and redhorse) populations are preferred and would be considered as primary forage and prioritized as best. Secondary forage species would include yellow perch and freshwater drum. The better priority category would include an abundance of secondary forage species with the presence of at least one primary species. Only secondary forage species in combination with other alternative forage species (e.g. carp, bullheads, and gizzard shad) would be considered as acceptable. Some latitude may be required in the southern part of the state where the dominant species present in a lake may include gizzard shad, freshwater drum, common carp, and bullheads.

The majority of current muskellunge waters in northern Minnesota contain some combination of tullibees, suckers/redhorse, yellow perch, and bullheads. Current muskellunge waters in southern Minnesota contain some combination of suckers/redhorse, yellow perch, bullheads, freshwater drum, and carp. Yellow perch are found in all muskellunge waters while coregonids, catostomids, and ictulurids are present in greater than 80% of the muskellunge waters statewide.

Table 2. Selected physical and biological characteristic comparison between native and introduced muskellunge waters.

Characteristic	Attribute	Measure	Muskellunge waters	
			Native	Introduced
Physical	Lake size (ac)	Maximum	110,527	132,516
		Inter-quartile	289-1,780	428-2,859
		Minimum	56	86
	Maximum depth (ft)	Maximum	150	113
		Inter-quartile	40-80	36-82
		Minimum	23	13
	Secchi (ft)	Maximum	21	16
		Inter-quartile	8-14	6-11
		Minimum	2	3
	Littoral area (%)	Maximum	0.99	0.80
		Inter-quartile	0.29-0.56	0.40-0.56
		Minimum	0.10	0.20
	SDF	Maximum	4.37	7.12
		Inter-quartile	1.44-2.29	1.38-2.70
		Minimum	1.04	1.04
Biological CPUE (indices – fish/GN)	Northern pike	Maximum	11.8	15.1
		Inter-quartile	3.7-6.7	1.3-5.7
		Minimum	0.8	0.0
	Coregonid	Maximum	28.4	15.7
		Inter-quartile	0.3-6.7	0.0-1.2
		Minimum	0.0	0.0
	Catostomid	Maximum	8.3	20.6
		Inter-quartile	1.3-5.1	0.3-2.1
		Minimum	0.1	0.0
	Yellow perch	Maximum	103.0	89.0
		Inter-quartile	9.7-45.2	8.7-37.5
		Minimum	0.8	0.6
	Freshwater drum	Maximum	-	25.8
		Inter-quartile	-	0.0-0.0
		Minimum	-	0.0
	Ictalurid	Maximum	20.2	35.2
		Inter-quartile	0.7-6.2	0.3-9.2
		Minimum	0.0	0.0
	Common carp	Maximum	-	2.5
		Inter-quartile	-	0.0-0.6
		Minimum	-	0.0
	Gizzard Shad	Maximum	-	-
		Inter-quartile	-	-
		Minimum	-	-
	Other	Maximum	-	-
		Inter-quartile	-	-
		Minimum	-	-

Table 3. Physical and biological characteristics for new introductions based on existing muskellunge waters.

Characteristic	Attribute	Priority	Criteria of attribute
Physical	Lake size (ac)	Best	> 3,000
		Better	300 to 3,000
		Acceptable	< 300, but ≥100
	Maximum depth (ft)	Best	> 80
		Better	40 to 80
		Acceptable	< 40, but ≥ 15
	Secchi (ft)	Best	> 10
		Better	5 to10
		Acceptable	< 5, but ≥ 3
	Littoral area (%)	Best	0.33 to 0.55
		Better	NA
		Acceptable	< 0.33, but ≥ 0.55
	SDF	Best	> 2.40
		Better	1.40 to 2.40
		Acceptable	< 1.40, but ≥ 1.05
Biological	Northern pike CPUE	Best	< 2.4
		Better	2.4-6.3
		Acceptable	≤ 15.1
	Forage (size quality abundance diversity)	Best	Primary and secondary species present, abundance inter-quartile ranges or above
		Better	Secondary species present, abundance inter-quartile ranges or above
		Acceptable	At least one secondary species present, with some mix of alternate species at moderate to high abundance

Social Considerations

This section describes a variety of social and economic considerations for muskellunge management that should be addressed in management proposals, evaluations, and decisions. Many of the specific issues and concerns are best understood through sharing information and public participation.

Public Input

Public input for making decisions is essential to gain understanding and support for a successful management program. Involving the public provides a means for incorporating the public's values, interests, needs, and desires into decisions that affect their lives, and

encourages the public to provide meaningful input into the decision process (IAPP 2006). It is the agency's responsibility to provide the necessary information so that the public can participate in a meaningful way. The following steps and timeline describe the decision making and public input process for new muskellunge management waters.

1) Area Fisheries Manager contacts stakeholders to initiate discussions and get initial feedback on muskellunge management.
2) Area Fisheries Manager prepares a proposal (described in Appendix E) for Regional and Statewide Review (December 15 of calendar year)
3) Proposal approved by the Division of Fish and Wildlife for broad public input by March of subsequent calendar year.
4) Proposal is discussed at Area Team and Regional Management Teams.
5) Notice of proposed management change published in local and statewide newspapers between 60 and 90 days before a public meeting (during the open water angling season). Signs posted at public accesses for a minimum of 90 days. Written proposal made available on DNR website.
6) Notice of proposed management change published in local and statewide newspapers within 30 and 7 days of public meeting.
7) Public meetings held in county where largest portion of water is located and in St. Paul Central Office.
8) Summary of public input and Area Fisheries Managers recommendation submitted with final proposal by December 15 of calendar year.
9) Section of Fisheries Management submits recommendation to Division Management Team and Commissioners office for approval.
10) Decision to proceed incorporated into production program by March of calendar year.

A key step to getting public input is to develop a list of stakeholders. Stakeholders may be individuals, business owners, clubs, organizations, or residents of a particular area; represent local units of government; or perhaps have a statewide interest. Common stakeholder groups include: lake associations, angling clubs and organizations, spearers, resort owners, bait retailers, riparian owners, and nearby residents. Each group may have unique concerns and interest in muskellunge management. Frequently asked questions and concerns include: additional angling pressure, effect on spearing, changes in resort and retail clientele, interest in other species, and potential for crowding at public accesses.

Fisheries managers have had difficulty reaching all stakeholders and getting their input on muskellunge management. It can be challenging to assess public sentiment regarding muskellunge management. Several resources for involving the public offer valuable guidance and tips, some of these include: 1) the Institute for Participatory Management and Planning, www.ipmp-bleiker.com and 2) the International Association for Public Participation www.iap2.org.

Effectively reaching a broad set of stakeholders will take a variety of communication efforts, meetings, and perhaps years of footwork to prepare for an initial proposal. Newsletters, radio/TV spots, and websites are passive forms of communication to keep the larger public informed. Interested stakeholders can view information about Minnesota's muskellunge management and research on the DNR website. Pertinent research, summaries, production, maps, and answers to frequently asked questions are posted here so that interested persons can easily research the topic of muskellunge management.

Fisheries managers have conducted "open house" and "single stage" meetings in order to gather public input. There are advantages and disadvantages to both. An open house meeting allows participants to ask questions in small groups, which is less intimidating for some people, and prevents any one person from dominating. The single stage meeting allows all participants to hear the same information but can create unsatisfactory situations. More recently, managers have had reasonable success using a combination of the two.

Soliciting comments on cards or prepared comment sheets has helped agency personnel understand and document different perspectives. A mix of opinion questions and open ended questions has proven helpful. It is important that people do not perceive these as votes. Meaningful input that helps the agency make an informed decision is most valuable. Comment sheets give participants an opportunity to provide input even if they are reluctant to speak to an entire group.

Compliance with regulations is a principal concern for the success of muskellunge management. The local Conservation Officers should be involved early and encouraged to provide their input during lake selection. Officers should be encouraged to attend public meetings about muskellunge management.

Dark-house spearing advocates may oppose new muskellunge introductions for fear of possible spearing bans (Note: no additional spearing bans are proposed). While some waters have been closed to protect muskellunge from inadvertent mortality, spearing bans will not be required as part of new introduction proposals for muskellunge waters. Managers should consider existing use, potential for conflict, and be clear on the intent for any potential northern pike regulations.

Many moderately to heavily exploited lakes that once produced large northern pike have long been depleted. Where public support is lacking for restrictive regulations to restore quality northern pike, muskellunge management may be a viable alternative. In this instance muskellunge are not displacing large northern pike, rather replacing a quality component of the fishery that has already been lost. This may be a win-win situation by providing a quality option (muskellunge), while allowing anglers who prefer to harvest an option (northern pike) as well.

Proximity to other muskellunge waters and large population bases are important considerations. In some instances the possibility of providing a unique angling opportunity not readily available within reasonable driving distance of a large population base may

justify muskellunge management on lakes with less than optimal physical and biological characteristics.

Access Considerations

Angling pressure and public access is another important consideration and frequent concern expressed by the public. Creel surveys provide quantitative estimates of angler effort (pressure), catch, and species harvest. They are one of the most useful ways to gauge opinions of stakeholders who actually fish a particular lake. Creel surveys can estimate the amount of winter spearing pressure and interest. A creel survey on Sugar Lake (Hiebert and Sledge, 1998) showed that 68% of riparian owners, who angle, supported muskellunge management.

Lakeshore property owners have asked questions about increasing angling pressure following muskellunge introduction. Creel data have documented increases in angling pressure on introduced muskellunge lakes. This is an interesting dilemma where successful management practices for any species will potentially increase total fishing pressure. Increases in angling pressure can be a positive or negative, depending on perspective. Resorts and other fishing related businesses generally consider it a positive. Fishing pressure is generally a good indicator of fishing quality. It is important to note that the pressure directed specifically at muskellunge is largely non-consumptive, potentially reducing overall harvest rates for other species. Angling pressure is typically highest during the first six weeks of the open water season with some of the highest use among anglers targeting walleye during the months of May and June. Angling for muskellunge tends to be highest during the months of July thru October.

Public access capacity should be considered with the assumption that there will be some increase in angler use. Department of Natural Resources Policy as managed by Trails and Waterways defines adequate access for categories of lake size. One parking space is provided for each 20 acres of lake surface on lakes 0 –1000 acres; one space is provided for each 20 to 30 acres of lake surface on lakes 1000 – 1500 acres; one space is provided for each 40 acres of lake surface on lakes 1500 – 5000 acres; for lakes larger than 5000 acres guidelines are established on an individual basis.

Workload Considerations

Area supervisors need to consider the additional workload that a muskellunge lake will demand. Proposals for new muskellunge waters should not be approved without specific objectives and detailed evaluation plans.

Muskellunge are not sampled adequately in standard survey gear and require special targeted sampling effort. Recommended protocol for a basic muskellunge assessment is spring trap netting with special large frame muskellunge trap nets. Operating Job Safety Analysis (JSA) requires a three person crew for setting and lifting assessment gear. Timing is dictated by water temperature

but generally occurs in late April to early May conflicting with a very busy field period for many fish management areas. Trap net assessments generally run at least 8-14 days to span the peak of the spawning period but are sometimes extended due to erratic weather patterns.

Spring trap net assessments provide basic CPUE and size structure information. CPUE data are a relative indicator of population density but can be strongly influenced by weather conditions and timing. While considerable effort is expended to acquire the basic CPUE information, some additional sampling can greatly enhance the information gained. Marking the fish handled in the initial trap net sample, and following it up with 2-3 nights of electrofishing for recapture, can provide a very good estimate of the adult population. It is strongly recommended that population estimates be included in muskellunge evaluation plans. Population estimates provide a more useful perspective on density than simple CPUE.

Regularly scheduled population assessments will be necessary to monitor any possible changes in fish communities. At times there will be additional public relations demands to explain the program and address concerns. Occasionally some additional special assessment work may be needed to adequately address some of the social concerns listed under Social Considerations.

Creel surveys are not required for muskellunge evaluation but have proven to be valuable for estimating catch, discerning angler opinions, and documenting shifts in angling pressure. New lake proposals with prior creel survey history or a regular creel rotation are good candidates since targeted pressure and catch rates may be adequate for evaluating program success.

Muskellunge Production Program

Fisheries managers have a limited number of options available for managing a water body to provide muskellunge angling opportunities. Stocking is a management tool available for fisheries managers to consider along with habitat protection and improvement, regulations, and angling access. Stocking is used in muskellunge management to achieve the following defined lake management goals:

A) Introduction of muskellunge into a new water;
B) Restoration of formerly self-sustaining natural populations; and
C) Maintenance of muskellunge waters that lack the capacity to maintain a fishable population.

The earliest documented efforts of propagating and stocking muskellunge in Minnesota occurred in 1911 (Minnesota Biennial Report 1912) and continued with limited success throughout the early 1900s. Information from this period, although fragmented, provides valuable insight into the state's earliest attempts at muskellunge propagation. The following efforts were initiated due to concerns about declining abundance of muskellunge and increased angling demands.

Surber (1929) reported muskellunge production and stocking of 115,000 fry in 1927 and 1928. Attempts by the division to propagate muskellunge in the spring of 1933 produced 50,000 fry, without, however, apparent stocking success (Minnesota 1934). Carbart (1937) described in some detail muskellunge propagation techniques attempted at Lake Belle Tain and the Park Rapids hatchery during the 1933 season (Minnesota 1934). Mature fish were seined and placed into a shallow bay that served as a natural spawning ground. The bay also provided for full protection of the fry. Eggs were stripped into a soupy mud solution, fertilized, and transported to Park Rapids hatchery where the eggs were placed in a tray. Fertilized eggs were then placed in a rocker shaped spawn tray and staked out along the edge of the bay in sluggish water. The use of natural spawning grounds by muskellunge on Lake Belle Tain was again attempted in 1935 and 1936 with limited success (Minnesota 1936). Attempts to use Lake Belle Tain muskellunge for propagation continued into the 1940s. A muskellunge hatchery was built on the shores of Lake Belle Tain at Nevis, Minnesota, circa 1940 (shown in photo below).

Continued failures in obtaining a reliable egg source from Lake Belle Tain and other nearby muskellunge waters resulted in a change in the muskellunge propagation program. Part of this direction included locating the program at the Park Rapids station. Attempts to dip net muskellunge at night during spawning season on lakes such as Bad Axe failed during the initial efforts in spring 1950.

A second attempt at securing brood stock consisted of angling for muskellunge on Shoepack Lake (St. Louis County) in early summer 1950. Fish were airlifted out of Shoepack in cream cans, transported to the Park Rapids hatchery, and placed in one of the hatchery ponds. Shoepack strain muskellunge became the main source of fish used in the stocking program from the 1950s through the early 1980s. Muskellunge spawning operations were conducted at Shoepack Lake from 1953 to 1960 and again from 1964 to 1972. Egg production ranged from 137,000 to 754,000. Fingerlings were stocked into Big Mantrap Lake and other muskellunge waters statewide. From 1969 to 1978 spawning operations were conducted on a

varying number of lakes ranging from 2 to 10 sites. Egg production ranged from 1.9 to 3.1 million. Pond production ranged from 5,140 to 26, 496 fingerlings.

After more than two decades of using muskellunge progeny with origins from Shoepack Lake, it became apparent that fish resulting from those stocks rarely attained a large size. Data from the sport harvest coupled with DNR net catch information indicated that most fish in those populations were less than 36 inches. Of the 1,826 muskellunge captured by members of Muskies Inc. from 1970 to 1980, 85% and 15% came from lakes with native and introduced populations, respectively. Lakes with natural populations produced over 97% of the fish greater than 40 inches and all of the fish 50 inches and larger. Shoepack strain was discontinued as the source of further stocking efforts.

During the late 1970s and early 1980s attention was focused on native muskellunge waters in the Upper Mississippi River drainage basin. A muskellunge radio telemetry study resulted in successful spawn taking operations on Leech Lake beginning in 1981. Six specific muskellunge spawning locations were documented and preferred spawning habitat was described (Strand 1986). This study provided critical information on an additional egg source of value for both management and research programs. The DNR's current muskellunge production program started 26 years ago with the first successful egg takes on Leech Lake.

Seven lakes were chosen to start as brood stock lakes in 1982 in order to minimize the use of Leech Lake due to the huge workload required to capture a few adult muskellunge. The selected brood lakes included Little Wolf, Elk, and Plantagenet in the Bemidji area; Owasso, Pleasant, and Rebecca in the metro area; and Island Lake near Hinckley. Rebecca, Elk, Plantagenet, and Little Wolf have been the most frequently used brood lakes with Pleasant Lake currently under redevelopment. Owasso and Island lakes are no longer used as brood stock lakes.

The brood lakes have been managed differently from the native and introduced muskellunge lakes. The emphasis is to manage for efficient spawn-taking operations each spring. The density of stocking has been 1.5 fish per littoral acre versus the typical stocking of 1.0 fish per littoral acre used in new introductions. Brood lakes also receive fish raised from eggs taken at Leech Lake. Restocking of brood lakes will be completed every four years to coincide with alternate year stocking on all brood waters beginning in 2009. Brood lakes are geographically distributed to provide strategic back-up options in case of a failure from other stations.

Fry stocking has not been a successful management tool for introducing, maintaining, or restoring muskellunge populations. Hanson et al. (1986) also found muskellunge fry survival was generally low. The success of the fall fingerling-rearing program has been based on the rearing of sufficient 2 inch muskellunge (transplants) for stocking rearing ponds. Three methods are used for rearing transplants: nursery ponds, dry diet feeding in rearing troughs, and live diet feeding in rearing troughs. The live diet feeding program uses brine shrimp, local zooplankton, and white sucker fry. Once muskellunge reach transplant size, they are moved out to drainable ponds, and natural ponds. The drainable ponds are filled with water

in the spring and stocked with brood fathead minnows to provide food for the transplant muskellunge; these ponds are then drained in the fall to remove fish. The program is now based on producing and stocking 10 to 14 inch fall fingerlings that weigh about one-third of a pound

Where applicable, installation of manifold barriers and catch basins is being considered for drainable ponds to capture fish in traps rather then to harvest them by seining. In 2003, the DNR began evaluating private purchase of pure strain and tiger muskellunge. The private sector program is currently under evaluation.

The future of the muskellunge production will face new challenges including pathogens such as viral hemorrhagic septicemia (VHS) and aquatic invasive species. These will require the DNR to increase biosecurity measures to prevent the spread of pathogens or aquatic invasive species. Due to the imminent introduction of VHS into Lake Superior, fish production shifts have been implemented to move white sucker egg incubation to inland facilities. White sucker fry are used during live diet feeding stage of rearing operations.

The Muskellunge Stocking Committee recommends that annual fingerling production quotas should be developed as the program evolves with lakes being added or dropped, as well as adjustments to stocking frequency or density. The following stocking guidelines were developed to guide prioritization of production, generation of new stocking proposals, and modification of existing management plans.

Muskellunge Stocking Guidelines

These stocking guidelines will be applied to all DNR muskellunge stocking requests submitted for the production year. Annual stocking requests are submitted in December and approved by Regional Managers, and will be consistent with stocking plans, including rate and frequency, identified in an approved Fisheries Management Plan.

Stocking Priorities

Broodstock lakes (Priority 1): Seven brood stock lakes were established with Leech Lake (Mississippi) strain (MS) muskellunge in 1982. Four of the seven lakes continue to be maintained as brood stock lakes. Current priorities for these four are: Rebecca, Elk, Plantaganette, and Little Wolf lakes. Source of fish should be from same lake or other brood stock lakes. Every four years brood stock lakes should be stocked with fish from the parent lake (Leech Lake) to enhance genetic diversity of the population. Pleasant Lake has been added as a brood stock lake and will continue to be stocked with Mississippi strain from Leech Lake.

Research lakes or projects (Priority 2): Research or management (Study 4) projects that were approved will receive fish necessary to meet study objectives.

Restoration of native waters (Priority 3): No stocking should occur in native waters that exhibit adequate natural reproduction. Native muskellunge waters where populations exhibit no or poor natural reproduction, have been impacted by over-exploitation, or require rehabilitation due to other natural or man-made actions should be considered for stocking. Genetic concerns will dictate whether the source of fish should be from within the lake, brood stock lakes, or Leech Lake.

Maintenance of existing waters A level (Priority 4): Maintenance stocking occurs in lakes where there is little or no natural reproduction and a plan is in place to evaluate the muskellunge population. Source of fish should be from brood stock lakes or Leech Lake.

New introductions (Priority 5): Expansion into additional waters is determined through the Fisheries Management Planning (FMP) process. Resource needs and available waters with suitable conditions for supporting a muskellunge population should be determined and prioritized using the criteria for selecting lakes outlined in the Long Range Plan (LRP). Source of fish should be from brood stock lakes or Leech Lake.

Maintenance of existing waters B level (Priority 6): Existing muskellunge waters that have no evaluation plan in place or have failed to conduct planned assessments will be the lowest priority for stocking until an evaluation plan is developed; recommended netting every five or six years. Source of fish should be from brood stock lakes or Leech Lake.

Other prioritization considerations:

Cooperative ponds – Leech Lake Reservation, Muskies Inc., or other cooperative rearing agreements may have a specific destination identified within the agreement.
Stocking logistics – The Fisheries Program Coordinator may make logistical decisions based on projected harvest to maximize harvest and distribution efficiency. Interagency trades and/or purchase from private aquaculture will be Section of Fisheries Management decisions.
Private stocking – Private stocking should be limited to lakes that will have little or no impact to native populations.

Stocking Rate, Frequency, and Size

Rate: Various stocking rates have been attempted and examined over a number of introduced populations. Stocking rates have ranged from 0.3-3.7 fingerlings/littoral acre, with 75% between 0.5 to 2.0 fingerlings/littoral acre. The most common stocking rate of one fish per littoral acre has provided good recruitment in a wide variety of waters and is the recommended rate at this time. There is some indication (from population estimates) that waters stocked at higher densities may be experiencing compensatory mortality resulting in similar recruitment rates to lower density stockings. Additional population/mortality estimates on some of the higher density waters will be useful in further defining optimal rates. Deviations from the recommendation may occur with justification identified in the Fisheries Management Plan for that specific water. Examples: Very large basins may prohibit

stocking at one fish per littoral acre due to production demands. Lower rates may be considered where management goals call for lower density populations or the presence of natural reproduction has been documented. Higher rates are an option when establishing a new muskellunge lake, with planned reductions after a number of years or when certain population goals are met.

Frequency: Most plans have stocking rotations ranging from annual to one-of-three years, with the majority on alternate years. Alternate year stocking has provided steady recruitment on many maintained waters and is the recommended frequency at this time. In addition, the stocking gaps provide an opportunity to better assess natural reproduction. Deviations from the recommended frequency may also occur with justification identified in the FMP. Examples: In instances of new introductions, annual stocking frequency may help establish a fishery more quickly, if that is desirable, with a reduction to alternate year frequency once the population begins to mature. There may also be opportunity to consider more one-of-three rotations where populations have been established and there are indications of some limited contribution from natural reproduction.

Size: Muskellunge stocking plans are proposed almost exclusively using fall fingerlings. Minnesota's production program has been developed with an objective of producing fall fingerlings in the 10 to 14 inch size range. Large fall fingerlings, harvested in late September-October, have experienced excellent survival and successful recruitment to muskellunge populations. The primary grow-out ponds for fingerling production are drainable, allowing for complete annual harvests. To a lesser extent production occurs in natural ponds, where the occasional carry-over to yearling or larger size fish is the result. In some instances a larger size may be desirable, where northern pike abundance is high, or possibly to jumpstart a new fishery. These instances should be identified in FMPs as suitable locations for possible carry-over muskellunge. Proposals written exclusively for carry-over will be subject to uncertain availability.

Adjustments to proposed stocking rates: There are instances where carry-over (yearling and age two) muskellunge are available and need to be used in place of proposed fingerlings to make up for quota shortages. Since spring yearlings or older muskellunge have already survived some major recruitment bottlenecks, stocking rates should be adjusted down accordingly.

The following adjustments are recommended:
1) spring harvested yearling – 1 fish equals 2 proposed fingerlings;
2) fall harvested yearling – 1 fish equals 3 proposed fingerlings; and
3) age two and older – 1 fish equals 4 proposed fingerlings.

These adjustments to stocking rates are considered preliminary and may be modified after further study of juvenile mortality rates from PIT tagging evaluations.

TIGER MUSKELLUNGE MANAGEMENT IN MINNESOTA

Background

The original intent of the tiger muskellunge program was to provide local anglers, particularly young anglers, an opportunity to catch a large fish that was relatively easy to catch. Tiger muskellunge grow faster than northern pike or pure strain muskellunge and are more readily caught than muskellunge (Brege 1986; Storck and Newman 1992). Hybrid (tiger) muskellunge, a cross between female muskellunge and male northern pike, were initially stocked in Minnesota waters in 1983. Since then, tiger muskellunge have been stocked in 29 different lakes. Introduction of tiger muskellunge has been limited to lakes within the Twin Cities Metropolitan Area (Dakota, Ramsey, Washington, Carver, Hennepin, and Scott counties). As of 2006, management continues on 21 lakes.

As the program matured and anglers encountered tiger muskellunge more often, interest grew in the trophy potential of this hybrid. As a result, management focus has been modified to provide numbers of fish for anglers to catch along with an opportunity for a trophy fish.

Lakes stocked with tiger muskellunge are scattered across the central and southern portions of the Twin Cities Metropolitan Area, all within 35 miles of Minneapolis. The lakes range in size from 60 to 424 acres with one lake at 780 acres. Physical characteristics of the lakes include average secchi disk readings of 2.9-13 feet; littoral percentage of 21-100; and trophic status ranging from mesotrophic to hypereutrophic. According to the lake classification system (Schupp 1992), tiger muskellunge lakes are in classes 23, 24, 29, 30, 34, 38, and 40-43.

Since the inception of the program, the statewide muskellunge regulation has applied to the tiger muskellunge lakes. Currently, the regulation is a minimum size limit of 40 inches and a one fish bag limit.

Egg takes have been conducted within the East and West metro areas, with eggs incubated in the St. Paul State Fish Hatchery. For most of the life of the program, tiger muskellunge fry were transferred to the Waterville State Fish Hatchery and placed in drainable ponds until fall, then stocked into the appropriate lakes. Since 2001, tiger muskellunge fry have been sold to private fish hatcheries, and fall fingerlings have been purchased from the same hatcheries.

Costs to produce tiger muskellunge in the St. Paul State Fish Hatchery have averaged $13.34 per 1,000 fry since 2001. The vast majority of fry produced have been sold to private hatcheries, recovering the total production costs. Also since 2001, all fingerlings stocked have been purchased in the fall from some of the same private hatcheries at a cost of $10-$11/fish.

Stocking rates have ranged from 1 to 5.9 fish per littoral acre. Throughout the life of the program, management plans on most lakes called for stocking once every three years. The

frequency of stocking was based on the management goal of providing an occasional "large" fish to local anglers, "large" not necessarily meaning a fish long enough to legally harvest. With increased interest in catching legal and trophy fish in recent years, stocking rates and frequencies have been modified on some lakes in attempts to improve the numbers and average size of tiger muskellunge.

Modifications to stocking rates and frequencies on a few lakes culminated in an internal review of the entire program in 2006. DNR staff in the East and West metro areas met to review the program and make recommendations on the future management of the hybrid. Data from creel surveys, lake surveys, conservation officer reports, and angler reports were examined with the goal of determining where stocking was working and where it wasn't. Of the 21 lakes in the program, staff recommended dropping tiger muskellunge management on 7 lakes. For half of the remaining 14 lakes, staff recommended a stocking frequency of once every three years, while the final 7 lakes would be stocked once every two years. If these changes were implemented, the average number stocked per year would go from 2,257 (2002-2006) to 2,343 fingerlings.

Future Management

As part of the review of the tiger muskellunge program, it is recommended that public opinions be solicited regarding any changes, particularly eliminating stocking of fish in lakes. Methods to obtain anglers' input should include posting lake accesses, news releases in local newspapers, accepting comments on Area websites, contacting interested angler groups such as Muskies Inc. directly, and holding public input meetings.

Regardless of whether or not these modifications are enacted, future management should focus on more in-depth assessments of the tiger muskellunge populations in managed lakes and measuring angling pressure for the hybrid. Existing fish data come from standard lake survey trap and gill nets and an occasional fish captured with electrofishing gear during assessments of largemouth bass populations. Additional sampling effort should be directed towards tiger muskellunge and attempts should be made to obtain statistically valid estimates of the tiger muskellunge population in a portion of the managed lakes. Suggested sampling techniques include electrofishing and organized angling events targeted at tiger muskellunge. For most lakes, existing creel data are from the 1990s and do not reflect the increased interest and angling pressure on muskellunge waters in recent years. Another round of creel surveys should be conducted on tiger muskellunge managed lakes, and consideration should be given to collecting additional information from anglers through the use of angler diaries.

NORTHERN PIKE MANAGEMENT IN MINNESOTA

Background

Northern pike is the most widespread game fish in Minnesota and provides for a tremendous amount of fishing opportunities in the state's lakes and streams. Northern pike populations are not easy resources to actively manage, as evidenced by many lakes in which small pike are common. Because there are complex interactions between their susceptibility to angling and their ability to reproduce readily, and because of their ecological role as a top level predator, northern pike present the Section of Fisheries Management with challenging problems and opportunities. Northern pike management today is influenced by lessons learned from past management, and also reflects our recognition of the tremendous variety of water bodies inhabited by northern pike. Minnesota lakes and streams exhibit diversity in chemical productivity and physical characteristics, differences that need to be considered in order to successfully manage northern pike.

Northern pike are valued principally as sport fish in Minnesota. One of the reasons for their popularity is that pike are very vulnerable to angling and are readily caught with spoons, spinners, and bait. Mortality of pike that are caught and released is relatively low, especially if the fish are not deeply hooked. A review of literature on hooking mortality (Tomcko 1997) found an average of 4.5% hooking mortality among six studies (mortality from j-shaped pike hooks, which are more lethal, was excluded). Winter darkhouse spearing through the ice is a traditional form of pike harvest during Minnesota winters and the legacy of spearing in Minnesota is long and laced with controversy. Conflicts between spearers and anglers have led to questions about relative harvests by each group, and their effects on pike populations. The reality, however, is that most spearers are also anglers. Creel surveys have shown that spearers harvest northern pike at a rate similar to that of summer and winter anglers who are specifically fishing for pike, but because there are fewer spearers, spearing harvests have clearly accounted for fewer fish than angling. Fish length and age data from creel surveys show that spearing harvests contain greater proportions of larger sized and older fish than angling harvests (Pierce and Cook 2000).

Where good natural habitat for northern pike exists, natural reproduction is usually not a limiting factor. In fact, a common phenomenon in many small central and northern Minnesota lakes is large numbers of small, slow growing northern pike. From a fisheries management viewpoint, these populations are difficult to alter because they arise from some combination of over-harvest of large fish, a lack of appropriate sized prey fishes, and habitat characteristics that fail to promote good growth. Maintaining an appropriate balance of large northern pike, in the face of heavy fishing pressure on large fish, may be a key problem for managing pike populations.

One of the earliest northern pike management tools used in Minnesota was the operation of northern pike spawning and rearing areas (Figure 10). Natural wetland areas adjacent to lakes were used as breeding and nursery areas for pike. By controlling outlets to wetland areas, factors such as water levels, movement of spawning fish, and fry stocking could be manipulated to produce pike fingerlings. Several intensive studies of hatching success and survival of northern pike fry in managed spawning areas were carried out during 1955-1967 (Franklin and Smith 1963; Woods 1963; Bryan 1967; Adelman 1969). Lessening use of managed spawning areas after the 1970s reflected the growing awareness that pike reproduction was not a limiting factor for most lakes, especially those in central and northern portions of the state. During 2000-2005, the average annual production from managed spawning and rearing areas was only about 35,000 fish produced in the Waterville, Spicer, and Windom management areas.

Figure 10 Northern pike rearing area, Cedar Pond, in the Waterville management area.

Another early management technique, pioneered in the late 1950s, was winter rescue of northern pike. Fall and winter trapping of northern pike from shallow lakes and sloughs in danger of winterkill became an extensive management practice with pike trapped and stocked in large numbers during the 1960s and 1970s. The unique trapping techniques were described by Hanson (1958) and Johnson and Moyle (1969), and stocking evaluations for these fish were conducted by Wesloh and Olson (1962) and Maloney and Schupp (1977). Stocking of winter rescue pike has been significantly curtailed because many fish populations already have

abundant numbers of small pike and research studies illustrated how pike stocking initiated some dramatic and long term changes in the fish community (Anderson and Schupp 1986; Colby et al. 1987). For example, pike predation on 5-6 inch yellow perch in Horseshoe Lake, Crow Wing County, nearly eliminated recruitment of perch to adult sizes, causing collapse of the perch population and affecting growth rates of other species such as walleye. The reductions in perch seemed to allow numbers of small bluegill to expand into ecological niches previously occupied by perch. Winter rescued northern pike used during the last decade have come from a single lake in the Aitkin management area.

Natural reproduction of northern pike is not a limiting factor in many lakes, but there are a few where it is. Where habitat has been destroyed, for example in areas of southern Minnesota, stocking has been used as a last resort for maintaining northern pike populations. Hatchery production of northern pike has been very limited compared to other states and compared to our own production of species such as walleye. Modern pike culture at the Waterville hatchery (Figure 11) began in 1991, and over the period of 1991-2006, egg take at the Waterville hatchery averaged 2.5 million eggs each year with an average annual production of 1.1 million fry for stocking. Northern pike are stocked at a rate of 250 fry/acre.

Figure 11 Aspirating milt from a male northern pike at the Waterville hatchery.

Habitat protection for northern pike occurs in all of the fish management areas and consists of reviewing permit applications for private and public projects impacting fish habitat. In the review process, emphasis is placed on protecting spawning habitat, underwater substrates, and shoreland and aquatic vegetation. Routine lake surveys include vegetation identification and mapping. Enforcement of violations for destroying aquatic vegetation has been improved so that, today, restoration orders can require violators to replace what they illegally destroyed in lieu of or in addition to paying fines. In spite of these efforts, loss of critical habitat remains an important issue for maintaining northern pike populations. Draining and filling of wetlands and so-called “improvement” of shorelines for lake homes have been increasingly responsible for lost habitat in urban, agricultural, and other developed and developing areas of Minnesota. Shoreline and related land development removes vegetation, reduces water quality, and reduces dissolved oxygen levels in the sediments (Burns 1991; Cross and McInerny 1995; Radomski and Goeman 2001). Shoreland zoning regulations that have been in effect in most counties since 1973 have failed in stemming the loss of habitat, but new initiatives are underway with county governments to update shoreland zoning ordinances.

Recreational Fishing and Special Regulations

Recreational fishing in Minnesota has had historical influences on northern pike populations. Recreational fishing is highly selective for large pike with creel surveys illustrating how fish over 24 inches are seldom released and compose a large proportion of the harvest (Figure 12) (Cook and Younk 1998).

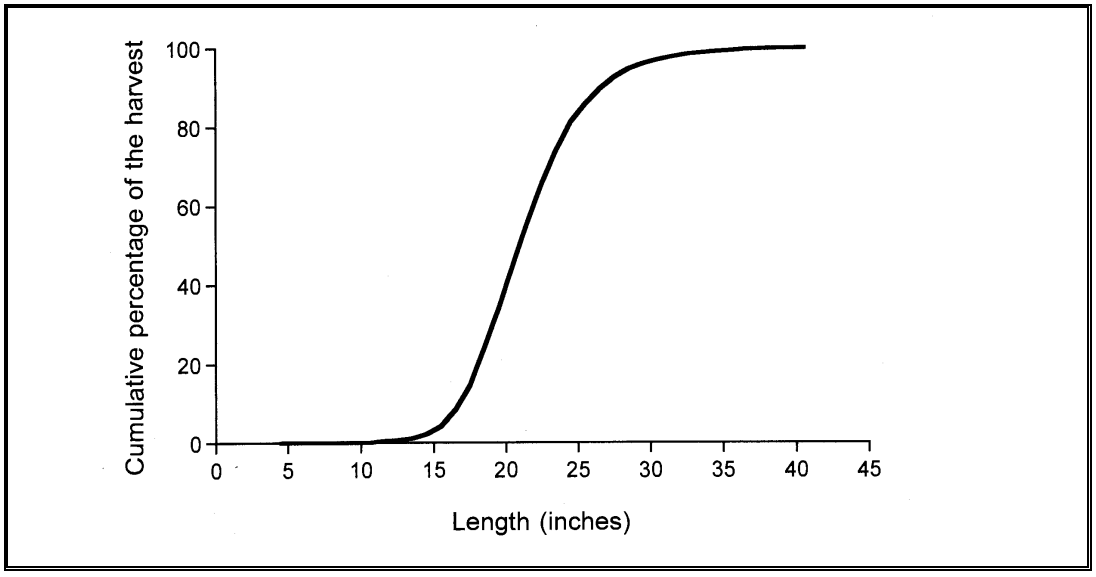

Figure 12 Length composition of the recreational harvest of northern pike in Minnesota.

A result of this size selectivity is that sizes of fish have suffered from historical increases in fishing effort, and fewer trophy size pike are caught today. A unique analysis of long term records from a fishing contest in the Park Rapids region of northwestern Minnesota offered insights into historical changes in the sizes of northern pike in response to increasing levels of exploitation by recreational fishing (Figure 13) (Olson and Cunningham 1989). Contest records show how numbers of trophy size pike entered in the contest peaked in 1948 and steadily declined after the peak.

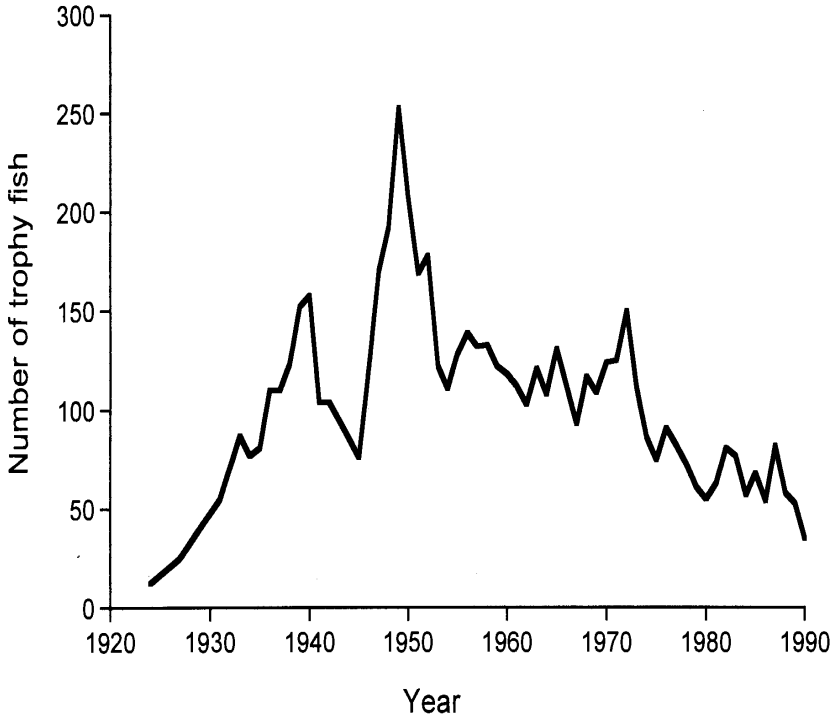

Figure 13 Numbers of large northern pike entered in Fuller's tackle contest (Olson and Cunningham 1989).

Average weights of northern pike entered in the contest declined annually from 10.1 pounds in the 1930s to 6.8 pounds in the 1980s, but were influenced somewhat by resort promotions during the 1950s and 1960s. The Olson and Cunningham (1989) study also illustrated how northern pike can be more susceptible to exploitation than some other species. For example, numbers of large walleyes and largemouth bass peaked in 1972 and 1977, respectively.

An intensive study 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 et al. 1995). Creel surveys also show that people harvest pike as small as 9 inches, although 14 inches is typically considered the minimum size that people will harvest. A standardized length characterization system used by fisheries managers in many states and provinces assesses fish stocks based on percentages of world record lengths (Anderson and Gutreuter 1983). The characterization system considers pike over 14 inches to be "stock" size fish available for harvest, fish over 21 inches are classed as "quality" size pike, fish over 28 inches are considered "preferred" size, fish over 34 inches are classed as "memorable", and fish over 44 inches are classed as "trophy" northern pike.

During the 1980s and 1990s, an increasing number of anglers were growing concerned about long term declines in fish sizes and individual waters management. The DNR began implementing special and experimental regulations designed to improve sizes of northern pike in at least some Minnesota waters. Experimental regulations were initiated beginning in the middle to late 1980s that were designed to test the effects of expanded bag limits and

length regulations. Expanded bag limits were not found to be effective for relieving high density, slow growing populations of small sized pike. Experimental regulations also included minimum, maximum, and slot length limits, some of which have now been evaluated. The lakes where length limits have been fully evaluated have not all produced significant results, but enough cases of improved sizes of pike were found to warrant expanded use of length limits. For example, a large-scale analysis of maximum length limits (11 lakes with 20, 22, or 24-inch maximum length regulations compared to 17 reference lakes) showed significant increases in proportions of large northern pike. The average increase in percentage of fish longer than 24 inches was 18% and the average increase in percentage of fish longer than 30 inches was 5%. Three of five lakes with slot length limits showed large improvements in sizes of fish within their northern pike populations (Figure 14). The other two lakes did not improve compared to reference lakes, but it should be noted that the slot length limits only protected intermediate size fish between 20 and 30 inches long. Three lakes with 30-inch minimum length limits all had increased proportions of northern pike longer than 20 inches, but those improvements did not carry over into fish over 30 inches that could be legally caught (Figure 15).

In 2000 and 2001 Fisheries initiated bag limit committees to review bag limits and make recommendations for statewide consideration. The angling public indicated a preference for lake-by-lake regulations rather than a statewide approach. Some of the special and experimental regulations implemented in the 1990's have seen strong positive results. Anglers are noticing the difference, which is increasing the interest in more special regulations. Areas Fisheries managers continue to get requests from lake associations and other interests to implement special regulations for northern pike. During the comment period on the initial draft of the long range plan, a majority of comments supported more special regulations and specifically the objective to manage up to 125 waters for large northern pike. There appears to be a growing interest in a statewide approach to improve northern pike populations. Kurrie and Fulton (2001) survey found that over 60% of anglers supported a statewide slot limit for northern pike. Objective 5 (p. 24) of the plan is intended to address the statewide concern for northern pike. The strategies and actions will require additional analysis and input before moving forward with specific proposals.

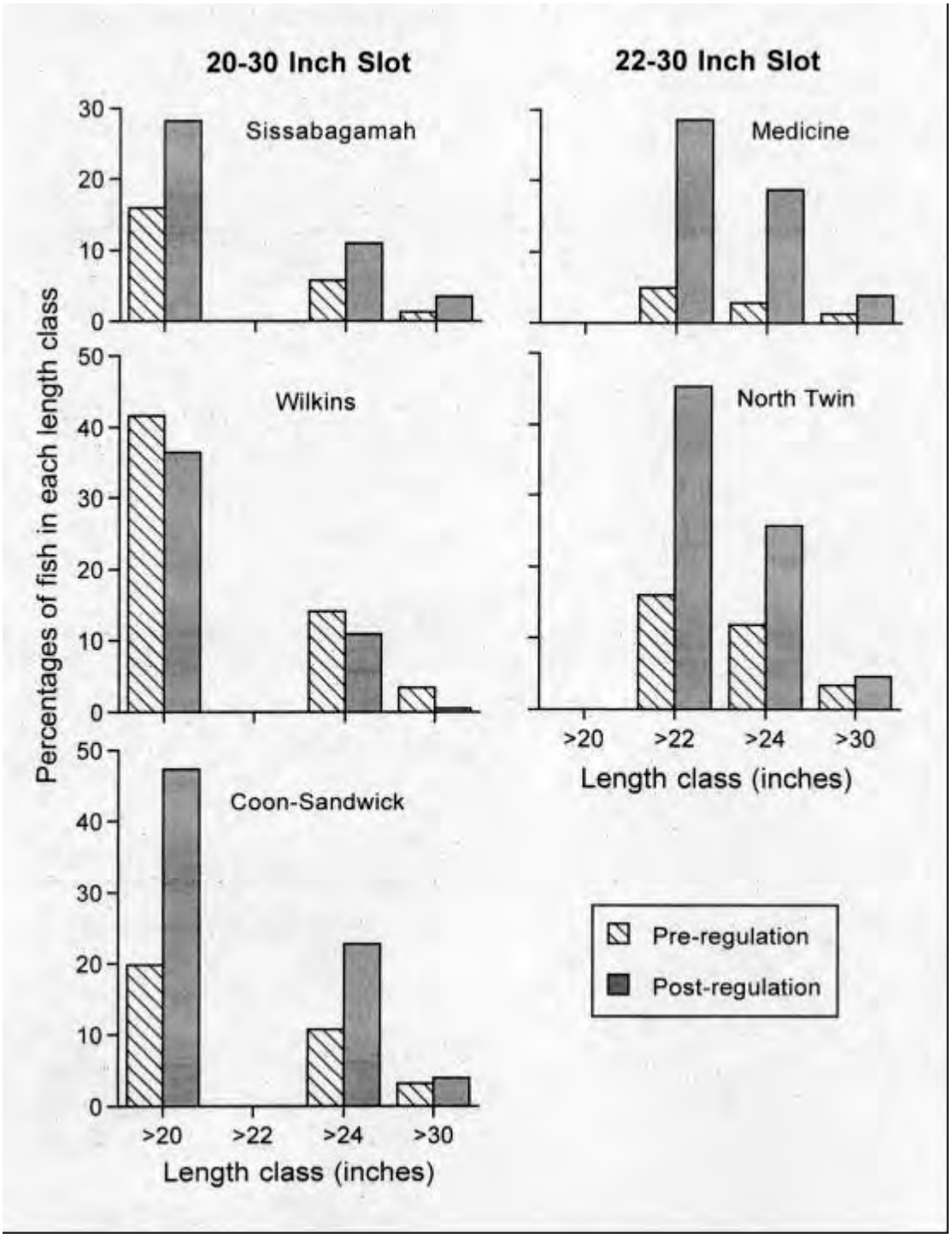

Figure 14 Changes in sizes of northern pike resulting from 20-30 and 22-30 inch slot length limits in five north-central Minnesota lakes. The regulations were implemented in 1989-1991.

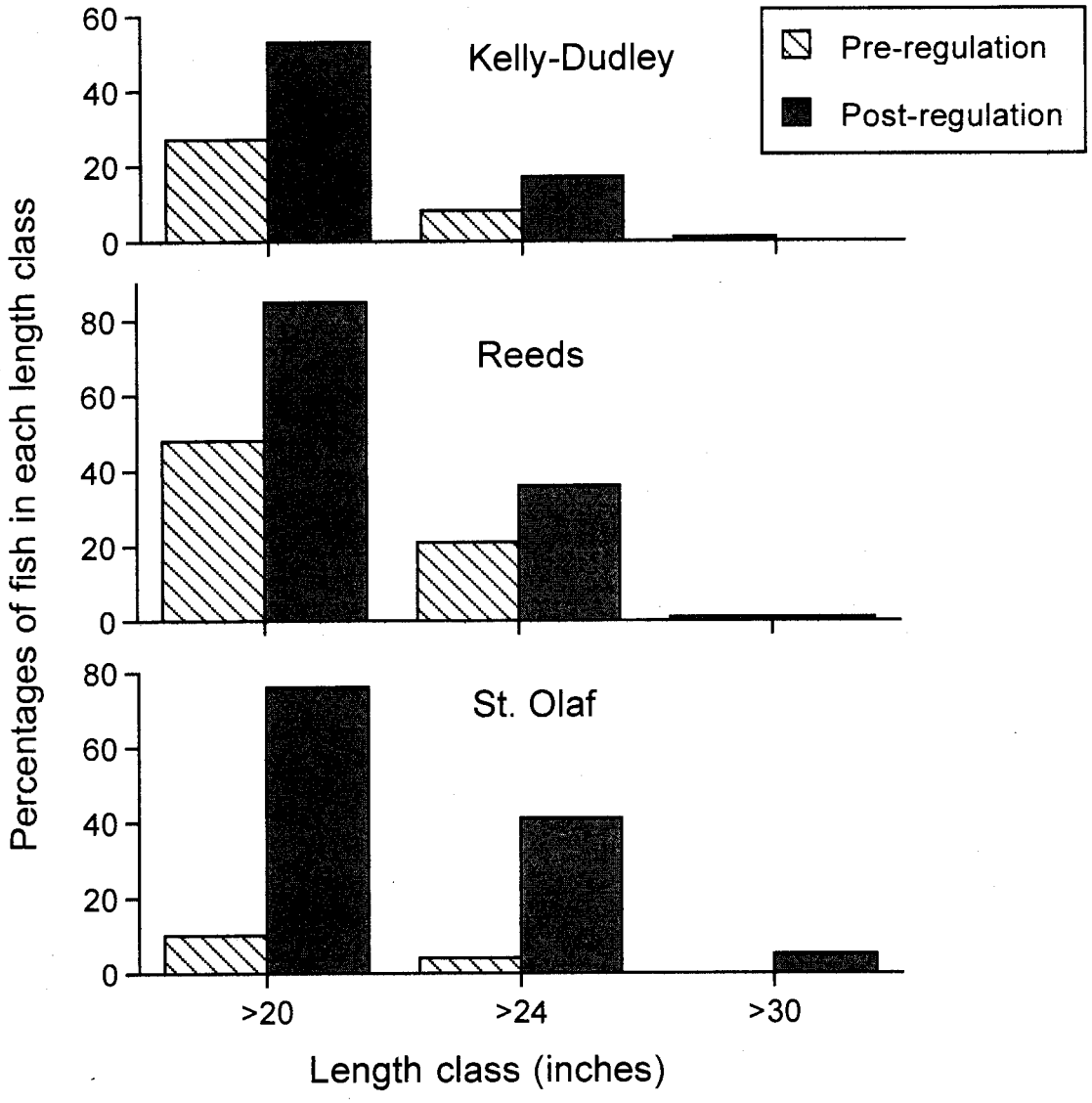

Figure 15 Changes in sizes of northern pike resulting from 30 inch minimum length limits in three southern Minnesota lakes. These regulations were implemented in 1998.

Experimental regulations were used sparingly for northern pike until 2003. In 2003, the number of lakes with special length limit regulations was increased to over 100 during an initiative to improve opportunities for quality pike fishing using a "toolbox" of three regulations. Reproductive success and over-harvest of large fish are the main drivers of pike population dynamics. Therefore, the following toolbox regulations were based on the magnitude of reproductive success in a lake, as well as the lake's potential for providing large fish:

40 inch Minimum Length Limit This regulation was designed for lakes having good quality northern pike populations that would benefit from additional protection. These lakes generally have low density pike populations and fast growth rates. As a result, these lakes have the potential to produce very large pike. However, anglers remove many of the fish once they reach quality sizes. This regulation was intended to protect pike until they approach trophy sizes. Several characteristics of a lake's basin can influence reproductive success and pike growth rates. Low reproductive success, good growth rates, and big fish are often associated with large and deep lakes that have limited spawning and nursery areas. Coolwater refugia in large, deep lakes also seem to support big pike.

30 inch Minimum Length Limit Another regulation intended for lakes with low density pike populations, this regulation has been used primarily in southern Minnesota lakes with more limited spawning and nursery habitat. Because of lower pike density, growth of pike in these lakes is faster due to reduced competition for prey. Angling mortality can quickly reduce the number of medium to large sized fish in these populations. The 30 inch minimum length limit protects small and medium sized pike to increase numbers of preferred sized fish (longer than 28 inches), and allows harvest of fish once they reach 30 inches long.

24-36 inch Protected Slot Limit The slot limit was intended for lakes with moderate to high rates of reproductive success where the goal was to provide opportunities to harvest small pike, while at the same time improving densities of medium to large sized fish. These lakes may have large areas of shallow water with wild rice beds, grasses, or sedges that provide good habitat for spawning and nursery areas and therefore produce adequate numbers of small pike. Growth rates in these lakes are slower than in lakes with low pike densities. This slot limit protects fish to larger sizes than some of the earlier experimental slot length limits.

The basis for length regulations protecting large northern pike has been research illustrating how large pike are very susceptible to over-harvest. Densities of large northern pike are comparatively 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 of the fish declines rapidly as they get to larger sizes and older ages, yet recreational fishing by all methods tends to select for large, older pike that are the least productive part of the population. Production of fish age 6 and older was estimated to average only 0.1 pounds per acre per year in several north-central Minnesota lakes (Pierce and Tomcko 2003). This is a very low number and shows how large fish can be easily over-exploited. For perspective, it means that removal of only one 10 pound pike uses up the entire production of large pike in a 100 acre lake for a full year. In this example, removal of more than one memorable or trophy size fish would deplete several years' worth of production.

Criteria for Lake Selection and Evaluating Special Regulations

The following criteria were used for selecting lakes during the toolbox initiative in 2003, and are again recommended for any additional lakes where new length regulations are considered for northern pike.

A) Assessment of recruitment;
B) Assessment of growth;
C) Connectivity to other waters; and
D) Social considerations (described in muskellunge management on pages 42-45).

Selection of regulations for northern pike relies primarily on correct assessment of recruitment (reproductive success). Because we do not have direct measures of recruitment, the extent of recruitment must be judged by combinations of gill net catch rates, assessments of available spawning habitat, evaluations of stocking practices, and (if available) population density estimates. Where we have density estimates, densities of 6 fish (14 inches and larger) or less per acre are indicative of low recruitment. Gill net catch rates associated with low recruitment are often less than 5 fish/net. Examples of lakes with moderate recruitment had gill net catch rates of 6-10 fish/net and high recruitment would likely be more than 10 fish/net. Evaluations of stocking and available spawning habitat will be judgments by field staff. Low recruitment typically results in good growth rates. Average back calculated lengths at age for low density/low recruitment populations have been at least the following:

	Average length (inches)	
Age	Males	Females
2	16.1	16.8
3	19.6	21.1
4	21.6	23.5

Growth information by sex should be provided and evaluations of regulations should include growth data collected by sex. Providing age distribution of gill net catches may also make it possible to calculate mortality rates for the population. Low recruitment/low density populations typically have average lengths in gill net catches of 21 inches or greater and good populations may be over 24 inches. Proportional stock densities (PSD = ratio of numbers of quality size to stock size fish; see Anderson and Gutreuter 1983) of greater than 40% are also indicative of low density populations. Moderate recruitment lakes had average lengths of 18-22 inches (usually less than 21 inches) and PSDs of 18-60% (usually less than 40%) in gill net catches.

Lake basins that are broadly connected with other basins make enforcement and evaluation of regulations more difficult. A further consideration is that high rates of development along a lakeshore make it difficult to communicate collectively with lakeshore owners compared to lakes with predominantly state or federal ownership.

Evaluation periods for new regulations should be a minimum of 10 years, and preferably 15 years since individual fish can live for 14 years or more. Evaluations will consist of some combination of spring trap netting, spring short term gill netting, and routine summer

population assessment netting every five years. Uniformly made multimesh experimental gill nets for summer assessment netting have been used as the standard technique for monitoring fish populations in Minnesota since 1941 (Moyle et al. 1950). Trap netting in early spring during ice-out and spawning is an effective method for sampling large numbers of pike. Trap nets are set along shorelines and take advantage of the tendency of pike to move into the warmest water they can find as the ice is receding. Spring short term gill netting consists of setting nets for 3-4 hours during the morning or mid day while water temperatures are still cool (less than 60^{o} F). Summer assessment netting is most useful for tracking historical changes in relative abundance and lengths of fish in the pike population. Similar long term information does not exist for spring trapping and short term gill netting. All three methods are useful for examining the size structure of pike populations; however, maximum length of pike observed is usually larger from spring trap netting. Catch rates from summer assessment netting correlate very well with population density estimates whereas spring trapping and short term gill netting do not. Criteria for evaluating regulations consist of changes in relative abundance (catch rates) of northern pike and other fish species, and changes in average length and proportions of various sizes of pike (e.g. PSD). Observed changes are compared to similar parameters in reference lakes without length regulations.

Public Input and New Proposals

Special regulations are implemented following the process for exempt permanent rules (Minn. Stat. Sec. 97C.005). Public input for making decisions is essential to gain understanding and support for a successful management program. Involving the public provides a means for incorporating the public's values, interests, needs, and desires into decisions that affect their lives, and encourages the public to provide meaningful input into the decision process (IAPP 2006). It is the agency's responsibility to provide the necessary information so that the public can participate in a meaningful way. The following steps and timeline describe the decision making and public input process for new special regulation waters.

1) Area Fisheries Manager contacts stakeholders to initiate discussions and get initial input on proposed changes. In some cases interested stakeholders initiate the request by contacting the area fisheries office.
2) Area Fisheries Manager submits a written proposal (described in Appendix F) for Regional and Statewide Review in January.
3) Proposals are reviewed and approved by the Division of Fish and Wildlife for broad public input by March.
4) Notice of proposed management change published in local and statewide newspapers between 60 and 90 days before a public meeting (during the open water angling season). Signs posted at public accesses for a minimum of 90 days. Date(s) of public meetings will be posted on the DNR website. Interested stakeholders should contact the area fisheries office for information on the proposed change.
5) Notice of proposed management change published in local and statewide newspapers within 30 and 7 days of public meeting.

6) A public meeting is held in county where largest portion of water is located and in St. Paul Central Office if the proposed water is 1,500 acres or larger.
7) Summary of public input and Area Managers recommendation submitted with final proposal by October/November.
8) Section of Fisheries Management submits recommendation to Division Management Team and Commissioners office for approval in November.
9) Decision to proceed incorporated into fisheries synopsis by December.

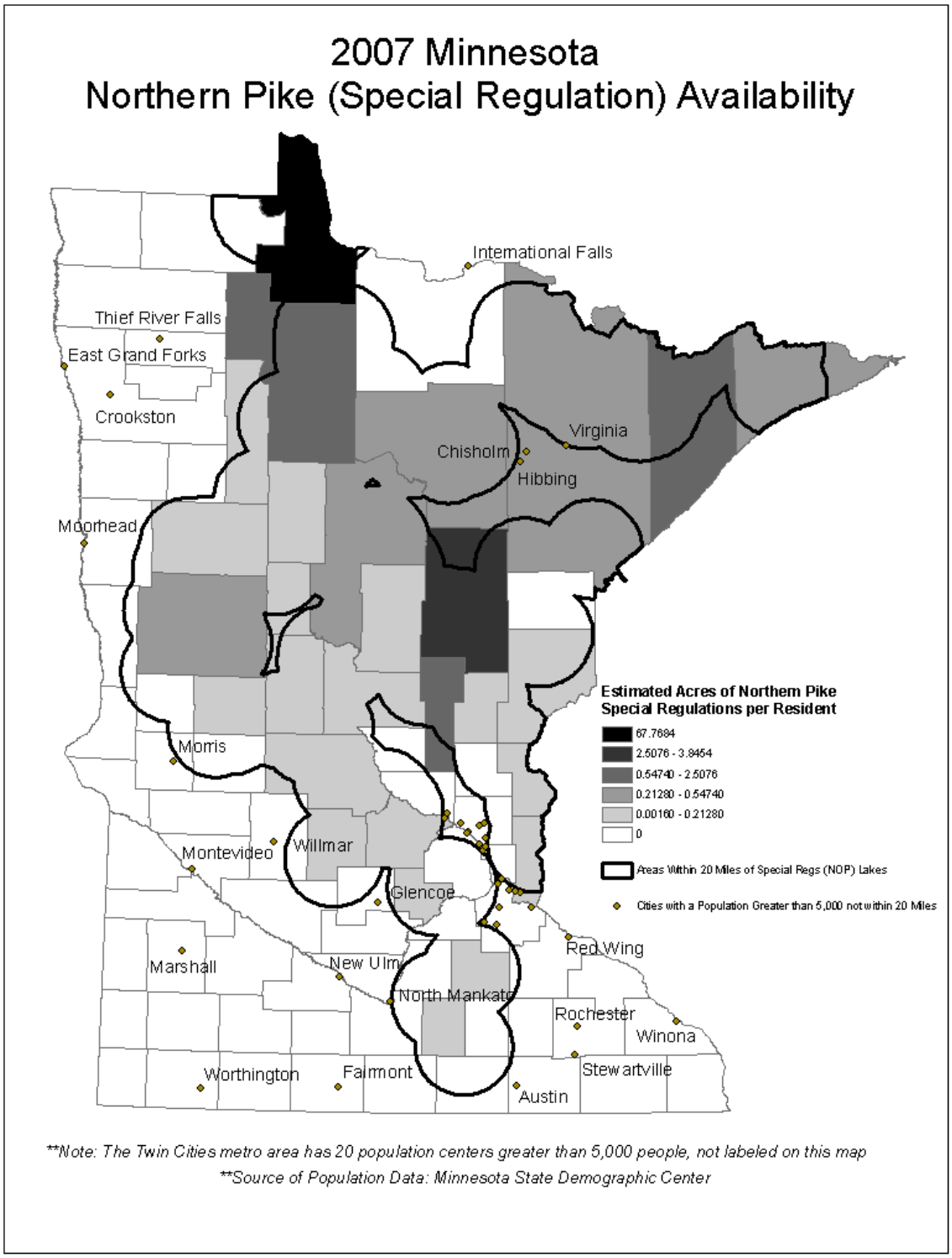

Figure 16 Geographic distribution of lakes with special regulations for northern pike relative to population data for 2005 for each county in Minnesota. Population data were divided by the acres of special regulation waters in that county. These ratios should not be viewed as targets.

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Appendix A Waters Managed for Muskellunge

Current listing of: (A) Inland waters and rivers recognized as native (N), native and stocked (NS), introduced (I), Shoepack strain (SP), or hybrid stocked (H) and managed as muskellunge waters in Minnesota, 2008; (B) Border muskellunge waters, 2008.

(A) Inland muskellunge waters

Water body	County	Acres	Status	Water body	County	Acres	Status	Water body	County	Acres	Status
Bryant	Hennepin	178	H	Alexander	Morrison	2,709	I	Andrusia	Beltrami	1,590	N
Bush	Hennepin	186	H	Bald Eagle	Ramsey	1,047	I	Baby	Cass	737	N
Calhoun	Hennepin	419	H	Battle, West	Otter tail	5,565	I	Bad Axe	Hubbard	303	N
Cedar	Hennepin	164	H	Beers	Otter tail	267	I	Belle Taine	Hubbard	1,442	N
Cedar	Scott	793	H	Cedar	Aitkin	1,745	I	Bottle, Lower	Hubbard	641	N
Clear	Washington	429	H	Cross	Pine	925	I	Bottle, Upper	Hubbard	459	N
Crystal	Dakota	289	H	Detroit	Becker	3,067	I	Boy,	Cass	3,452	N
Crystal	Hennepin	79	H	Dumbbell	Lake	406	I	Boy, Little	Cass	1,452	N
Eagle	Carver	183	H	Eagle	Hennepin	287	I	Cass	Cass	15,958	N
Elmo	Washington	281	H	Elk	Clearwater	305	I	Child	Cass	285	N
Gervis	Ramsey	235	H	Forest	Washington	2,271	I	Deer	Itasca	4,094	N
Island	Ramsey	59	H	Fox	Martin	949	I	Emma	Hubbard	78	N
Isles	Hennepin	108	H	French	Rice	876	I	Girl	Cass	428	N
Johanna	Ramsey	212	H	Harriet	Hennepin	341	I	Ida	Hubbard	74	N
Nokomis	Hennepin	201	H	Harris	Lake	122	I	Inguadona	Cass	1,125	N
Orchard	Dakota	235	H	Independence	Hennepin	832	I	Kichi	Beltrami	1,858	N
Phalen	Ramsey	198	H	Island	Pine	536	I	Kid	Cass	168	N
Pierson	Carver	297	H	Island Res.	St. Louis	8,000	I	Leech	Cass	102,948	N
Silver	Ramsey	75	H	Lobster	Douglas	1,329	I	Long	Cass	284	N
Wasserman	Carver	165	H	Many Point	Becker	1,701	I	Mann	Cass	491	N
Weaver	Hennepin	152	H	Mille Lacs	Aitkin	128,224	I	May	Cass	143	N
	Total	**4938**		Miltona	Douglas	5,724	I	Mckeown	Cass	168	N

Boulder	Cook	129	SP[2]
Crescent	Cook	755	SP[2]
Lichen	Cook	253	SP[2]
	Total	**1137**	

Rivers

Big Fork R.	Itasca	na	N
Kettle R.	Pine	na	N
Little Fork R.	Koochiching	na	N
Prairie R.	Itasca	na	N
Snake R.	Pine	na	N
Mississippi R.	(various)	na	NS
St. Louis R. /Estuary	St. Louis	7,230	NS

Minnetonka	Hennepin	14,101	I
North Star	Itasca	832	I
Orange	Itasca	104	I
Oscar	Douglas	704	I
Owasso	Ramsey	375	I
Pelican	Ottertail	3,963	I
Plantaganette	Hubbard	2,531	I
Pleasant[1]	Ramsey	607	I
Rebecca	Hennepin	261	I
Rush East and West	Chisago	3,059	I
Shamineau	Morrison	1,428	I
Spider	Itasca	1,392	I
Sugar	Wright	1,020	I
Vermilion	St. Louis	39,272	I
Waconia	Carver	3,080	I
White Bear	Washington	2,428	I
Wolf, Little	Cass	528	I
Zumbro Res.	Olmsted	715	I
	Total	**243,628**	

Moose	Itasca	1,274	N
Moose, Little	Itasca	285	N
Mule	Cass	525	N
Pike Bay	Cass	4,751	N
Sand, Big	Hubbard	1,635	N
Sand, Little	Hubbard	410	N
Shoepack	Lake	299	N
Shoepack, Little	Lake	51	N
Spider	Hubbard	570	N
Steamboat	Cass	1,756	N
Stocking	Hubbard	100	N
Swift	Cass	357	N
Wabedo	Cass	1,226	N
Winnibigoshish, Big	Cass	56,470	N
Winnibigoshish, Little	Itasca	932	N
Wolf, Big	Cass	1,073	N
Woman	Cass	5,520	N
Bemidji	Beltrami	6,580	NS
Big	Beltrami	3,592	NS
Blandin Res.	Itasca	490	NS
Mantrap, Big	Hubbard	1,618	NS
	Total	**227,692**	

(B) Border muskellunge waters

Lake of the Woods	MN/ONT	305,535	N	St. Croix River	MN/WI	na	N

[1] No fishing allowed, water supply lake

[2] Introduced shoepack populations no longer managed for muskellunge. These populations were never enhanced by stocking Leech Lake strain muskellunge.

Appendix B Listing of Connected Waters for Muskellunge

Listing of connected waters associated with managed muskellunge waters because of regulation changes. These waters are included as part of the 48 inch minimum size limit regulation to facilitate enforcement of regulations. Connected waters may have muskellunge present, however they are not managed specifically for muskellunge.

Water body	Connected water body	Water body	Connected water body
Bemidji	Stump	North Star	Little North Star
	Irving		
	Carr	Vermilion	Crane
	Marquette		
		Woman	Little Woman
Boy	Swift		
		Winnibigoshish	Little Cutfoot Sioux
Cass	Big Rice		Cutfoot Sioux
	Little Rice		Egg Lake
	Pug Hole		Ravens Lake
	Buck		Sugar Lake
Leech	Benedict		Dixon Lake
			Rabbits Lake
Inguadona	Rice		Pigeon River
	Louise		
Mississippi River	Pokegama		
	Blackwater		
	Big Jay Gould		
	Little Jay Gould		

Appendix C Waters with Spearing Bans

Water Body	County
Baby	Cass
Bald Eagle	Anoka, Ramsey, Washington
Beers	Otter Tail
Big	Beltrami
Big Mantrap	Hubbard
Cass	Beltrami and Cass
Cross	Pine
Deer	Itasca
Eagle	Hennepin
Forest	Hennepin
Libbs	Hennepin
Lobster	Douglas
Mille Lacs	Aitkin, Crow Wing, Mille Lacs
Minnetonka	Hennepin and Carver
Moose	Itasca
North Star	Itasca
Owasso	Ramsey
Peavey	Hennepin
Rebecca*	Hennepin
Rush	Chisago
Spider	Itasca
Stieger	Carver
Sugar	Wright
Tanager	Hennepin
Wabedo	Cass
West Battle	Otter Tail

* Brood Stock Water

Appendix D Waters Managed for Northern Pike with Special and Experimental Regulations

Water Body	County	Acres	Regulation	Type	Date Implemented
Long	Aitkin	433	24-36" slot, 1 over 36	Special	2003
Sissabagamah	Aitkin	400	20-30" slot, 1 over 30	Special	1991
Mille Lacs	Aitkin, Crow Wing, Mille Lacs	128,226	24-36" slot, 1 over 36	1837 Treaty	2003
Cotton	Becker	1,783	24-36" slot, 1 over 36	Special	2003
Eunice	Becker	370	24-36" slot, 1 over 36	Special	2008
Floyd, Big	Becker	1,178	24-36" slot, 1 over 36	Special	2003
Floyd, Little	Becker	214	24-36" slot, 1 over 36	Special	2003
Little Toad	Becker	405	24-36" slot, 1 over 36	Special	2008
Maud	Becker	511	24-36" slot, 1 over 36	Special	2008
Melissa	Becker	1,850	24" maximum	Experimental	1996
Sallie	Becker	1,273	24" maximum	Experimental	1996
Beltrami	Beltrami	722	24-36" slot, 1 over 36	Special	2003
Big Lake	Beltrami	3,592	24-36" slot, 1 over 36	Special	2003
Campbell	Beltrami	462	24-36" slot, 1 over 36	Special	2003
Deer	Beltrami	298	24-36" slot, 1 over 36	Special	2003
Fox	Beltrami	165	24-36" slot, 1 over 36	Special	2003
Medicine	Beltrami	461	24-36" slot, 1 over 36	Special	1997, 2007
Movil	Beltrami	853	24-36" slot, 1 over 36	Special	2003
North Twin	Beltrami	326	24-36" slot, 1 over 36	Special	1997, 2007
Red, Upper	Beltrami	47,850	26-40” slot, 1 over 40	Special	1999
Three Island	Beltrami	722	24-36" slot, 1 over 36	Special	2003
Turtle River Lake	Beltrami	1,740	24-36" slot, 1 over 36	Special	2003
Turtle, Big	Beltrami	1,591	24-36" slot, 1 over 36	Special	2003
Turtle, Little	Beltrami	465	24-36" slot, 1 over 36	Special	2003
Ann	Carver	110	24-36" slot, 1 over 36	Special	2003
Steiger	Carver	166	catch and release, spearing ban	Special	
Ada	Cass	963	24-36" slot, 1 over 36	Special	1989
Child	Cass	285	24-36" slot, 1 over 36	Special	2003
Girl	Cass	428	24-36" slot, 1 over 36	Special	2003
Horsehoe	Cass	260	30" minimum, bag limit 1	Special	2006
Little Boy	Cass	1,452	24-36" slot, 1 over 36	Special	2003
Ten Mile	Cass	5,047	24-36" slot, 1 over 36	Special	1997
Wabedo (+ Louise)	Cass	1,285	24-36" slot, 1 over 36	Special	2003
Woman (+ Little Woman)	Cass	4,772	24-36" slot, 1 over 36	Special	2003
Center, North	Chisago	749	24-36" slot, 1 over 36	Special	2003
Center, South	Chisago	898	24-36" slot, 1 over 36	Special	2003
Rush, East	Chisago	1,481	24-36" slot, 1 over 36	Special	2005
Rush, West	Chisago	1,579	24-36" slot, 1 over 36	Special	2005
Elk	Clearwater	305	40" minimum, bag limit 1	special	2007
Little Cascade	Cook	262	24-36" slot, 1 over 36	Special	2003
Loon	Cook	1,095	30" minimum, bag limit 1	Special	2003
Mission, Lower	Crow Wing	724	24-36" slot, 1 over 36	Special	2003

Mission, Upper	Crow Wing	875	24-36" slot, 1 over 36	Special	2003
Mitchell	Crow Wing	429	40" minimum, bag limit 1	Special	2003
Rabbit, Big	Crow Wing	663	24" maximum	Experimental	2003
Rabbit, East Big	Crow Wing	535	24" maximum	Experimental	2003
Round	Crow Wing	1,650	30" minimum, bag limit 1	Special	2003
Latoka	Douglas	753	24-36" slot, 1 over 36	Special	2003
Rachel	Douglas	442	24-36" slot, 1 over 36	Special	1997
Big Mantrap	Hubbard	1,618	24-36" slot, 1 over 36	Special	2003
Crow Wing, 10th	Hubbard	175	40" minimum, bag limit 1	Special	2003
Crow Wing, 5th	Hubbard	400	40" minimum, bag limit 1	Special	2003
Crow Wing, 6th	Hubbard	340	40" minimum, bag limit 1	Special	2003
Crow Wing, 8th	Hubbard	493	40" minimum, bag limit 1	Special	2003
Crow Wing, 9th	Hubbard	224	40" minimum, bag limit 1	Special	2003
George	Hubbard	826	24-36" slot, 1 over 36	Special	2003
Balsam	Itasca	714	24-36" slot, 1 over 36	Special	2006
Bowstring	Itasca	9,528	22-36" slot, 1 over 36, bag limit 9	Experimental	2007
Coon-Sandwick	Itasca	594	24-36" slot, 1 over 36	Special	1997,2007
Haskell	Itasca	93	24-36" slot, 1 over 36	Special	2006
Island	Itasca	3,108	24-36" slot, 1 over 36	Special	2003
North Star (+ Little North Star)	Itasca	886	24-36" slot, 1 over 36	Special	2003
Round (+ Alice)	Itasca	2,893	22-36" slot, 1 over 36, bag limit 9	Experimental	2007
Sand, Birds Eye, Little Sand, Portage, Rice, Unnamed lakes, & Bowstring River	Itasca	5,331	22-36" slot, 1 over 36, bag limit 9	Experimental	2007
Scrapper	Itasca	172	24-36" slot, 1 over 36	Special	2007
Spider	Itasca	1,392	24-36" slot, 1 over 36	Special	2006
Knife	Kanabec	1,259	24-36" slot, 1 over 36	Special	2006
Basswood	Lake	14,071	24-36" slot, 1 over 36	Special	2003
Farm	Lake	1,292	24-36" slot, 1 over 36	Special	2003
Garden	Lake	653	24-36" slot, 1 over 36	Special	2003
South Farm	Lake	564	24-36" slot, 1 over 36	Special	2005
Lake of the Woods	Lake of the Woods, Roseau	305,540	30-40" slot, 1 over 40	Special	1996
Minnie Belle	Meeker	578	24-36" slot, 1 over 36	Special	2003
Black Bass	Mille Lacs	32	catch and release	Special	2005
Ogechie	Mille Lacs	410	24-36” slot, 1 over 36	1837 Treaty	2000,2007
Alexander	Morrison	2,709	24-36" slot, 1 over 36	Special	2003
Fish Trap	Morrison	243	24-36" slot, 1 over 36	Special	2003
Shamineau	Morrison	1,175	24-36" slot, 1 over 36	Special	2005
Cedar	Morrison, Todd	1,428	40" minimum, bag limit 1	Special	2003
Annie Battle	Otter Tail	354	catch and release	Experimental	1997
Battle, West	Otter Tail	5,565	24-36" slot, 1 over 36	Special	2005
Fladmark	Otter Tail	52	catch and release	Special	1997
Norway	Otter Tail	485	1 fish bag	Special	2000
Otter Tail	Otter Tail	14,074	30" minimum, bag limit 1	Special	2003

Twenty One	Otter Tail	142	catch and release	Special	1997
Sturgeon	Pine	1,706	24-36" slot, 1 over 36	Special	1997
Ash	St. Louis	690	24-36" slot, 1 over 36	Special	2001
Caribou	St. Louis	539	24-36" slot, 1 over 36	Special	2003
Elephant	St. Louis	724	40" minimum, bag limit 1	Special	2003
Pelican	St. Louis	11,546	24-36" slot, 1 over 36	Experimental	2000
Prairie	St. Louis	794	30" minimum, bag limit 1	Special	2003
Vermilion	St. Louis	39,272	24-36" slot, 1 over 36	Special	2003
White Iron	St. Louis	3,238	24-36" slot, 1 over 36	Special	2003
Birch Lake Reservoir	St.Louis	7,074	24-36" slot, 1 over 36	Special	2003
Big Fish	Stearns	533	24-36" slot, 1 over 36	Special	2005
Crooked and Long	Stearns	143	24-36" slot, 1 over 36	Experimental	2007
Bass	Todd	124	40" minimum, bag limit 1	Special	2003
Big Swan	Todd	887	24-36" slot, 1 over 36	Special	1997
Little Sauk	Todd	289	24-30" slot, 1 over 30	Permanent Rule	2000
Long	Todd	397	24-36" slot, 1 over 36	Special	2006
Big Birch	Todd, Stearns	2,112	24-36" slot, 1 over 36	Experimental	1996, 2005
Blueberry	Wadena	533	24-36" slot, 1 over 36	Special	2003
St. Olaf	Waseca	91	30" minimum, bag limit 1	Special	1998
Big Carnelian	Washington	457	24-36" slot, 1 over 36	Special	2003
Mink-Somers	Wright	431	24-36" slot, 1 over 36	Special	2003
Sugar	Wright	1,020	24-36" slot, 1 over 36	Experimental	2007
	Total	**675,111**			

Appendix E Checklist for New Muskellunge Written Proposals

General Characteristics

- ❑ Lake management and history
- ❑ Geographic proximity
- ❑ Trophy potential
- ❑ Winterkill potential
- ❑ Connection to other waters

Proposed Stocking and Evaluation

- ❑ Rate and frequency
- ❑ Evaluation plans

Physical and Biological Considerations

- ❑ Lake size
- ❑ Littoral area
- ❑ Basin depth
- ❑ Shoreline development factor (SDF)
- ❑ Water clarity
- ❑ Northern pike population density
- ❑ Adequate forage base

Social and Economic Considerations

- ❑ Public input
- ❑ Angling pressure
- ❑ Public access sites

Workload Considerations and Evaluation

- ❑ Spring netting
- ❑ Muskie population density and estimates
- ❑ Creel and angler diary surveys

Decision Making Process

- ❑ Proposal initiated at the area fisheries office
- ❑ Regional office review and approval
    - o Public participation and public meeting
- ❑ Central office review and approval

Appendix F Checklist for New Northern Pike Written Proposals

General Characteristics

- ❑ Lake Management and History
- ❑ Geographic Proximity to Other Opportunities

Physical and Biological Considerations

- ❑ Lake size
- ❑ Littoral area
- ❑ Basin depth
- ❑ Assessment of recruitment (reproductive success)
    - o Gillnet CPUE
    - o Evaluations of spawning habitat
    - o Stocking practices
    - o Population density estimates (if time permits)
- ❑ Adequate forage base

Social and Economic Considerations

- ❑ Public input
- ❑ Angling pressure
- ❑ Public access sites

Workload Considerations and Evaluation

- ❑ Spring netting
- ❑ Evaluation timeframe (10 to 15 years)
- ❑ Proportional Stock Density (PSD ratios)
- ❑ Compare northern pike population changes or PSD shifts to nearby control lakes
- ❑ Creel surveys

Decision Making Process

- ❑ Proposal initiated at the area fisheries office
- ❑ Regional office review and approval
    - o Public participation and public meeting
- ❑ Central office review and approval