Dakota Chapter Report, 2023

North Dakota: The North Dakota Game and Fish Department (NDGF) has wrapped up our 2017-2021 trophy northern pike (≥ 100 cm) tagging studies on Lake Sakakawea and Lake Oahe (two mainstem Missouri River Reservoirs). Our goal was to assess current angler use of trophy northern pike in these fisheries and compare this use to guidance available for sustaining trophy muskellunge fisheries (exploitation should not exceed natural mortality; Casselman et al. 2017). We tagged 341 trophy pike on Lake Sakakawea and documented an annual exploitation rate of 12.3% along with an annual mortality rate of 15.7%. For Lake Oahe, we tagged 324 trophy pike and documented an annual exploitation rate of 7.4% along with an annual mortality rate of 20.6%. Exploitation did not exceed natural mortality for either fishery. This indicates that exploitation of both Lake Sakakawea and Lake Oahe trophy northern pike is acceptably low and the general statewide NDGF northern pike harvest regulations (5 fish daily limit, 10 fish possession limit, no length restrictions) are currently compatible with the long-term sustainability of these fisheries.

South Dakota: South Dakota received 114 adult Muskellunge from the Utah Division of Wildlife Resource in 2022. The fish were broodstock at the Lee Kay Fish Rearing Ponds (Salt Lake City, Utah). Interestingly, the Utah Muskellunge had originated from a South Dakota private hatchery. The fish made the journey (1,015 miles) back to South Dakota and their new home at Middle Lynn Lake in April. The fish were PIT tagged in their dorsal musculature before their release. The average size of the Muskellunge was 34.6 inches.

Fingerling Muskellunge were received from Iowa in July 2022 and stocked into a pond at Blue Dog State Fish Hatchery. Fathead Minnows were fed to the Muskellunge until draining the pond on October 25, 2022. The harvested fingerlings averaged 11.8 inches TL. A total of 1,008 were stocked into Middle Lynn Lake, and 1,096 were stocked into West Highway 81 Lake. Stocked Muskellunge had PIT tags implanted in their dorsal musculature before their release.

South Dakota has started experimenting with raising Muskellunge in recirculating aquaculture systems (RAS). The first RAS fish stocking is anticipated to occur in 2023.

Iowa's ETC Report, 2023 -*Jonathan Meerbeek*

Muskellunge Stocking, Tagging, and Population Dynamics (Contact: Jonathan Meerbeek jonathan.meerbeek@dnr.iowa.gov) – Fourteen lakes and impoundments are managed as Muskellunge fisheries in Iowa and populations are maintained via stocking spring-stocked, pellet-started minnow finished yearlings. In 2022, 3,704 yearling Muskellunge (mean TL ranged from 12.5-14.0 in among systems) were stocked in 3 natural lakes and 9 impoundments. In lakes where Muskellunge are used as broodstock, populations are monitored via annual spring gillnetting and population metrics are estimated using the Jolly-Seber model. Sampling in 2022 was conducted at Clear Lake and the Iowa Great Lakes. Estimated adult Muskellunge (≥ 30 inches) abundance via Jolly-Seber method was 621 fish in the Iowa Great Lakes. Alternative techniques to estimate abundance, such as using angler recapture data, was explored in for the Iowa Great Lakes and using Lincoln-Peterson models, population estimates of ≥ age-4 fish were 1,223 (139 fish reported by anglers via PIT tag readers). No estimate was available at Clear Lake due to a lapse in sampling in 2020 and 2021. All yearling Muskellunge stocked into Iowa's natural lakes are tagged via PIT tags prior to stocking (since 2011). To date, over 1,400 yearling Muskellunge have been recaptured and initial analyses indicate that size (TL) at stocking is an important variable influencing survival to age-2+. However, we have observed that survival rates vary considerably among lakes. More specifically, survival is much higher in general in lakes where large populations of top-level predators are absent (i.e., Clear Lake; Figure 1).

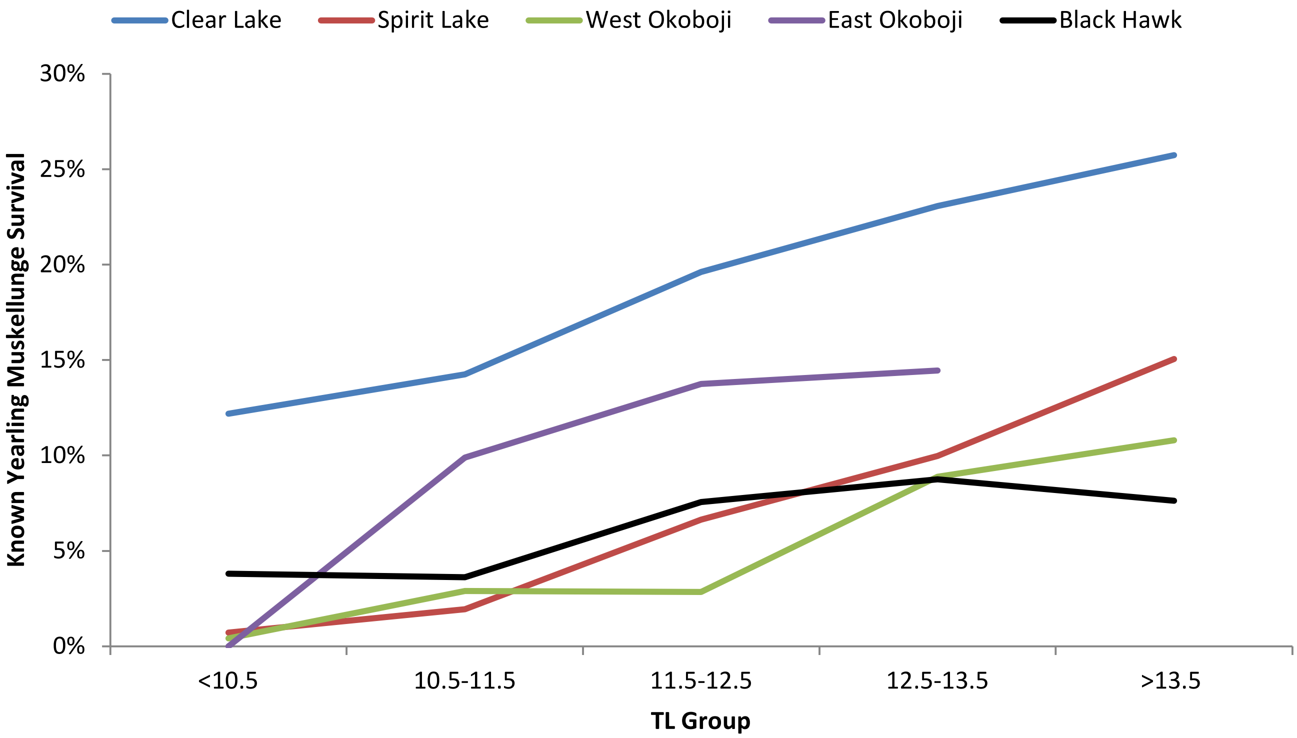

Figure 1. Known yearling Muskellunge survival to age-2+ by length group (0.5 in) in Clear, Spirit, East Okoboji, West Okoboji, and Black Hawk lakes.

Effectiveness of an electric barrier to reduce emigration of Walleye and Muskellunge in Iowa's natural lakes (Principle Investigator: Jonathan Meerbeek jonathan.meerbeek@dnr.iowa.gov) - Downstream movement of adult Muskellunge in an interconnected chain of lakes has been extensively documented in Iowa via the states broodstock collection program and extensive PIT tagging database. In some years, approximately 50% of the adult Muskellunge population has moved from Spirit Lake downstream to the Okoboji chain via a spillway that connects the two waterbodies. Since the spillway acts as a fish barrier to fish migration upstream during most of the year, Muskellunge populations in Spirit Lake have suffered and drastic population imbalances have been observed. A similar problem exists at the outlet structure of the interconnected system and Muskellunge loss to the river has commonly occurred. However, an electric fish barrier was installed in 2013 to prevent Asian Carp from entering the lake system and as a side-benefit, hopefully reduce Muskellunge loss. Since July 2017, the area directly below the outlet dam has been sampled via electrofishing to collect Muskellunge and determine if escapement has occurred post-barrier installation via PIT tag information. In 2019, 97 Muskellunge have been collected below the barrier during 19 electrofishing events. Collectively, 254 Muskellunge (25.0-47.0 in) have been collected below the electric fish barrier and returned to the lake. Many of these fish had moved into the river post-electric barrier installation. In summer 2019, a low-pulse (0.5 volts/in) electric fish electrode was installed directly above the electric fish barrier in attempt to prevent downstream movement of Muskellunge and Walleye. The effectiveness of the barrier was planned to be evaluated in 2020-2022; however, water levels were not conducive to perform the evaluation. The evaluation will be conducted in 2023 if water levels remain high throughout the open water period.

As part of the barrier evaluation, a project evaluating adult Muskellunge movement among the Okoboji lakes and escapement to the river was began in 2022 by implanting acoustic transmitters into a subsample of 25 adult

Muskellunge captured during broodstock gillnetting (stocked back into lake in late April). Movements were documented via strategically placed Vemco acoustic receivers (n = 20) throughout the lake chain and within the river system. Data from acoustic arrays were downloaded in late September. Cumulatively, 697,405 detections were recorded between 4/30/2022 and 9/21/2022 and ranged from 2,419 to 63,046 detections per fish. Of the 25 fish stocked into the lake chain, one was reported dead on 7/22/2022, four have not been detected for ≥ one month, and two not been detected for 29-30 days (believed to be in location of damaged receivers). The remaining 18 tagged Muskellunge were detected within < 2 days of downloading the receiver data and many of those fish were detected almost daily throughout the study period. Overall, Muskellunge movement varied considerably among fish. Seventeen tagged fish were detected at two or more lakes within the lake chain and eight fish visited at least four of the five interconnected lakes. Connectivity size or type appeared to not influence fish movement among lakes. For example, one fish moved from East/West Okoboji on eleven different occasions between 5/21/2022 and 6/19/2022. Four of the 25 lake tagged fish were detected at the Lower Gar Outlet receiver, but none of those fish left the lake system nor did they stay near the outlet for more than two days. By the end of September, all fish that had been detected consistently throughout the study were located within either East Okoboji or West Okoboji lakes.

Northern Pike Propagation and Stocking (Fairport Hatchery Manager and Mississippi River Management Station: Andy Fowler andy.fowler@dnr.iowa.gov - Northern pike adults were captured from the Mississippi River using fyke nets in March and either stripped or stocked in hatchery ponds where they were allowed to spawn naturally. The fry production was 353,462 which were bagged and stocked into Middle Sabula and Green Island on April 14. The pond yielded 8,517 fingerlings that were stocked in the Mississippi River.

Spirit Lake Hatchery Manager: Kim Hawkins kim.hawkins@dnr.iowa.gov) The 3rd addition of the fish hatchery management book is being written. Aaron VonEschen from North Dakota and Kim Hawkins are in charge of writing the Esocid section. If anyone would like to edit it for additions from their state, they can send Kim Hawkins an email. Production of Northern Pike at the Spirit Lake Hatchery in 2022 was limited to fry only and 1.6 million were stocked. Small fingerlings (3.inch) were provided from North Dakota and over 200,000 were stocked in northeast Iowa rivers and shallow lakes.

Iowa State University Esocid Projects (Principle Investigator: Michael Weber mjw@iastate.edu) – Students from ISU have been involved in the evaluation of Walleye and Muskellunge escapement in Brushy Creek and Big Creek reservoirs. Below are abstracts that were prepared for the Iowa AFS meeting in March. For more information, contact Dr. Weber.

(1) Muskellunge movement and residency indices in Iowa reservoirs

Understanding fish movement and habitat use is vital to informing management of populations and can provide information regarding habitat selection, vulnerability to sources of mortality or loss, and responses to changing abiotic conditions. Passive acoustic telemetry enables continuous monitoring of individuals, providing valuable insights into fine-scale temporal variation in movements and habitat use. In fall 2021, we deployed passive acoustic telemetry receivers in Big Creek Lake (n=9 receivers) and Brushy Creek Lake (n=10), Iowa. We subsequently tagged 15 Muskellunge *Esox masquinongy* per lake and evaluated residency indices at each receiver and near spillways. We found differences between species regarding temporal variation in residency indices and in the number of receivers fish were detected on per day in both reservoirs. Fish habitat use near spillways varied by reservoir, with more consistent presence of fish near the Brushy Creek spillway and seasonal increases in fish presence adjacent to the Big Creek spillway. Understanding spatial and temporal distributions of Walleye and Muskellunge will enable a better understanding of when fish are most vulnerable to loss from systems, informing management actions to minimize the unintentional loss of sportfish from populations.

(2) Economic evaluation of physical barriers to minimize escapement of reservoirs sportfishes

Escapement of fish over reservoir spillways or other water release structures can have a substantial role in regulating reservoir sportfish populations. Losing stocked fish due to escapement can be detrimental to the fishery, reducing the number of catchable fish present for anglers, and can have financial ramifications, as the resources put into raising the fish are wasted when fish are lost. Barriers can be an effective method for reducing escapement of reservoir sportfish; however, it is necessary to evaluate whether the benefits of a barrier will outweigh the initial cost of barrier construction and ongoing costs associated with barrier maintenance and repairs. To facilitate the comparison between costs and benefits of physical barriers for reducing sportfish escapement, we used data from two barrier construction projects in Iowa to quantify the value of fish lost due to escapement over time while accounting for temporal variability in escapement rates. We then compared the value of escaped fish to the cost of barrier construction and maintenance over time. Finally, we developed an interactive Shiny application to enable comparison and visualization of the costs and benefits of physical barriers under varying levels of escapement, fish production costs, fish survival, and barrier costs. Results from this study will enable managers to make informed decisions regarding options to minimize fish escapement. Additionally, quantifying the value of escaped fish and barrier construction on an economic scale will enable the use of formal decision-making tools to address complicated and multi-faceted issues associated with reservoir management.

(3) Laboratory Assessment of Parallel-Bar Barrier Spacing Effects on Reservoir Fish Escapement

Escapement of sportfishes over reservoir spillways can have negative effects on in-lake populations. To prevent escapement, managers have implemented physical parallel-bar barriers with 51-mm gaps on spillways in multiple states. Parallel-bar barrier gap spacing is modifiable, although there are no evaluations of how spacing influences the number or sizes of fish that escape. We evaluated the effectiveness of multiple bar-spacings [no-barrier, 25-mm, 51-mm, 76-mm (fingerlings only), 102-mm, and 152-mm (adults only)] on escapement of adult and fingerling Walleye *Sander vitreus* and fingerling Muskellunge *Esox masquinongy* using a controlled experiment. We placed ten adult Walleye (267-726 mm) or ten fingerling Walleye (156-267 mm) and ten fingerling Muskellunge (217-338 mm) into the upstream end of flow-through raceways for two-hours to test the barrier. Adult Walleye escapement averaged 82% without a barrier (control) and was reduced to 2% with a 51-mm bar-spacing and 0% with a 25-mm bar-spacing whereas 76- and 102-mm bar spacing did not reduce escapement. Fingerling Walleye escapement averaged 74% without a barrier and was reduced to 20% with a 25-mm barrier while fingerling Muskellunge escapement averaged 76% without a barrier and was reduced to 42% with a 25-mm barrier. Fingerling escapement was not reduced with any other bar spacing. Adult Walleye escaping the 51 mm bar spacing tended to be smaller in total length and body depth than those that escaped other spacings but bar spacing did not significantly affect length or body depth of escapees. Our results indicate 25-mm and 51-mm gap spacings are effective at preventing adult Walleye escapement whereas only the 25-mm barrier reduced fingerling escapement. Parallel-bar barriers with spacings <51-mm could provide a valuable tool for reducing reservoir escapement, but our results in the lab should be validated in the field.

(4) Understanding and Mitigating Walleye and Muskellunge Reservoir Spillway Escapement

Reservoir fish escapement has been an overlooked source of population loss. Understanding when and under what conditions reservoir sportfish escapement occurs would help develop strategies to mitigate this important source of fish loss. Further, few field evaluations of physical spillway barriers designed to prevent fish escapement exist. Our objectives were to compare seasonal, diurnal, and spatial variation in Walleye and Muskellunge escapement in relation to water levels in a reservoir with and without a physical barrier. In 2016, we installed passive integrated transponder (PIT) antennas at Big Creek Lake (physical bar barrier) and Brushy Creek Lake (no barrier). We captured Walleye and Muskellunge from each lake semi-annually using boat electrofishing and gill netting and injected them with a 32 mm PIT tag. We also tagged juveniles of both species at the hatchery prior to stocking. From 2016-2020, we tagged 14,745 Walleye and 2,983 Muskellunge and we have detected 272 Walleye and 190 Muskellunge escaping Brushy Creek while we detected 88 Walleye and 8 Muskellunge escaping Big Creek. Adult fish were more likely to escape than their juvenile counterparts who rarely escaped before age-3. We documented escapement with little water flowing over the spillway, but increased water levels led to increased escapement, especially during spring. Fish tended to escape through the deeper parts of the spillway and primarily escaped during nighttime hours. Fish escapement past the physical barrier was rare but did occur under limited conditions, especially when it partially failed during high water events. Due to the apparent success of the Big Creek barrier, we installed a barrier on Brushy Creek during summer 2020 and have not documented escapement since its completion. Our results suggest the addition of physical spillway bar barriers can be an effective method to reduce reservoir fish escapement.

Kansas ETC Report, 2023

Micah Waters (District Fisheries Biologist)-Kansas Department of Wildlife, Parks, and Tourism

There are only two bodies of water in the state of Kansas with populations of Northern Pike *Esox Lucius.* Lyons State Fishing Lake and Kingman State Fishing Lake. The population at Lyons SFL currently has a very low abundance. There has been no evidence of natural recruitment and there have only been a few Pike sampled at Lyons SFL in the last few years.

Kingman State Fishing Lake is a shallow impoundment that used to have suitable habitat of emergent and submerged vegetation. There is a spring in the lake which provides thermal refuge and allows for the survival of Northern Pike during the summer. The Pike population was self-sustaining before the was lake was renovated in 2012 to remove Aquatic Invasive Species. However, since the renovation, there has been no natural recruitment. Increased turbidity and decreasing vegetation have led to a decline in abundance of Northern Pike as well as other species. Due to the current turbidity and habitat conditions, we are planning on renovating the lake again in 2023. We hope to have restored vegetation and plan to restock Northern Pike in 2024. Hopefully, we will observe natural reproduction once the new population becomes mature, otherwise we will need to stock Pike to maintain the population.

Michigan Esocid Technical Committee Report, 2023

Musky: Inland broodstock lakes are still in process with Lake Hudson and Thornapple Lake. Angler PIT tagging data has been extremely useful in assessing year class strength and fish still present in the systems. The largest Musky are nearing 50 inches in Thornapple Lake and 40 inches in Lake Hudson. It would be ideal to start taking eggs from these inland sources, but unlikely to occur in 2023. Finding the Musky during spring has been challenging to date. Currently all Great Lakes strain Muskellunge eggs are taken in the Detroit River, which is becoming more of a challenge.

Thompson State Fish Hatchery just completed it's second season rearing GL Musky with high success. The implementation of the second coolwater facility has greatly increased the number of Musky that are available for stocking. Thus, larger systems with known small levels of natural reproduction, will be starting to be stocked in 2023 (e.g. The Antrim Chain and Inland Waterway). Ongoing experiments at both Thompson and Wolf Lake State Fish Hatcheries are proving to be worthwhile in raising larger Musky at higher densities.

Angler hours have been increasing on lakes across the state with the heaviest reported effort in small (<500 acre) lakes in southwestern Michigan. Based on population densities, this is not surprising that more anglers are fishing smaller lakes that are closer to their homes.

Pike: The Northern Pike sampling protocol was completed in 2022 and is proving that Michigan has high data gaps compared to most other Midwestern states. Currently, the Northern Pike regulation tool-box has three options: statewide (2 bag, 24 inch minimum), protected slot (2 bag, no harvest 24-34 inches), and the liberalized reg (5 bag, no minimum, but only 1 fish over 24 inches). Most lakes are managed with the statewide regulation, but the liberalized regulation is highly desired by many anglers in the upper peninsula and northern lower peninsula. Few lakes are in the protected slot and most are in southwestern Michigan.

Of course the gold standard for pike sampling is ice out, spring mark recapture surveys. Given the high demand for field work in spring, these surveys are very limited across the state. Typically, pike are picked up during early ice-out surveys targeting Walleye. Additionally, crews in the UP are utilizing under the ice gill netting to gather information prior to the spring ice-out surveys. The new standardized protocol should help to align the sampling efforts across the state to make better informed management decisions.

Minnesota ETC Report, 2023 – Nate Hodgins (MNDNR)

On the Pike front: The Following are preliminary findings related to Initial Northern Pike Zone Regulations that were implemented statewide in 2018.

The length-based zone regulations (ZR) were implemented in 2018 to change size-structure in Northern Pike populations according to zone-specific management objectives. It was expected to take ten years or more to reliably detect changes in Northern Pike populations driven by the new regulations because of high variation in catch rate data and the need to allow time for new recruitment to change the size-structure of the populations. Prior to ZR implementation, a statistical frame work was created to test for changes in catch rates of Northern Pike after 10 years of post-ZR data collection. This memo discusses a preliminary examination of 2019-2021 Northern Pike gillnet data to describe pre-ZR data within the evaluation framework and to evaluate its applicability for detecting changes after the monitoring period is completed; it is not intended as an analysis of the effects of the ZR.

The evaluation framework is based on gill net catch rates (CPUE) of varying size categories related to management objectives and the length-based regulations for each zone. To evaluate temporal changes over the monitoring time period (1993-2021 excluding 2018), linear mixed effects models were fit to overall CPUE and zone-dependent size group CPUE with year and lake as random effects. Plots of annual CPUE for the 3 zones were highly variable, with higher catch rates in earlier surveys relative to the ten years preceding ZR implementation.

Lakes survey pace is meeting objectives for adequate power to detect changes after the ten-year post-ZR monitoring period. From 2019 to 2021, Area fisheries staff surveyed 461 of the 1,027 lakes included in the evaluation. As more lakes are surveyed (and re-surveyed) in the coming years, there should be adequate data to detect demographic changes in Northern Pike populations following ZR implementation.

Results

North-central Zone

Evaluation metrics for the North-central zone were based on the 22-26” protected slot and focused on tracking abundance of fish below, within, and above the protected slot. With management objectives for the North-central Northern Pike populations in mind, specific data tests developed in the evaluation framework were:

• decrease in gill net catch of Northern Pike less than 22” (under protected slot).

• increase in gill net catch of Northern Pike 22-26” (within protected slot).

• increase in gill net catch of Northern Pike greater than 26” (above protected slot).

As noted above, there are insufficient data at this point to statistically evaluate post-ZR changes. Generally, estimated catch rates in the North-central zone were higher in the earlier monitoring period and experienced a decline to a lower level for decade preceding the ZR implementation.

Northeast Zone

Evaluation metrics for the Northeast zone were based on the 30-40” protected slot and focused on tracking abundance of fish above and below the lower bound of the protected slot; very low catch rates of Northern Pike > 40” in the Northeast zone precluded using three size groups as in the North-central zone. Northeast management’s main objective was to protect existing size structure rather than to change it, data evaluation metrics were:

• No change in gill net catch rate of Northern Pike overall.

• No decrease in gill net catch rate of Northern Pike less than 30” (below protected slot).

• No decrease in gill net catch rate of Northern Pike greater than 30” (within and above the protected slot).

There are insufficient data at this point to statistically evaluate post-ZR changes. As in the North-central zone, estimated Northern Pike catch rates were higher in the earlier time period, and experienced a decline to lower levels in the decade preceding ZR implementation.

Southern Zone

Evaluation metrics for the Southern zone were based on the 24” minimum size limit and focused on tracking abundance of fish above and below the size limit. With the management objective of increasing recruitment to larger sizes in mind, specific data evaluation tests were:

• Increase in gill net catch rates of Northern Pike greater than 24” (above minimum size limit).

• Increase in gill net catch rates of Northern Pike less than 24” (below minimum size limit).

• Overall change in gill net catch rates of Northern Pike.

There are insufficient data at this point to statistically evaluate post-ZR changes. As in the other zones, there was higher catch rates in the earlier time period compared to the decade prior to ZR implementation, most pronounced in CPUE > 24”.

Northern Pike Toolbox Regulations Revision (alternatives to zone regulations)

This revision of the Northern Pike regulation toolbox still provides three special regulation options. Recruitment is still a key variable in selecting a regulation option. Previous toolbox regulations only affected the protected size range, defaulting to statewide regulations for bag and one over limits. Since the change to zone regulations those limits now need to be defined in rule for toolbox regulations.

1. 30-inch Minimum Size Limit, one fish bag limit over 30 inches. For low recruitment lakes where the goal is to improve densities of medium to large size pike. This type of population will usually also have good potential for fish growth. This is the regulation option best suited for Southern Zone lakes where there is demand for higher quality fisheries, but it may have application in low recruitment lakes elsewhere.

2. 24–36 inch Protected Slot Limit, three fish bag limit, one fish allowed over 36 inches. For moderate recruitment populations where the goal is to provide opportunities to harvest smaller sized pike while maintaining or improving densities of medium to large size fish. This regulation may not be the best fit for high density lakes where growth is suppressed, and medium size fish are already depleted. Protected slot limits can only be effective if there are significant numbers of fish within the protected size range to benefit from protection, or steady recruitment of new fish into the protected range. This regulation may be an option for lakes that respond favorably to the North-Central Zone regulation and there is demand for continued improvement in quality.

3. 22–30 inch Protected Slot Limit, ten fish bag limit, one fish allowed over 30 inches. For moderate to high recruitment populations where the goal is to improve densities of medium size pike. This toolbox regulation was specifically added to provide an option for higher density pike lakes that have the potential to improve size structure and may have underperformed with the 24–36inch PSL. Underperformance may be attributed to poor growth potential due to low prey density or density dependent growth resulting from consistent recruitment attributed to abundant spawning habitat. This PSL is positioned two inches lower so slow growing fish can recruit sooner to the protected size range and reduce the potential for an exploitation bottleneck of 22–24 inch fish. Additional harvest opportunities of individuals less than 22 inches are provided by the ten fish bag limit, which is appropriate if pike rarely exceed 30 inches. This also provides a starter option for high density pike lakes with the previously described growth characteristics or where the intent may be to ramp up to more protective quality regulations later.

On the Muskie front: Statewide Muskie Production

For 2022, 38 lakes were stocked with Muskie fingerlings and one lake (Minnetonka) was also stocked with yearlings. In total, 27,177 fingerlings and 856 yearlings were stocked which was just shy of the total fingerling quota of 27,357 in 2022. Minnetonka will now be stocked with fall yearlings annually instead of fingerlings every other year. For the most part it was a decent year with later than usual egg-take operations and higher mortality in the transplant phase of production. Muskies Inc. purchased an additional 500 fingerlings for Lake Vermillion in 2022. There are 11 lakes in the Metro area that are managed for Tiger Muskie. Four lakes were stocked in 2022 (Johanna, Crystal, Orchard, and Nokomis) with a total of 1000 fingerlings and 313 yearlings. Lack of Muskie forage (fathead minnows) continues to be a primary reason for reduced numbers and average size of fingerlings produced Statewide. Costs have increased but in addition, lack of bait dealers willing to trap minnows for State purchase has decreased. In 2022, DNR Fisheries Staff from some Areas found sources and trapped fathead minnows to feed the Muskie fingerlings. This will likely continue into the near future as private sources are hard to find.

Statewide Technical Committee Work

The DNR Muskie Technical Committee worked on the following in 2022:

- Coordination with Twin Cities Muskies Inc. to produce Muskie Yearlings for stocking in 2022.

- Implemented a plan to increase production of Muskie yearlings for stocking from state drainable ponds.

- Will have a draft of the new Muskellunge Long Rang Plan by mid-April, 2023. Previous Muskellunge/Large Northern Pike plan expired in 2020.

  Three Main Priorities for Guiding the Muskie Management through 2035

  1) Focus management on improving existing waters that appear to be underperforming. These waters may be introduced and maintained by stocking or may be native waters with very low or extirpated populations.

  2) Focus production on evaluation of the product while transitioning from fall fingerlings to fall yearlings. Improving production efficiency should result in expanding production capability.

  3) Consider adding new waters should priority 1 and 2 be sufficiently accomplished, the fish community research has been completed and published (Predator diet/stable isotope, Bioenergetics, etc.), and there is local support for establishing a new Muskie water.

- Members of the Committee met face to face with the Muskellunge Workgroup to discuss issues and topics related to Muskie management in Minnesota.

DNR Muskie Research

Update: Niche overlap and diets of Muskellunge and other piscivores - Contact Brian Herwig

This was the fourth and final year of fieldwork for a collaborative study among MN DNR, University of St. Thomas, and Bemidji State University that is gathering data on the diets of muskellunge, walleye, northern pike, and largemouth bass in a set of 20 Minnesota lakes with contrasting prey fish communities. This year's lakes included North Star, Cass, Little Boy, and Fox lakes. Diets have been sampled with two methods throughout this study: traditional stomach content analysis and stable isotope analysis. In a nutshell, traditional stomach content analysis involves a technique called gastric lavage where water is used to flush stomach contents from the fish. For stable isotopes, diets are inferred indirectly as fish stable isotope signatures reflect those of their prey in a "you are what you eat" fashion. Resulting data are being used to quantify the feeding niches of muskellunge, walleye, northern pike, and largemouth bass. Data analyses and conclusions are still preliminary, but here are some of our initial findings:

Stomach content analysis–

• Kamden Glade, the graduate student and now research specialist, who is leading this work, along with other members of our research team have a paper in review at the North American Journal of Fisheries Management summarizing our findings from the first 10 lakes. We have collected 2,754 diets to date (326 muskie, 741 pike, 877 walleye and 810 largemouth bass).

We found:

- Muskellunge have broad diets that include not only yellow perch and sunfish, but also species such as white sucker, northern pike, and bullheads.
- While not consistent in every lake, walleye and northern pike appear to have the highest amount of diet overlap, with yellow perch and sunfish being the most important prey in many lakes.
- Lastly, largemouth bass eat crayfish and other invertebrates to a greater extent than the other three top predators, but sunfish were also important in some lakes.
- Diet patterns are related to lake characteristics (littoral area, trophic state index (how productive), and shoreline development index (shoreline habitat complexity)

• Patterns were a little different this year in Cass and North Star lakes, with more cisco found in muskie, northern pike, and walleye stomachs than observed in the 10 previously studied lakes. Yellow perch were again important in the diets of these three predators. Rusty crayfish also form an important component of diets on Cass Lake at times, especially for largemouth bass.

Stable isotope analysis–

- Zebra mussels fundamentally restructure food webs –fishes shift from pelagic (offshore) to littoral (nearshore) sources of energy compared to lakes without zebra mussels.
- We are learning a lot about the individual niches of the predators and important prey species, including the unique and important roles of cisco and minnows in lake food webs.
- We are also learning a lot about food web architecture in different types of lakes (i.e., how predator and prey fish seem to move around in concert in ecological space given all the different conditions found in different lakes). Said another way, most fish species have unique niches, especially prey fishes. Others are more generalist and more redundant with one another (perch, bass, and northern pike are some examples). But, even those more redundant species are still quite unique, and they partition out how they use and share food resources it seems.
- Muskellunge have unique niches and occupy the highest trophic positions (i.e., have the most fish-based diets), along with walleye. Largemouth bass and northern pike tend to have higher niche overlap in most lakes.
- In lakes with cisco, muskie are consistently pelagic (i.e., they are likely eating cisco) from the smallest through largest fish sampled. In lakes without cisco, muskie become more littoral as they grow larger (perhaps consuming more bullheads, white suckers, etc.). We are going to be conducting some specific modeling to confirm these patterns soon, so stay tuned for more detailed results.

Comparing consumption by muskellunge, northern pike, walleye, and largemouth bass populations–Contact Tyler Ahrenstorff

This study is designed to build on the predator diet study, summarized above by Brian Herwig, by combining diet information with estimates of predator population size to examine how much food, and how much of each prey species, is consumed by each predator population in a lake over the course of the year. Three lakes are included in this study, including Lake Shamineau sampled in 2021, North Star Lake in 2022, and Bald Eagle Lake in 2023. The results of this study will better inform the public, policy makers, and fisheries professionals about not only what these predators eat, but also how much food they eat in relation to each other. This information is important for managers, for example, when considering future muskellunge introductions, stocking, and/or possible regulation changes for muskellunge and other species.

Preliminary results from Shamineau and North Star lakes have shown a similar pattern. Muskellunge consumed the least amount of food because they were considerably less abundant than the other predators in both lakes. Muskellunge also consumed different prey resources such as white sucker, northern pike, and bullheads. Walleye and northern pike had intermediate densities in both lakes with yellow perch and sunfish being their preferred prey. Largemouth bass were the most abundant species in both lakes, consuming mostly crayfish and yellow perch. After we complete sampling on our third lake in 2023, we will provide a more formal analysis of the results and summary of the findings.

Nebraska Esocid Technical Committee Report, 2023

The following report is being submitted to the Esocid Technical Committee meeting in February 2023 at the Midwest Fish and Wildlife Conference. Nebraska has limited use of esocids within our systems. We are managing to stock muskie, tiger muskie, and northern pike in the requested systems and anticipate trying to provide each species of fish every three years from the hatchery system. However, in 2022, a second straight year of muskellunge were produced in order to meet growing management requests as in the previous year's requests. A total of 12 different waters received muskie this past fall. Esocid species receive protection from harvest with a statewide 40 inch minimum is in effect for muskie and many stocked waters have a 30" minimum on northern pike. A 50" minimum length regulation has been implemented on Merritt Reservoir.

With an interest in creating a potential muskellunge destination fishery and the observed fast growth rate and potential from the Sandhills region of Nebraska, a muskellunge project has been proposed and funded with a Hugh Becker based grant. This project would focus on getting accurate age-growth analysis of Muskellunge from both Merritt Reservoir and Cottonwood Steverson Lake. Use of PIT tags in newly stocked individuals would allow for improved age and growth information over time, as well as determination of natural recruitment. A second year of stocked muskie were tagged this fall. Thus, both Merritt Reservoir and Cottonwood Steverson Lake received age-1 stockings in March (409 at Merritt and 337 at Cottonwood Steverson) and age-0 (600 in both lakes) in October. The dual stocking will provide an opportunity to monitor survival of fish that were fall versus spring stocked. The overwinter mortality of muskie fingerlings produced in 2021 was <8%, but these fish grew less than 1" in an extensive culture pond from October 2021 to April 2022. It was also noted that the mean length of overwinter survivors was significantly greater than muskie that perished during the winter. Spring sampling in 2022 collected 31 and 39 muskellunge from Merritt and Cottonwood Steverson, respectively. Pelvic fins were collected from newly captured fish and length was recorded on all fish to assist with determining growth potential for each water.

Our hatchery system has been asked to produce muskie, tiger muskie and northern pike next year and space available will try to fulfill those requests. The muskie and northern pikes will be used to supplement existing Nebraska lakes, while the tiger muskies are primarily to fulfill trade obligations with western states.

Wisconsin ETC Report, 2023 -Jordan Weeks (WDNR)

Wisconsin has been working to finalize a genetics management plan for muskellunge. Although WDNR has been working under these principals for several years, the final document was just recently approved and inserted into our Fisheries Management Handbook. Some of the language is summarized below:

Genetics Management.

A central goal for all stocking in Wisconsin is to ensure the protection of existing self-sustained populations and to preserve the genetic integrity of existing fish stocks, pursuant to s. NR 1.02(4)(c), Admin. Code. Native and naturalized populations that are self-sustained through natural reproduction provide some of the best fishing opportunities in the state, are the most cost-effective to manage and, if impacted or lost, cannot be easily replaced. Stocking should, first and foremost, be considered an important restoration tool used to reestablish naturally reproducing populations and should not be conducted to the potential detriment of natural reproduction.

Considerable work has been done on the differentiation, fitness, and performance of individual populations within a species (see Simonson et al. 2020, for a review). The "stock concept" (i.e., managing individual breeding populations) has been bolstered over the last 3 decades with improved technology (ability to discern stocks) and documentation of the superior performance of "locally adapted" populations. Indiscriminate transfer and mixing of stocks can negatively affect the genetic resources of a species by reducing genetic diversity among populations and by decreasing the genetic fitness of locally adapted populations through outbreeding depression (i.e., when genetically different populations interbreed to produce inferior offspring). In order to protect existing genetic diversity and ensure that fish stocked are best suited to survive and thrive in the unique ecological conditions found throughout the state, the following guidelines are used when stocking fish, pursuant to s. NR 1.02(4)(c), Admin. Code:

Preserving the genetic integrity of fish stocks that are documented and proven to survive and thrive in Wisconsin waters is a central goal of fisheries management in Wisconsin. All fish stocking in Wisconsin inland waters shall be authorized under a permit issued by the department and shall be conducted to maintain the genetic boundaries of fish best adapted to those waters. Stocking shall be considered an important restoration tool used to reestablish naturally reproducing populations and may not be conducted to the potential detriment of natural reproduction.

Waters with adequate natural reproduction should not be stocked.

All stocking of fish in Wisconsin waters must follow the genetic boundaries, or Genetic Management Units (GMU), as outlined in the map, below. If products cannot be obtained for a specific GMU from DNR hatcheries or private fish farms, field transfers of wild fish may be used.

We take a conservative approach to stocking for all species in the state based on scientific information and evidence that protecting genetic diversity of existing populations is paramount and is generally applicable to all freshwater fish species (based on Fields et al. 1997). These recommendations for sources of fish, based on whether the species is native to the waterbody or GMU (based on Greene 1935) and the reproductive status of the population in the receiving water, are summarized in the table below.

Table of Stocking Decisions for Conservation of Native Stocks (from Simonson et al. 2010; modified from Fields et al. 1997). "NR" means natural reproduction; "GMU stock" means the broodstock originates from within the Genetic Management Unit of the receiving water.

Stock Origin	Reproductive status	Source of broodstock
Native to waterbody	Self-sustained through NR	Fish should not be stocked
	Some NR; not self-sustained	GMU stock
	Extirpated (restoration)	GMU stock
	Dependent on stocking	GMU stock
Introduced to waterbody; native to GMU	Self-sustained through NR	Fish should not be stocked
	Some NR; not self-sustained	GMU stock
	Dependent on stocking; or new introduction	GMU stock
Introduced to waterbody; not native to GMU	Self-sustained through NR	Fish should not be stocked
	Some NR; not self-sustained	Nearest available GMU stock
	Dependent on stocking; or new introduction	Nearest available GMU stock

Stocking Strategies

Stocking should be used as part of an integrated approach to the management of a body of water, which considers habitat restoration or improvement, harvest regulations, public access, and public education and involvement (Simonson et al. 2010). As part of an integrated management plan, stocking may be needed to accomplish specific objectives for the waterbody. The ultimate success of any stocking activity should be judged based on its contribution to achieving the overall management goals. The following stocking strategies used in Wisconsin waters are listed in priority order:

Research/Evaluation (Priority 1) - This strategy is intended to answer questions related to hatchery practices or related to the success or impact of stocking. Stocking practices will vary depending on the objectives of the project. An existing or approved funded evaluation project in the work planning system is required prior to stocking. The project should specify the duration of the stocking effort.

Restoration (Priority 2) - This strategy is intended to restore a previously naturally reproducing population to a level that sustains itself without further stocking. This strategy has also been referred to as "rehabilitation". This is a temporary strategy that is limited in time and requires frequent surveys to document the results of stocking. This may include waters with recent, dramatic reductions in the population related to winterkill, chemical treatment, chemical spills or other pollution, or other external factors that result in reductions to the adult population that limit its ability to sustain itself. Field transfer of adults to repopulate the waterbody is often preferred, provided Fish Heath Certificates are completed or fish from a connected water upstream are used. Documentation of a reduction in a previously self-sustained population is required, based on historical data, surveys or an intentional management action (e.g., chemical treatment), and that the habitat is still suitable for the species or has since been improved to be suitable for the species.

Maintenance (Priority 3) - This strategy is intended to maintain a fishable population that would not otherwise have sufficient recruitment to sustain itself at the target adult density without ongoing stocking. Also referred to as "Put, Grow and Take", where stocked fish realize significant survival and growth prior to being harvested. This includes 1) "remediation", or stocking to replace reproduction lost due to factors that will likely never be corrected (e.g., habitat loss, etc.); 2) "biomanipulation", which seeks to enhance an adult population at artificially high levels to increase predation on target prey species, and 3) "recreation", which is stocking to maintain a fishery that would otherwise not persist in the waterbody without ongoing stocking. Documentation that stocked fish are contributing to the fishable population is required for ongoing stocking. For new waters, an abundance estimate showing the population is not meeting a minimum level and that public use opportunities are substantial is required for ongoing stocking.

Put-and-Take (Priority 4)- This strategy is intended to temporarily create a recreational fishing opportunity that would not otherwise exist, usually on a seasonal basis, by stocking catchable sized fish where the habitat will not typically support the species throughout the entire year. Documented angler use, such as an estimate of fishing effort (hours/acre or hours/mile) or harvest, is required for ongoing quota requests; new requests will require thorough evaluation of angler use before continuing.

Introduction (Priority 5) - This strategy is intended to create a new recreational fishing opportunity that did not previously exist. In this case, the species has never been documented in the waterbody. New introductions are generally discouraged because they have the potential to disrupt the existing fish community and can change the character of the waterbody. New waters also typically result in a higher, long-term demand on the propagation system. In some cases, the intent of a new introduction is to establish a self-sustaining population with natural reproduction (e.g., introducing trout to cold water streams). An internal Environmental Assessment will be required before quotas or Private Stocking Permits are approved for any new introductions. This should include some explanation of why the habitat appears suitable for the species proposed for introduction.

Wisconsin is following these same genetic management principles for all species of fish we manage including northern pike.