North Central Division of the American Fisheries Society

Joint Winter Business Meeting of the Centrarchid, Esocid,
and Walleye Technical Committees

3:00 – 5:00 PM (CST), Sunday, January 28, 2024
In association with the Midwest Fish & Wildlife Conference (Sioux Falls, SD)
Zoom link: https://unk.zoom.us/j/92927314060

WTC Chair: Logan Zebro, zebrol@lopers.unk.edu
WTC Chair-elect: Jason Gostiaux, gostiauxj@michigan.gov
WTC Immediate past-chair: Jason DeBoer, jadeboer@illinois.edu
WTC Secretary: Joe Rydell, joe.rydell@nebraska.gov
ETC Chair: Jonah Dagel, jonah.dagel@state.mn.us
CTC Chair: Will Radigan, wradigan2@huskers.unl.edu

1. **Call meeting to order**
   Meeting called to order by Logan Zebro (WTC chair) at 2:15pm
   a. **Introductions** 26 in-person attendees went around the room introducing themselves and their affiliation with the meeting. 3 additional participants viewed via zoom

2. **Agenda additions and approval**

No additions were mentioned to the agenda.

3. **Approve minutes from 2023 summer joint meeting (E-*mailed out prior to meeting*)** .
   Jordan Weeks made a motion to approve the meeting minutes from the 2023 summer business meeting, Sean Farrier seconds it. Motion passed.

4. **2024 Summer Meeting: Proposals from IN and IL**
   Logan Zebro suggested that the summer meeting be held the end of July as that was the time frame the summer meeting has typically been held. Logan proceeded to go over the two options for hosting the meeting in 2024. One option was Pokagon SP in Indiana with the following details provided by Aaron Voirol.

Pokagon State Park Hosting WTC Meeting Details

- Pokagon State Park is located on beautiful Lake James in Angola Indiana. The Indiana DNR will be having the annual conference at Pokagon in February. The facilities are in great condition and plenty of space available. I thought it would be fun to do a fishing event one evening like last summer.

Room Costs (Potawotimi Inn)

- $139.99/night
- $107/night (Government rate)
  - 2 queen beds
- Need reservations completed 60 days in advance. (June and July available)

    - Room blocks available up to 30-40 guests.
    - Be sure ask about tax exempt before arriving onsite and getting that taken care of.
- Hotels also available in area
    - Holiday Inn Express
    - Best Western
    - Comfort Inn
    - Wingate by Wyndham

Meeting Room/Social

- Holds up to 80 guests (Classroom Style)
    - Projector
    - Hors d' oeuvres during meeting available
- We may need to supply our own necessary equipment for presentations based on cost.
- Outside balcony and firepit for possible social evening networking.
- With DNR permission, a fish fry at outside balcony.
- Food
    - Recommend that we do a private meal if catering is done.
    - Depending on costs, would we allow them to cater us for 1 evening?
- Alcohol is allowed.
    - Outside event we would supply beverages

Parking/Access

- Inn guests pay $7 fee for full access in/out.
- Outside guests will stop at gatehouse for offsite waiver
- Parking lot by the cabins is labeled for the boat trailers and they can be parked there.
- Also, boat slips are first come first serve.

Address:

450 Ln 100 Lake James, Angola, IN 46703

Contact: **Cheyenne Giddings** Director of Sales

260-833-1077 ext 438

Aaron mentioned that it is in NE Indiana and has boat slips available and adequate parking. Alcohol is allowed. Jordan Weeks asked about muskie and the answer was no. The fishery is mainly a bass and bluegill fishery.

The other option at the table is Kibbe Life Science Station in Warsaw, IL as described by Andrya Whitten.

- **Location:** The station is on 222 acres of land near the Mississippi River at Lock and Dam 19.
- **Meeting Space:** They have a 4,200 sq ft multi-use building that includes a large meeting area that can hold about 44 people comfortably with a projector and Wi-Fi. Meeting room is connected to a kitchen (alcohol is acceptable).
- **Housing:** They have nine dormitory style rooms with bunks (4-6 each) that can hold up to 44 guests. Nearby Keokuk, IA (11 min) has many (~7) hotel options as well.
- **Parking:** Free onsite
- **Availability:** Open after July 4th because of June classes.

- **Cost:** Donation. For example, 15 people paid $100/day recently.
- **Website link:** https://www.wiu.edu/cas/biological_sciences/kibbe.php
- **Address:** Alice L. Kibbe Life Science Station 545 Frank, Warsaw, IL 62379
- **Contact:** Station Manager Neil Gillespie ND-Gillespie@wiu.edu 217-256-4519

Discussions made about the two options included asking if the only option at Pokagon State Park was for catered meals or if could we cook on our own like we did in Wisconsin to save money. Aaron mentioned that we could cook some outside for part of it, but most of the meals would be catered.

Jason DeBoer asked if Beaver Island was on the table for 2025. It was decided that we will discuss that at the summer meeting but yes it will be an option.

The two locations were put to a vote as no one had any preference one way or another. The group was split with 6 votes each with several meeting participants not caring which option. Logan Zebro was the deciding vote and picked Illinois as the location for the 2024 summer meeting. Andrea asked for specific dates to try and reserve the venue for and the group decided to go with July 16th – 18th, 2024. It was mentioned that the venue has plenty of kitchen space and that they would like to find some volunteers to help cook.

a. Continuing Education Course ideas?

Jason DeBoer asked about continuing education and if anyone was interested in seeing explosions of invasive carp. Joe Rydell mentioned that a program looking at the impacts of invasive carp would be beneficial to managers who don't have them in their areas yet. Jason suggested that we could put together some presentations and an on the river portion to follow.

5. Break-out for CTC, ETC, and WTC

Before break-out session, Jordan Weeks announced the two winners of the esocid travel awards to Riley Mounsdon (SDSU) and Ryan Eastman (UWSP) and thanked them for their participation in the meeting.

6. Percid travel award

The percid travel award was presented to Riley Mounsdon. Brain Blackwell from the Dakota Chapter presented Riley with a matched check of $300.00 and NCD secretary Drew Holloway mailed the $300.00 check from WTC. Riley was also presented with a copy of <u>Biology, Management and Culture of Walleye, and Sauger</u> and a copy of <u>Yellow Perch, Walleye and Sauger. Aspects of Ecology Management and Culture</u>.

7. **WTC state and provincial reports attached.**
   Jason G. gave some updates on Michigan fingerling stockings, forward facing sonar, and talked about the work with a tribal treaty for long term monitoring.
   Todd Casper read his full report (see attached).
   Jason D. highlighted using RAS system improvements that worked well on the Mississippi River.
   Aaron V. provided a summary of the Indiana report and highlighted Indiana's participation in the walleye challenge.

   Joe Rydell mentioned that there were reports from other states attached to the meeting notes below and provided a summary of the Nebraska report.

8. **WTC Treasurer's report by Joe Rydell**
   a. WTC general/operating fund (expenses, deposits, and balances for calendar year)

Summer Meeting Summary

2023 summer meeting was held at Kemp Research Station, Woodruff, WI with 42 participants (9 students and 33 professionals)

	Income
Meeting Registration	$3,845.00
Paypal Fees (credit card payments)	$128.66
Meeting Cost (meals, Monday social, event room, etc.)	$4,228.43
Balance	$512.09
Previous 2022 Account Balance	**$21,230.72**
2023 Percid Travel Awards (Ben V., Logan Z., and Logan C.)	**$900.00**
WTC Publication (raised funds)	**$15,550.00**
WTC Publication remaining Balance	**$3,230.00**
Summer Meeting Balance	**$512.09**
2024 Percid Travel Award (Riley M.)	**$300.00**
Past Chair awards	**$226.24**
WTC Account Balance	**$512.39**

Joe mentioned to the group that the WTC has no income to the general account and unless some future income is figured out, there will be no funds to help with the summer meeting costs or the Percid Travel awards.

Logan Z. mentioned working with Drew to get shirts on sale on the website. Will Radigan mentioned that the CTC only gains 13% from shirt sales and didn't make much money in 2023. Other options discussed include increasing summer meeting registration costs by $10.00 per person over the estimated cost to cover any additional costs and add a bump up the account if there are none. Attendance was lower at the summer meeting and trying to tie in lodging into the registration for one fee made estimation of fees difficult. Joe Rydell suggested that we could hold a raffle to try and raise additional funds at the summer meeting.

Dan Isermann asked if we received any income from the publication of the Walleye book and was going to look into that more.

b. WTC AFS Investment Account

AFS Managed Unit Investment Program

Fund or Unit Name:	**Walleye Technical Committee NCD**
For the period ending:	6/30/2023

Contributions	**Date**	**Amount**
Contribution	10/15/2018	$5,000
Contribution	Nov 2019	$2,500

Description	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**
Beginning Balance	$0	$4,739	$8,641	$9,355	$10,633	$8,848
Contributions / Withdrawals	$5,000	$2,500	$0	$0	$0	$0
Income	$222	$355	$166	$139	$190	$78
Gains / Loss	-$458	$1,109	$588	$1,188	-$1,927	$555
Fees	-$25	-$62	-$40	-$49	-$48	-$13
Ending Balance	$4,739	$8,641	$9,355	$10,633	$8,848	$9,468

Mark Ermer mentioned that the investment account was originally designed to raise money for the projected cost of publishing the walleye symposium that drained the account. He suggested that it wasn't put in place to raise any money and suggested that the group take out funds as needed and use it. Joe R. is going to look into any fees and the process to take money out of the investment account. Todd Casper asked the group if the income from the investment was taxable profit, and Mellissa Wuellner mentioned that it was not since we are tax exempt.

9. Old business WTC

a. WTC Merchandise, Logan Z is working with Drew Holloway to get merch on the threadless store on the NCD website. This was discussed previously with the treasurer report.

b. Percis VI conference possibly Columbus 2026 in conjunction with the annual AFS meeting? Jason D. volunteered to help with the organization but would not do it himself. It was noted that the Percis V conference was a success as described by John Bruner at the 2023 meeting.

10. New business WTC

a. Approval of new WTC chair (Jason Gostiaux) and recognition of outgoing chair (Logan Zebro)
Dan I. motioned to approve Jason. Joe Rydell Second the motion. Motion passed.

b. Recognition of past Chairs (Jason Deboer and Logan Zebro). Jason G presented a plaque to Logan and also had one for Jason Deboer for his service. Jason D. will receive his award at the summer meeting in Illinois.

c. Recruiting for WTC chair-elect (will be chair in 2025)

Aaron Voirol was nominated and showed interest through email prior to the meeting. A call was asked if there were any other nominations. No other nominations were brought to the table. Jason G. motioned that Aaron gets elected for the chair elect to be the WTC chair in 2025. Joe R. second the motion and the motion passed.

d. Interest in Walleye symposium at the Honolulu meeting? Dan mentioned that it would be lightly attended. Travel to this would be tough. San Antonio in 2025 has a black bass symposium going on at the same time and not a good option either. The topic for a symposium was tabled till a later time.
e. General fisheries track – Walleye management Monday 3:20 – 5:00 Just an FYI announcement of the meeting.
f. Other?

Alison Coulter brought up that there is an SDSU alumni social on Tuesday. 5:00 or 5:30.

Adjourn

Dan Isermann made a motion to adjourn and Todd Caspers second the motion. Meeting adjourned.

State reports:

Minnesota update to NCD Walleye Technical Committee
Winter business meeting, 2024
Submitted by Dale Logsdon

2023 Walleye Stocking:

243,086,663 fry
15,000 small fingerlings
1,806,534 fall fingerlings
27,717 yearlings or adults

General:

Walleye fishing has been good across the state this year but ice fishing got a late start due to unusually warm winter. DNR is developing 2 new egg takes for walleye strain associated with the Mississippi River watershed below St. Anthony Falls. Concern continues about forward facing sonar and barotrauma from catch and release out of deep water. A new “Advanced Technology” citizen/DNR committee was formed to address concerns. The DNR is working with media to get information on barotrauma out to public. New hatchery in Waterville is in design stage, funding for hatchery improvements elsewhere. DNR emphasis in improving shore fishing opportunities through better access and fishing piers. No movement on reduced bag limit for walleyes. Tournament fishing is increasing and creating parking issues at boat ramps. Have had some bait shortages in recent years as dealers learn to deal with restrictions in working in waters infested with zebra mussels.

Large lake summaries:

<u>Winnibigoshish</u>: Major system changes following the infestation of zebra mussels continues to challenge our understanding of the current status, and historical comparisons, of fish populations in Winnie. Gill net catches for all game fish were up from the previous year. Walleye are narrowly back within the interquartile range for Winnie, and the 2019 year class is making up about 2/3 of the sample. The size of this year class and the lack of perch and cisco in the system in recent years has resulted in slow growth, and because of that the majority of the 2019’s have not recruited to the 18-23” protected slot limit. A modest number of age 2 perch and cisco were caught in the nets after a long dry spell, so we are hoping that the downward trend for both forage species is stabilizing. The 2023 field season produced more record breaking secchi readings (up to 27 feet in June, in comparison to a pre-zebra mussel summer average of ~6 feet). Anglers seem to be adapting well to the new water clarity and are happy with the abundance of harvestable size walleye available right now.

<u>Leech Lake</u>: This year the catch rate of walleye was above average, the northern pike catch rate was below average and the yellow perch catch rate was an historic low. Catch rates of tullibee (cisco) remain well below average. The young of year yellow perch catch rate was the fourth highest observed since trawling began in 1987. Hopefully these fish will be able to recruit the fishery in the coming years. The 2019 and 2021 year classes are still carrying the walleye fishery. We have a winter 2023-24 creel survey and summer 2024 summer creel survey scheduled.

<u>Mille Lacs:</u> 2023 fall forage levels, consisting of both age 0 Yellow Perch and age 0 Tullibee, dropped well below median levels for both species. This is likely responsible for increased angler Walleye catch rates in the latter half of summer and we expect the higher Walleye catch rates to persist at least through early summer 2024. Walleye condition decreased for all size groups

commensurate with the reduction in forage; however, medium (14" – 20" inch) and large (> 20") Walleye were the least impacted, likely due to less desirable forage in the form of age 1 Yellow Perch being still available for the larger fish. Reproduction was readily evident in our annual fall electrofishing sampling for YOY Walleye, but age 0 Walleye length was the second lowest observed in the 28 year history of using this gear, suggesting that very few 2023 year class Walleye will likely still be available to recruit to age 1 fish by fall of 2024.

Overall raw numbers of Walleye were below median in the 52 standard gill nets set in fall; however, it appears the observed reduction in catch was likely just typical sampling noise as a spring lake-wide population estimate for Walleye greater than 14" indicated little change in population numbers. 2022, 2017, and 2013 year class Walleye were well represented in fall sampling and we observed very few fish greater than age 11, likely due to four consecutive failed year classes that occurred from 2009-2012 and severe fishing mortality on the 2008 class when they first became desirable for harvest at age 3-4.

<u>Vermilion</u>: It continues to be the "good ol' days" for the Lake Vermilion Walleye population. Gill-net catches have remained above average for the 4th consecutive year with high numbers of harvestable sized fish. The Walleye population has experienced good recruitment in recent years with a notably strong 2018 year-class and moderate to strong year-classes in 2019, 2021, and 2022. Most management plan objectives are being met.

<u>Red Lake</u>: Gill net catch rates remain high with lots of young fish in the population. Spawning stock biomass is toggling between our surplus and optimal conditions, both of which allow for regulations that provide good harvest opportunities. This trend expected to continue as we have two exceptional year classes of young fish (2019 & 2022) in addition to good support from adjacent year classes.

<u>Cass Lake</u>: Meeting or exceeding most management plan goals except recruitment. The strong 2018 year class is carrying the fishery with modest support from adjacent year classes. However, good numbers of quality-sized fish being caught. The 2021 year class is above average and just entering the harvest fishery. The age-0 catch rate in 2023 was poor for the second consecutive year.

<u>Lake of the Woods</u>: All Walleye population metrics currently exceed management objectives. High catches observed in September were driven by young Walleye age-0 to 2. The 2021 year-class looks promising as is the strongest observed in a decade. Harvestable-sized Walleye (14-19 inches) are at average abundance.

Sauger abundance and recruitment both exceed management objectives. Abundance has dropped since near record levels observed from 2016 to 2021. This largely due to less than average year-classes in 2020 and 2021. The bulk of the catch was driven by the 2019 and 2022 year-classes. Harvestable-sized Sauger (> 12 inches) abundance remains high.

<u>Lake Pepin/Pool 4</u>: Walleye gill net CPUE continues to be quite good, with the last four years all in the top five CPUE years since 1965. This is largely being driven by four consecutive strong year classes that occurred between 2018 and 2021. Additionally, changes in bag limit and the addition of a 1 over 20" regulation in the spring of 2020 may be spreading the harvest and allowing these quick growing fish to persist longer once they reach 20" around Age-3 for females. Habitat restoration work being done in the vicinity or known and suspected Walleye spawning locations in upper Pool 4 are continuing to be monitored to document any shifts in usage that can be identified. Lower numbers of YOY Walleye in the last two years (particularly 2022) will likely moderate catch rates over the next few years, but anglers should have plenty of opportunities for

both numbers and trophy potential until at least 2027 when the 2018 year class is likely to have largely aged out of the system.

Despite near record Walleye catches in recent years Pepin/Pool 4 remains a Sauger dominated fishery with approximately a 3:1 catch ratio in our gill nets. The last decade has been spent almost entirely within the interquartile range (20-30 per net). Traditionally Sauger in this system have had very consistent recruitment, but in the last decade or so recruitment has become more stochastic with isolated strong year classes interspersed with relatively weak ones. Interestingly this historically was the pattern for Walleye, but they have shifted to more consistent reproduction leading to their surge in abundance. The 2020 year class represents the third strongest year class we have documented since 1965, but without consistent recruitment this has not led to a surge in CPUE.

<u>Rainy Lake</u>: Walleye catch rates have increased during the past two surveys, largely driven by younger fish from the 2019 and 2021 year-classes. The overall Walleye catch rate was 7.5 per net in 2023. There were above average numbers of fish in the 9 to 14 inch size range. The 2019 year-class is the first strong year-class produced since 2011 with most individuals in the 12-14 inch length groups. The 2021 year-class has been caught in above average numbers in the past 2 surveys and is on track to recruit to the fishery as a very strong year-class. The majority of Individuals from the 2021 year-class were in the 9-11 inch length groups in the 2023 survey.

<u>Kabetogama</u>: The overall Walleye catch rate on Kabetogama was similar to 2022 at 8.2 per gillnet. Kabetogama has seen consistent recruitment of strong-year classes in recent years. The most recent strong year-class was 2020 with individuals from the 2023 survey primarily in the 11-13 inch range. The 2021 and 2022 year-classes appear weak and the strong 2016 year-class has now largely grown into the protected slot, averaging 19.5 inches in 2023. As a result, there were below average numbers of 15-18 inch fish in the 2023 survey.

DNR research:

Tom Jones, Matt Jones (Dartmouth University), Missy Treml, Tom Heinrich – Developed a method to determine the "recycling rate" of fish in recreational fisheries. The recycling rate is the actual catch when most fish are released divided by the number of individual fish caught. While a precise estimate is a bit of a mathematical tangle, a very good approximation can be expressed as a function of catch and abundance. Recycling rate is always > 1, and is greater than the average number of times an individual fish is caught. For walleye in Mille Lacs Lake, in which harvest has been very limited in recent years, the recycling rate varies from about 1.2 to 1.4. For Mille Lacs Smallmouth Bass, the recycling rate is closer to 2.5. Published in December 2022 *Fisheries*.

Loren Miller-High levels of remnant ancestry were detected in additional waters of Minnesota's lower Mississippi drainage despite decades of stocking from non-local sources. The latest examples include several streams in the St Croix River watershed and a lake in southern Minnesota with an estimated 79% LMS ancestry.

Dale Logsdon, Loren Miller, and Steve Shroyer - This year's data continue to indicate higher survival of the Lower Mississippi strain walleyes in southern Minnesota lakes.

Tyler Ahrenstorff and Brian Herwig – We are examining consumption patterns between muskellunge, northern pike, walleye, and largemouth bass populations by using fish bioenergetics combined with population estimates for each predator. Preliminary population estimates from our 3 study lakes have shown a remarkably similar pattern where largemouth bass were the most abundant (48-52% of the total predator population), followed by northern pike (31-35%), walleye (18-20%), and muskellunge (1-5%). When combining these population estimates with diet data in a bioenergetics model, we found that the northern pike populations are estimated to eat the most food in Shamineau and North Star lakes (Bald Eagle Lake results in progress) compared to the other predators over the course of a year. This result is driven by the fact that northern pike eat more food on an individual basis than largemouth bass, so despite northern pike being less abundant than largemouth bass in both lakes, their population eats more food. Largemouth bass and walleye populations ate similar amounts of food in both lakes. Lastly, muskellunge ate considerably less food than the other predators in Shamineau Lake, but a similar amount compared to largemouth bass and walleye in North Star Lake, which is driven by muskellunge eating the most amount of food on an individual basis compared to the other predators. Notably, muskellunge consumed many different prey resources, such as white sucker, northern pike, and bullheads, compared to the other predators. Walleye and northern pike consumed primarily yellow perch and sunfish while largemouth bass ate mostly crayfish. We will wrap up our analyses and final report writing this winter, so stay tuned for future final results!

Bethany Bethke and Beth Holbrook – The MN DNR project titled "Assessing Yellow Perch Populations with Experimental Gears" is in the final stages of analysis and writing. As part of this project, Yellow Perch of all sizes were collected and examined from 28 Minnesota lakes (some in more than one year for a total of 37 sampling events). Estimated length of 50% maturity (L50) for female Yellow Perch in the sampled populations ranged from 55 to 204 mm with a median of 97 mm. Estimated age of 50% maturity (A50) for female Yellow Perch ranged from 0.4 to 2.8 with a median of 1.3 years. Note: we sampled these populations in the fall, meaning the first spawn would occur during the following spring.

We confirmed dimorphic growth in Minnesota's Yellow Perch populations, with a negligible difference (< 1 mm) between sexes at age-0 that increased to an average difference of 6, 16, and 28 mm by ages 1, 2 and 3, respectively. Within the same population, on average female Yellow Perch reached a maximum length approximately 58 mm larger than males and a maximum age approximately 1.3 yrs older than males. Growth rates of female Yellow Perch age-0 to age-3 ranged from 19 mm to 66 mm yr^{-1} with a median of 33 mm yr^{-1}.

One of the most promising findings was the utility of the metric mean maximum length (mean length of the 15 longest fish sampled, MML). This simple length-based metric was highly correlated with estimates of $L_{infinity}$ from growth models (R^2 = 0.75) and with female L50 (R^2 = 0.48). MML was a comparatively easy metric to calculate and could be estimated using data from standard lake assessments where Yellow Perch sex data and aging structures were not collected. We evaluated trends in mean maximum length using data from nearly 1,700 Minnesota lakes and determined that there was a significant statewide decline in Yellow Perch maximum size over the past 25 years.

Another advantage of MML may be that this metric could be comparable between survey methods if differences in selectivity are considered. Future investigations of Yellow Perch mean maximum length in states across the Midwest could determine whether the loss of size structure in Minnesota is a more widespread regional phenomenon, in which case a larger regional dataset could provide greater statistical power to determine factors correlated with this decline in size.

For more information, please contact Bethany Bethke (Bethany.bethke@state.mn.us) or Beth Holbrook (beth.holbrook@state.mn.us).

University of Minnesota Research:

The Hansen lab has collated fish data (catch and effort, as well as length/age) from 7 Midwestern States (Iowa, Illinois, Indiana, Michigan, Minnesota, South Dakota, Wisconsin). We targeted Walleye, Yellow Perch, Cisco, Northern Pike, Largemouth Bass, Smallmouth Bass, Bluegill, and Black Crappie but received data from over 100 taxa. We have developed a common structure and workflow for accessing, filtering, and summarizing these data and are excited to make them available publicly this year. We continue to build landscape level models of fish abundance and how it is predicted to respond to climate change. Making use of the multi-state dataset, we have developed models that account for different gear types, and also models that incorporate physiological thermal tolerances to improve our predictive capacity. We are also analyzing fish growth responses to temperature using a number of approaches, including statistical models of growth and Bioenergetics modeling. When examining relationships between temperature and fish populations, we make use of lake temperature products produced in collaboration with USGS partners, including both process based and deep learning models. These lake temperature products are publicly available and could be used for a variety of questions related to walleye and yellow perch. We continue to examine the impacts of zebra mussels on walleye and yellow perch populations, and have documented negative impacts on walleye recruitment and gillnet catch rates, negative impacts on early life growth of both walleye and yellow perch, increased littoral reliance of both walleye and yellow perch, and increased mercury concentrations in both walleye and yellow perch. Work on these topics is ongoing. We are in the early phases of a project taking a closer look at mercury in walleye and the role of species invasions and landscape drivers in mercury hotspots. We are involved in a collaborative project examining the characteristics of "bright spots" for walleye in the Midwest - that is, places where walleye populations are doing better than expected given environmental conditions. We are in the early phases of this project, and are identifying metrics of "success" for walleye populations (i.e., adult abundance, recruitment, size structure, angler catch rates) and collating data on these metrics.

2023 Publications related to walleye and yellow perch:

Frater, PN*, ZS Feiner, GJA Hansen, DA Isermann, AW Latzka, OP Jensen. 2023The incredible HALK: Borrowing data for age assignment. Fisheries. https://doi.org/10.1002/fsh.11019

North, JS**, EM Schliep, GJA Hansen, H Kundel**, CA Custer**, P McLaughlin*, T Wagner. 2023Accounting for spatiotemporal sampling variation in joint species distribution models. https://doi.org/10.1111/1365-2664.14547

Bethke, BJ, HM Rantala, TD Ahrenstorff, HAW Kelly, KE Kovalenko, RP Maki, JK Hirsh, JD Dumke, VJ Brady, JF LeDuc, **GJA Hansen**. 2023. Walleye and yellow perch resource use in large lakes invaded by spiny water fleas and zebra mussels. Aquatic Ecology 00: 1-14 https://doi.org/10.1007/s10452-023-10030-0

Wagner, T, EM Schliep, JS North**, H Kundel**, CA Custer**, JKR Nelson, GJA Hansen. 2023. Predicting climate change impacts on poikilotherms using physiologically guided species abundance models. Proceedings of the National Academy of Sciences 120 (15): e2214199120, https://doi.org/10.1073/pnas.22141991

Vitense, K.* and GJA Hansen. 2023. Non-linear water clarity trends and impacts on littoral area in Minnesota lakes. Limnology and Oceanography Letters 8:657-665. https://doi.org/10.1002/lol2.10323

Mahlum*, S, K Vitense*, H Corson-Dosch, L Platt, PJ Schmalz, M Treml, and GJA Hansen. 2023. Connecting habitat to species abundance: the role of light and temperature in the abundance of walleye in lakes. Canadian Journal of Fisheries and Aquatic Sciences.| dx.doi.org/10.1139/cjfas-2022-0109

Krabbenhoft, CA*, SA Ludsin, EA Marchall, RR Budnik, ZL Almeida, CL Cahill, HS Embke, ZS Feiner, PH Schmalz, MJ Thorstensen, MJ Weber, MR Wuellner, and GJA Hansen. 2023. Synthesizing professional opinion and published science to build a conceptual model of walleye recruitment. Fisheries 48: 141-156. https://doi.org/10.1002/fsh.10884

2023 Data releases related to walleye and yellow perch:

Masui, HK**, MR Verhoeven, PPN Frater, JKR Nelson, AW Latzka, ZS Feiner, OP Jensen, GJA Hansen. 2023, Data in Support of The Incredible HALK: Borrowing Data for Age Assignment to Create Hierarchical Age Length Keys for Several Fish Species in the Midwest Region: National and Regional Climate Adaptation Science Centers, https://doi.org/10.21429/t1r7-dt42

Blinick, NS**, TD Ahrenstorff, BJ Bethke, AB Fleishman, D Link**, JKR Nelson, HM Rantala, CL Rude[†], GJA Hansen. 2023. Data and R code for analysis of mercury concentration and food web differences in walleye and yellow perch from Minnesota lakes with and without invasive zebra mussels, 2019 - 2021. Data Repository for the University of Minnesota, https://doi.org/10.13020/xb7g-yc85

Kundel, H** and GJA Hansen. 2023. Data in Support of Widespread declines in walleye recruitment following zebra mussel invasion in Minnesota lakes. Data Repository for the University of Minnesota, https://doi.org/10.13020/N6TZ-VJ60.

St. Thomas University research:

Mary Thelen, David Gallagher, Payton Johnson, Sara Kangas, Dylan McNulty, Alexandra Morrison, Brian R Herwig, David F Staples, and Kyle D Zimmer. 2023. Lake characteristics drive concordant trophic responses across ecosystems in three top predator fish species Canadian Journal of Fisheries and Aquatic Sciences. 4 December 2023 https://doi.org/10.1139/cjfas-2023-0240

Abstract
Understanding similarities in trophic ecology of top predators is crucial given their influences on food webs. We sampled walleye (Sander vitreus), northern pike (Esox lucius), and muskellunge (Esox masquinongy) from 17 Minnesota (USA) lakes and used δ13C and δ15N to estimate littoral carbon use, trophic position, and isotopic niche size of each species. All three species showed large inter-lake variability yet had concordant trophic responses across lakes, as littoral carbon use, trophic position, variability in littoral carbon and trophic position, and niche size were all positively related among species across lakes. Concordant responses were driven by a few key lake variables, with trophic position positively related to proportion littoral area and depth of hypoxic water, littoral carbon positively related to depth of hypoxic water and presence of zebra mussels (Dreissena polymorpha), and niche size inversely related to lake area. Our results indicate lake characteristics may influence food webs via consistent effects on multiple top predators. They also show that the amount of suitable habitat can be important for the ecosystem size hypothesis for trophic position.

Bemidji State University research:

Trophic Structure and Mercury Bioaccumulation in Walleye and Yellow Perch in the Upper and Lower Red Lake Basins

Marissa Pribyl, Tyler Orgon, Pat Brown, Andrew Hafs, Richard Koch

Mercury is a persistent global contaminant that is known to travel through aquatic food webs by biomagnification. Mercury accumulation in fishes is primarily influenced by dietary and habitat influences. Trophic structure and total mercury concentrations in Walleye *Sander vitreus* and Yellow Perch *Perca flavescens* were examined in the Upper and Lower Red Lake Basins in Red Lake, Minnesota, between 2024 and 2025. Diets were collected through stomach dissection in Walleye and Yellow Perch to determine the trophic structure surrounding these specific species. Tissue samples were obtained from both species to analyze total mercury concentrations. Additionally, length, age, sex, and lake basin were recorded to examine mercury and dietary differences in Walleye and Yellow Perch in the Red Lakes. Finally, mercury concentrations were determined in Spottail Shiners *Notropis hudsonius,* Gastropods and species of Diptera in the larval stage. Spottail Shiners are the most abundant shiner species in the Red Lakes and are an important part of the Walleye and Yellow Perch food chain. Specific invertebrates like Diptera and Gastropods were targeted for mercury analyzation because they are hypothesized to be another huge component of Yellow Perch diets in the Red Lake system. Dissimilarities in mercury concentrations in Walleye between Upper and Lower Red Lake were observed in 2019 and 2020 by a previous study. It was determined that lake basin in the Red Lakes is an important variable for estimating total mercury concentrations. These observed differences between Upper and Lower Red Lake could be the result of multiple factors, one being diet composition in Walleye. The objectives of this study are to (1) explore prey assemblage and mercury concentrations in Walleye and Yellow Perch to determine trophic structure in Upper and Lower Red Lake and how it relates to the trophic transfer of mercury; (2) determine if changes in diet composition is the primary factor explaining the difference in Walleye mercury concentrations observed between the Upper and Lower Red Lake basins.
Protect predicted to start May 2024

Factors Influencing the Body Condition of Yellow Perch in Minnesota Lakes

Georgina F. Laramo, Andrew W. Hafs

In the aquatic ecosystem of Minnesota lakes, detailed information on fish population and environmental factors plays a vital role in maintaining ecological health. Among the notable species contributing to this balance is Yellow Perch *Perca flavescens,* a percid species of management interest in the Upper Midwest region of the United States, occupying diverse lentic systems from the Great Lakes to glacial ponds. Yellow Perch fulfils dual ecological roles as a primary forage species for top predators, such as Walleye *Sander vitreus*. They are piscivorous and targeted for harvest at larger body sizes. Yellow Perch life history traits, size structure, and abundance have been related to various lake characteristics, inter- and intraspecific competition and prey availability, predation, and harvest, making them a potential indicator of ecosystem change. However, the response of Yellow Perch to ecosystem change varies across life stages and conditions within individual water bodies. To understand how environmental factors, particularly water clarity could influence the overall health and condition of the younger life stage of Yellow Perch. This study

will characterize the relative body condition of Yellow Perch from 28 lakes by sex, age/length of maturity, fishing methods (fine mesh gillnet and nearshore electrofishing) and compare the body condition of Yellow Perch with Walleye, and its correlation with water clarity. The total length, weight, sex, and age of sampled Yellow Perch and Walleye were well documented. Relative weight will be used as the body condition metric to enable straightforward comparisons over a wide range of lengths, as other metrics such as Fulton's K do not allow such comparisons under allometric growth.
Project updated December 2023

Interactions Between Rusty Crayfish Invasion and Yellow Perch Population Dynamics in North-Central Minnesota Lakes

Kendra L. Fink, Kamden C. Glade, Brian R. Herwig, Bethany J. Bethke, Andrew W. Hafs

Over the last 50 years, Minnesota Department of Natural Resources standard fisheries survey catch rates of Yellow Perch have declined. Yellow Perch *Perca flavescens* are an important, widespread game fish, are essential prey species for Walleye *Sander vitreus* and other piscivorous fish, and rely greatly on benthic resources through many life stages. Aquatic invasive species (AIS) like rusty crayfish *Faxonius rusticus* and zebra mussels *Dreissena polymorpha* have the potential to change water quality, vegetation and prey assemblages in aquatic systems and could cause shifts in energy flow, subsequently altering growth, condition, and maturity of native fish species. In this study, we investigated potential effects of these AIS by sampling 1,783 Yellow Perch from 14 lakes in north-central Minnesota. We found that Yellow Perch growth, condition, and mortality were not significantly different between groups of lakes with only rusty crayfish present, only zebra mussels present, both AIS present, and neither AIS present. Additionally, even though the probability of crayfish presence in stomach contents was different between groups, variation in these metrics among lakes was not explained well by crayfish consumption. Lake effect and individual variation among populations was more important than the presence or absence of either AIS, indicating that Yellow Perch appear to be adaptive to changing lake conditions resulting from establishment of zebra mussels and/or rusty crayfish.

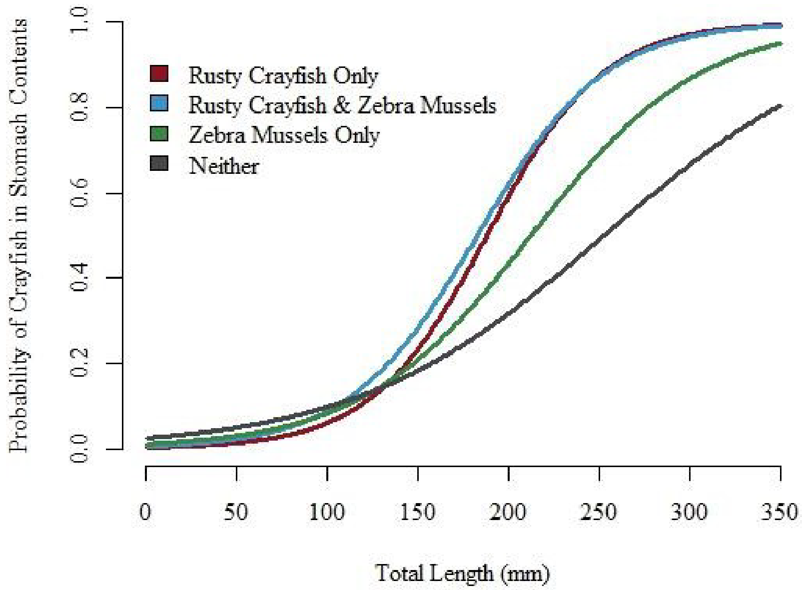


Figure 1. Logistic regression for estimating the probability of crayfish presence in stomach contents versus total length (mm) of Yellow Perch, where slope and intercept varied by aquatic invasive species group. Akaike information criterion adjusted for small sample size (AICc) was used to determine the best model based on Akaike differences (ΔAICc).

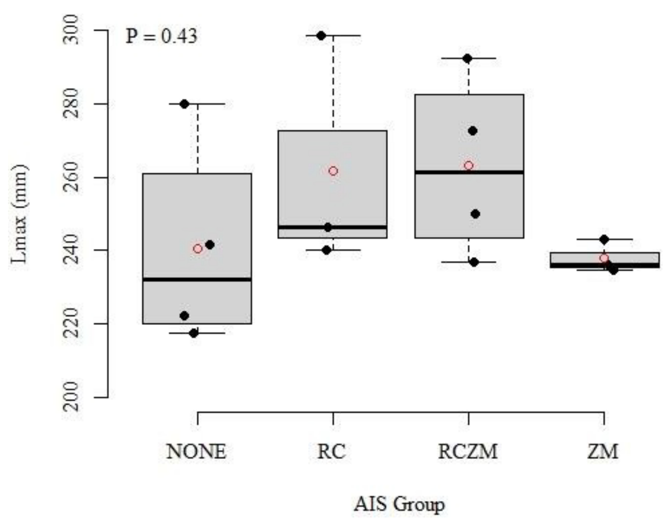


Figure 2. Box and whisker plots of mean maximum length (Lmax) of Yellow Perch by aquatic invasive species (AIS) group. AIS groups include no AIS present (NONE), rusty crayfish present (RC), rusty crayfish and zebra mussels present (RCZM), and zebra mussels present (ZM). Lmax was calculated by averaging the length of the largest 15 Yellow Perch sampled. For each group, the median is shown with a dark horizontal bar, the upper and lower quartiles are represented by the shaded boxes, and means are indicated by open, red circles. The dark circles represent mean Lmax values calculated for each of the 14 study lakes.

Project completed December 2023

Diet Patterns and Niche Overlap of Muskellunge and Co-occurring Piscivores in Minnesota Lakes

Kamden C. Glade, Brian R. Herwig, Tyler D. Ahrenstorff, Jeffrey R. Reed, Andrew W. Hafs

Muskellunge *Esox masquinongy*, Northern Pike *E. lucius*, Walleye *Sander vitreus*, and Largemouth Bass *Micropterus salmoides* are popular sport fish that often co-occur in aquatic systems. Although numerous studies have investigated interactions among these species, the simultaneous evaluation of diet patterns and niche overlap among all four species has not been conducted. Our experimental design aimed to quantify diet overlap among Muskellunge and other piscivores, while lakes without Muskellunge were also sampled to compare the diets of other piscivores in their presence or absence. Diets of piscivores from 10 Minnesota lakes were collected via gastric lavage and quantified using an index of relative importance. Diets of individual species were compared among seasons and length categories, and among-species comparisons were also conducted by season and relative to Muskellunge presence using permutational multivariate analysis of variance (PERMANOVA). Muskellunge consumed a wide range of prey, whereas Northern Pike and Walleye diets consisted primarily of Yellow Perch *Perca flavescens* and centrarchids. Largemouth Bass consumed more invertebrates, especially crayfish *Faxonius* spp. No species exhibited seasonal diet shifts, but diets were different among length categories for all species except Walleye. Although NMDS ordinations indicated shared prey use, PERMANOVA results indicated diets of Muskellunge and Largemouth Bass were most different from each other and other piscivores across all seasons. Conversely, Northern Pike and Walleye diets were similar regardless of season or Muskellunge presence. Finally, lake- scale habitat variables were correlated with piscivore diets and Yellow Perch abundance was correlated with Walleye diets. Our results indicate that while Muskellunge, Northern Pike, Walleye, and Largemouth Bass can co-exist in a variety of lakes, populations of important prey and habitat variables should be examined before management actions (e.g., stocking) are implemented to ensure adequate prey availability and competition among these piscivores is not increased to the detriment of existing fisheries.

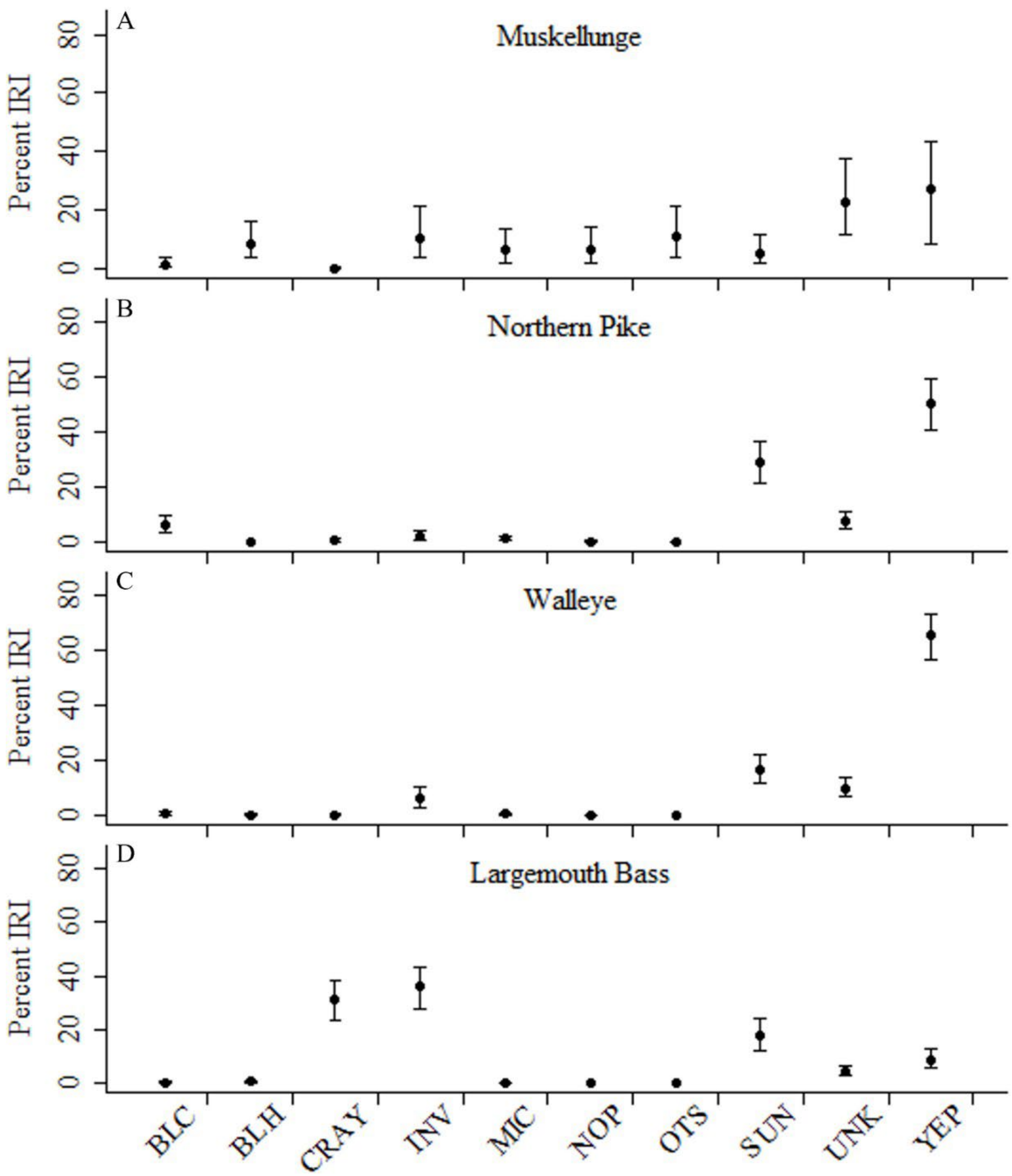


Figure 1. Percent Index of Relative Importance (IRI) of important prey taxa in diets of Muskellunge (A), Northern Pike (B), Walleye (C), and Largemouth Bass (D) in Minnesota Lakes. Error bars represent 95% confidence intervals calculated using bootstrapping methods with 1000 iterations. Prey taxa include Black Crappie (BLC), Bullheads *Ameiurus* spp. (BLH), crayfish (CRAY), other invertebrates (INV), *Micropterus* spp. (MIC), Northern Pike (NOP), catostomids (OTS), *Lepomis* spp. (SUN), unidentified fish (UNK), and Yellow Perch (YEP).

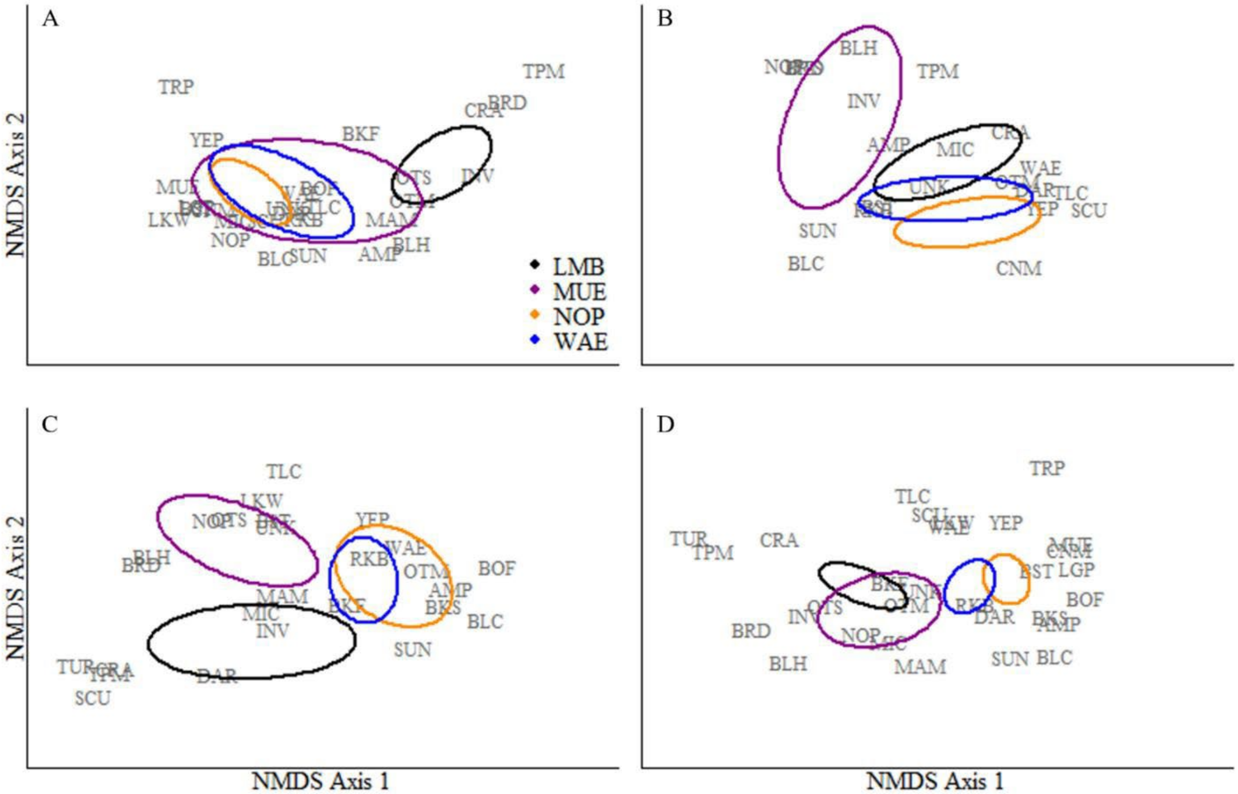


Figure 2. Non-metric multi-dimensional scaling (NMDS) ordinations of Largemouth Bass (LMB), Muskellunge (MUE), Northern Pike (NOP), and Walleye (WAE) diets in spring (A), summer (B), fall (C), and across seasons (D). Ellipses represent the 95% confidence interval centered on centroids of each species' overall diet in multivariate space and prey categories are presented in gray text.

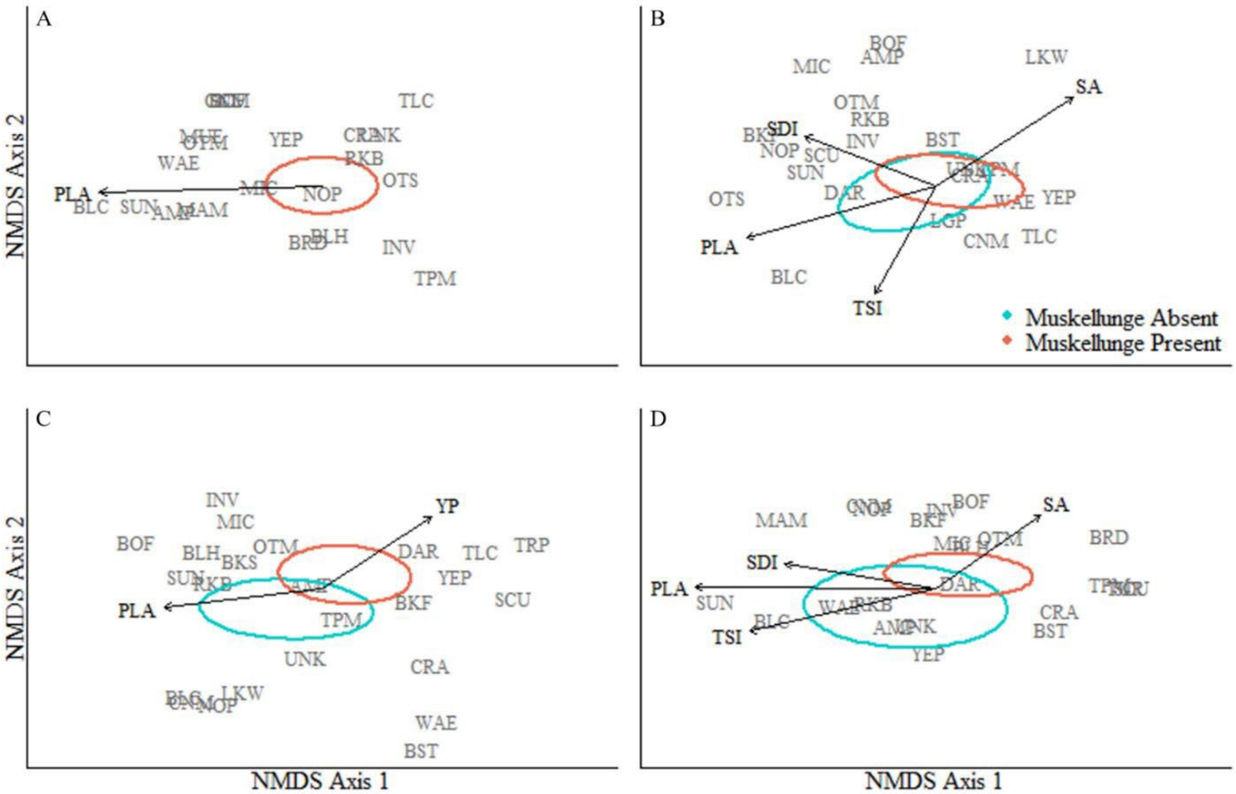


Figure 3. Non-metric multi-dimensional scaling (NMDS) ordinations of Muskellunge (A), Northern Pike (B), Walleye (C), and Largemouth Bass (D) diets in lakes with and without Muskellunge. Ellipses represent the 95% confidence interval centered on centroids of overall diets by lake type in multivariate space, black arrows represent environmental variables correlated with predator diets, and prey categories are presented in gray text. Significant environmental variables include percent littoral area (PLA), surface area (SA), shoreline development index (SDI), trophic state index (TSI), and Yellow Perch gillnet catch per unit effort (YP).

Glade, K.C., B.R. Herwig, T.D. Ahrenstorff, J.R. Reed, and A.W. Hafs. 2023. Diet patterns and niche overlap of Muskellunge and co-occurring piscivores in Minnesota lakes. *North American Journal of Fisheries Management* 43:656-676.

Project completed February 2023

Comparisons of Walleye Fecundity Before, During, and After Rehabilitation of the Red Lakes Fishery

Kamden C. Glade, Anthony J. Kennedy, Benjamin J. Miller, Benjamin D. Erb, Andrew L. Thompson, Andrew W. Hafs

The Red Lakes, Minnesota, supported a substantial Walleye *Sander vitreus* fishery from the early to mid-20th century, but experienced a major crash in the late 1990s. The population has since rebounded following a successful inter-agency recovery program and now supports valuable commercial and recreational fisheries. The variation in population densities associated with the collapse and subsequent recovery in the Red Lakes Walleye population provides a rare opportunity to study potential changes in relative fecundity (eggs/kg of body mass) under varying rates of exploitation: overexploited (1989 data), recovering (2004 data), and recovered (2017 data). Female Walleye were collected spring 1989 (n=30) in the Blackduck and Tamarac rivers and spring 2004 (n=30) and 2017 (n=30) in the Tamarac River. Results indicate relative fecundity was significantly lower in 2017 (50,768, SD=10,266) than in 1989 (58,216, SD=6,211) and 2004 (61,964, SD=7,472). We hypothesize differences in relative fecundity among fishery states were due to differences in Walleye population abundances caused by varying exploitation rates in the years leading up to fecundity estimates.

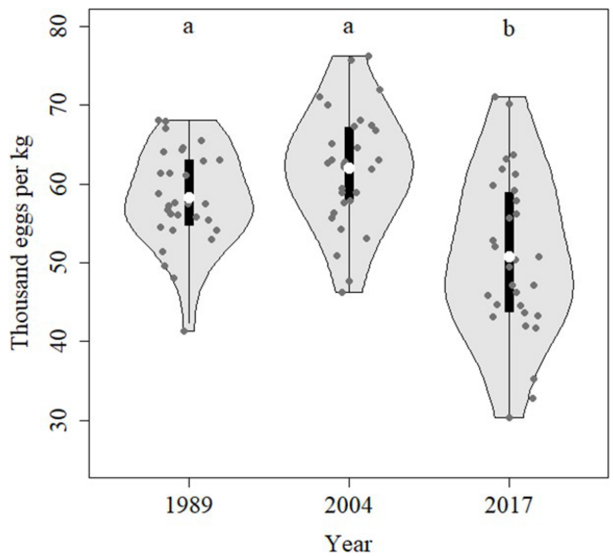


Figure 1. Violin plot of female Walleye *Sander vitreus* relative fecundity (thousand eggs per kg body mass) by year from the Red Lakes, Minnesota. Different letters indicate significant differences (one-way test, P<0.0001). Gray points represent individual observations, white points represent yearly means, and thick black bars represent interquartile ranges.

Glade, K.C., A.J. Kennedy, B.J. Miller, B.D. Erb, A.L. Thompson, A.W. Hafs. 2023. Comparisons of walleye fecundity before, during, and after rehabilitation of the Red Lakes Fishery. Journal of Fish and Wildlife Management. https://doi.org/10.3996/JFWM-22-047

Project completed October 2023

Environmental Influences on the Growth of Inland Cisco Populations in Three Sentinel Lakes

Edward Carlson, Casey Schoenebeck, Beth Holbrook, Andrew Hafs

Cisco *Coregonus artedi* are a pelagic cold-water fish that are widely distributed throughout many inland lakes across the northern Midwest and play an important role as forage for large piscivores. Inland Cisco populations have been observed to vary in their overall size and recruitment potential based on the system in which they are found. Since Cisco are sensitive to oxythermal stress, they are at risk from stressors such as climate change, land use, and invasive species which are ultimately changing aspects of lake ecosystems. To investigate how different factors were affecting the population dynamics of inland Cisco, three lakes with a range of size structure and densities were selected within Minnesota's northern lakes and forests and north central hardwoods ecoregions. Targeted, standardized, annual pelagic fish sampling was conducted from 2013-2019 using a combination of hydroacoustic sonar and vertical gillnets. Fish sampled in vertical gillnets were measured, weighed, and used to aid hydroacoustic estimates for Cisco abundance and biomass. In addition, metrics that describe the pelagic oxythermal habitat, food availability, and fish density were collected to understand the relationship between inland Cisco populations and different environmental factors. A total of 16 linear regression and mixed effect models were developed for two selected response variables: upper 95th % total length (mm) and standardized age-0 density (no · ha-m^{-3}). Cyclopoid copepod densities explained the most variability in the observed size differences found in Cisco ($t = 4.05$, var = 2796) while Cisco biomass best explained the variability amongst the age-0 density response variable ($p < 0.01$. $R^2 = 0.41$). Additionally, the number of growing degree days at dissolved oxygen of 3.0 mg/L explained variability in both selected response variables ($t = 2.36$, var = 3632; $p = 0.022$, $R^2 = 0.29$). The results from this study document the importance of zooplankton prey and oxythermal habitat on Cisco and therefore provide fisheries managers with further knowledge to help closely monitor these populations in order support large game species such as Walleye.

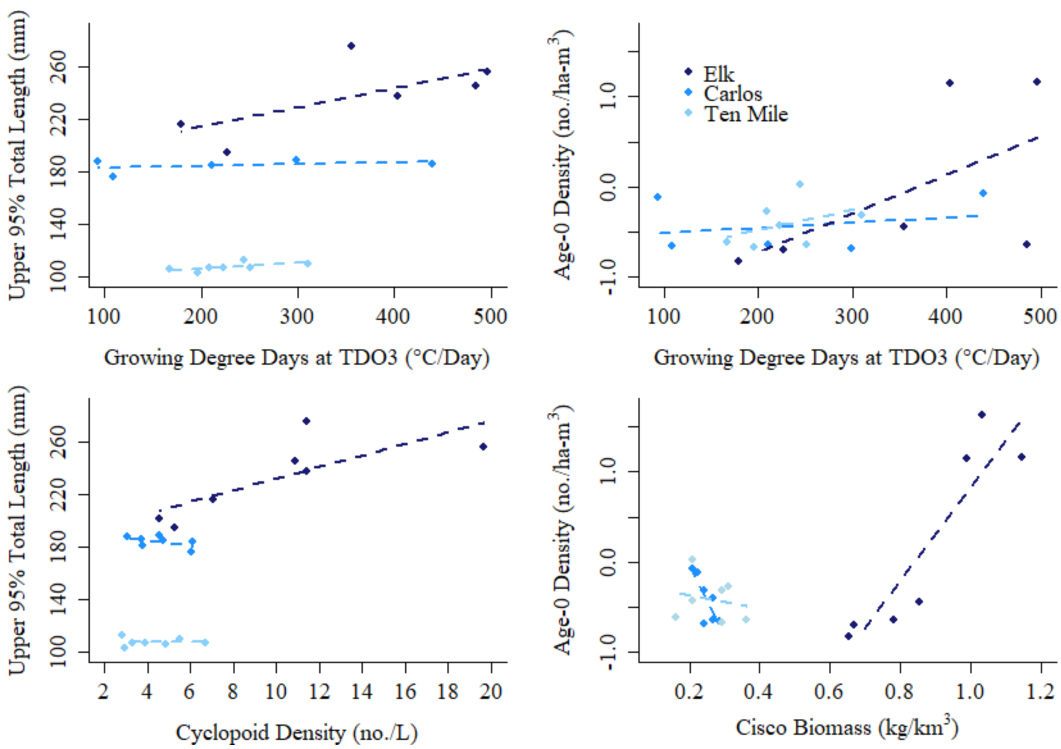


Figure 1. Individual predictor variables that explained a significant amount of the variation in both selected response variables of the upper 95% total length of age-1+ Cisco and standardized age-0 density. Significant variables included growing degree days where dissolved oxygen was 3.0 mg/L ($t = 2.36$, var = 3632; $p = 0.02$, $R^2 = 0.29$, average cyclopoid density ($t = 4.05$, var = 2795), and Cisco biomass ($p < 0.01$, $R^2 = 0.41$).

Project completed December 2022

Spatial and Temporal Variability of Mercury in Upper and Lower Red Lake Walleye

Tyler Orgon, Andrew Hafs, Carl Isaacson, Shane Bowe, Mark Brigham

Mercury is a global pollutant that is released into our environment by natural and anthropogenic processes resulting in extensive studies of mercury cycling in aquatic ecosystems, and the issuance of human-health-based fish-consumption advisories. We examined total mercury concentrations in Walleye *Sander vitreus* from Upper and Lower Red Lakes, located in north central Minnesota, between 2019 and 2020. Sampled Walleye ($n = 265$) ranged from 158 to 610 mm in total length from an age range of 0 to 16 years. Mercury concentrations within the Red Lakes ranged from 0.030 mg/kg to 0.564 mg/kg ($\bar{x} = 0.179 \pm 0.105$ mg/kg; $\bar{x}$ = mean ± sd, all fish-mercury concentrations expressed in wet-weight). The best supported model for predicting mercury concentrations in Red Lake Walleye included the independent variables: length, age, sex, and lake basin. This model indicated that basin is an important predictor variable for estimating mercury concentrations between Upper and Lower Red Lake Walleye (Figure 1; $\bar{x} = 0.215 \pm 0.117$ and 0.144 ± 0.077 mg/kg, respectively), and also suggests that individuals who rely on fish for subsistence should target ≤ 400 mm Walleye from Lower Red Lake (Figure 2). The observed differences in mercury concentrations could be linked to wetland area, fish growth rates, and physicochemical parameters between the two basins. After adjusting for length as a covariate, Upper and Lower Red Lake exhibit fish-mercury concentrations comparable to other large lakes within the region. Given that our results illustrated a significant difference in fish-mercury concentrations between basins, future pollutant monitoring efforts should treat Upper and Lower Red Lake as separate lakes and not assume that data from one basin can apply to the other. This will be important over a longer time scale as ecosystems respond to changes in mercury emissions and other environmental changes.

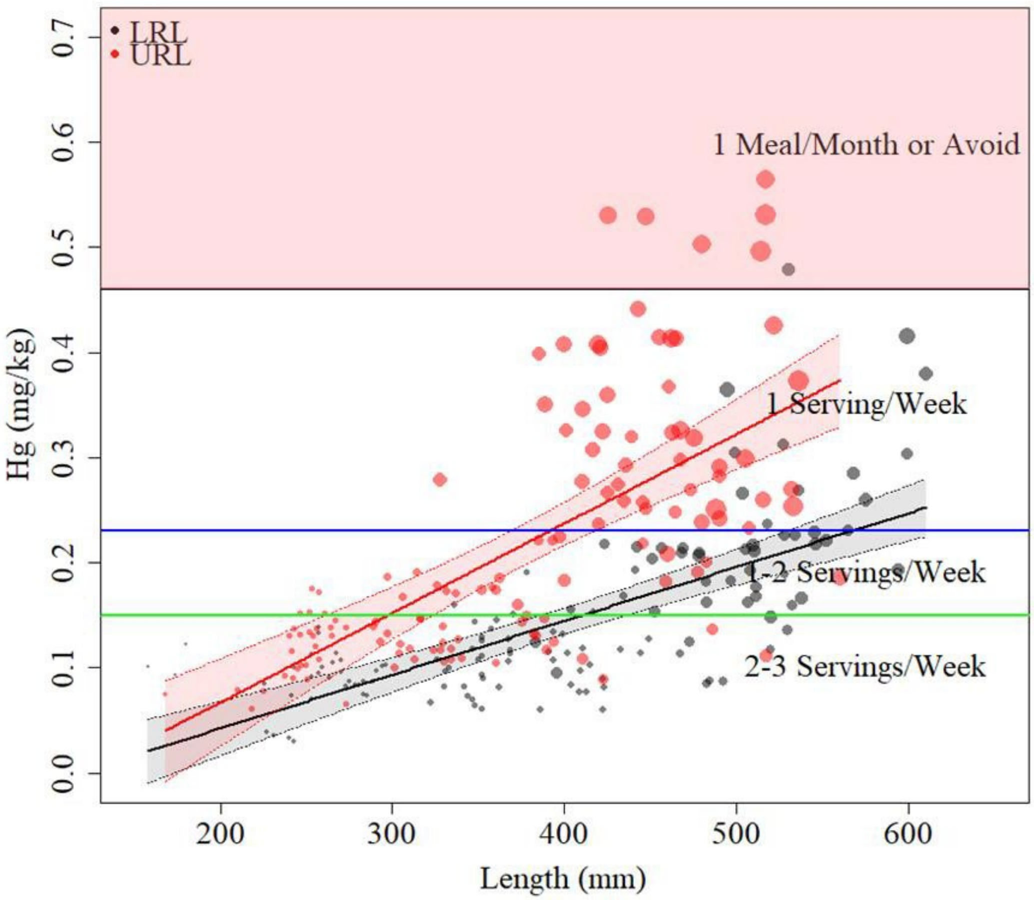


Figure 1. Mercury concentration (by wet weight) from Upper (URL) and Lower (LRL) Red Lake Walleye. Points are weighted based on age on individual Walleye and horizontal-colored lines indicate the current fish-based consumption advisory set by the US EPA.

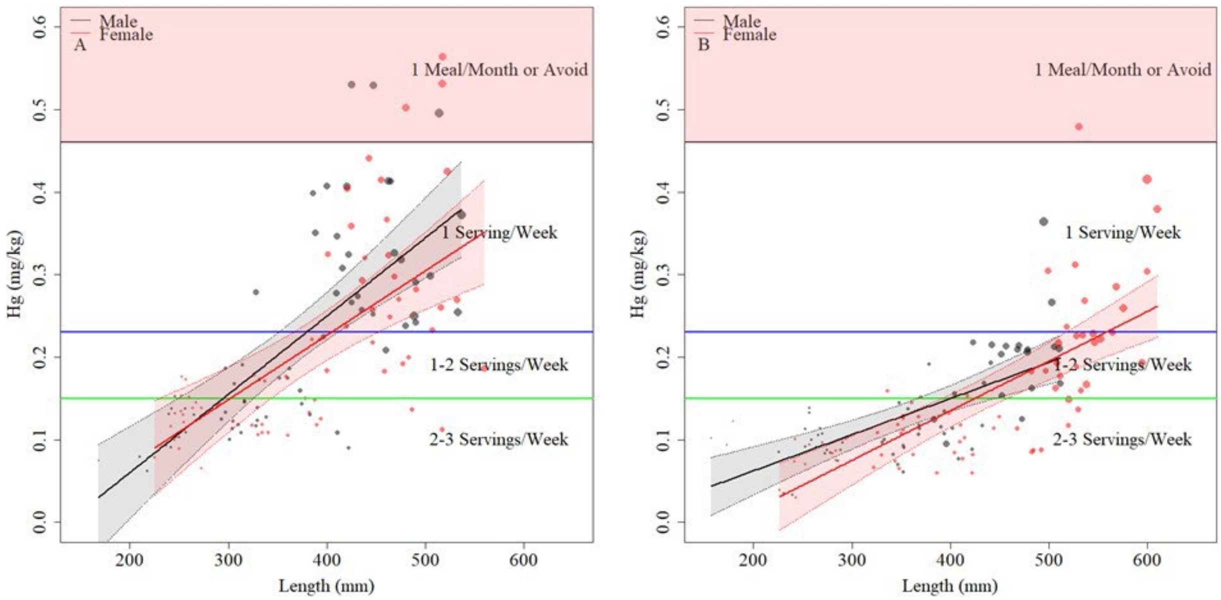


Figure 2. Upper (left) and Lower (right) Red Lake Walleye mercury concentrations (by wet weight) separated by sex (males in black, females in red). The points are individual Walleye that are weighted based on age, and horizontal lines illustrate the fish-based consumption advisory set by the US EPA.

Orgon, T.J., A.W. Hafs, C.W. Isaacson, and S.E. Bowe. 2023. Spatial and temporal variability of mercury in Upper and Lower Red Lake walleye. *Ecotoxicology* 32:811-823.

Project completed January 2022

Effects of Shallow Lake Condition Shifts on Habitat, Zooplankton, and Yellow Perch Population Dynamics

Alicia Skolte, Casey Schoenebeck, Andrew Hafs

Aquatic ecosystems around the world exist on a continuum between turbid, algal-dominated and clear, macrophyte-dominated conditions, which may influence population dynamics of fish in these systems (such as Yellow Perch *Perca flavescens*). Since turbidity influences the amount of light penetration and occurrence of vegetation, spawning and nursery habitat as well as food availability may change depending on lake condition. For example, a decrease in turbidity encourages a shift in the prevalent zooplankton taxa from *Bosmina* spp. to *Daphnia* spp. We hypothesize many factors associated with a condition shift may combine to influence Yellow Perch, including increased abundance and therefore, intraspecific competition resulting in a reduced length and body condition. We used long-term monitoring data from Lake Shaokatan, Minnesota to examine whether a rarely documented condition shift from a turbid, algal-dominated to a clear, macrophyte-dominated condition occurred in 2014 and whether that shift influenced population dynamics of Yellow Perch, including relative abundance (gillnet CPUE), mean total length (mm), and mean relative weight. A condition shift from turbid to clear was determined in 2014 using mixed effects models that showed significant decreases in phosphorous and chlorophyll-a concentration as well as an increase from a mean of 22% to over 90% vegetation occurrence. The zooplankton community qualitatively showed a prevalence of *Daphnia* spp. and Cyclopoids over small cladocerans during the clear condition period until

2018. Mixed effect models were also used to determine the shift to a clear condition resulted in a significant decrease in Yellow Perch mean total length and relative weight. Therefore, the condition shift and resulting habitat changes that occurred in 2014 and later influenced the size and condition of Yellow Perch. Continued monitoring may overcome variability in relative abundance and help elucidate emerging trends.

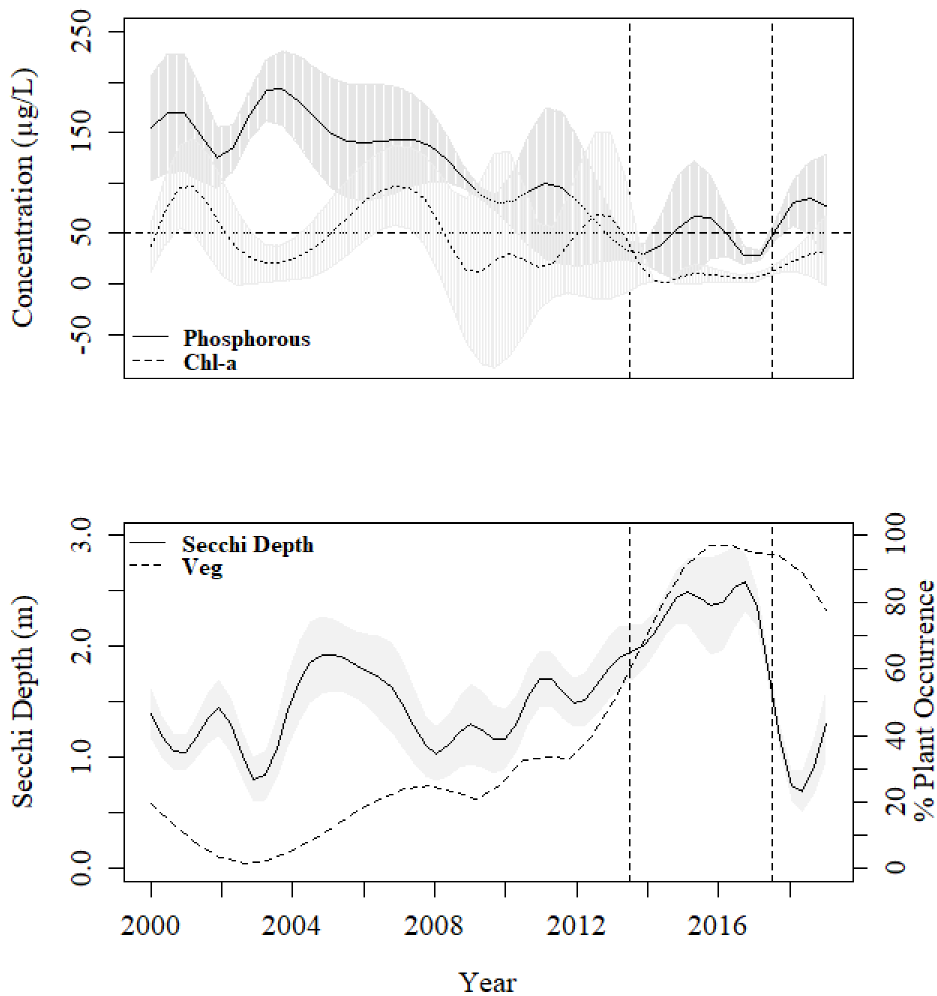


Figure 1. Annual averages of total phosphorous and chlorophyll-a concentration (µ/L) collected April-November, Secchi depth (m) collected May-October, and percent vegetation occurrence in August from 2000 to 2019 in Lake Shaokatan, Lincoln County, MN. Shaded regions represent 95% confidence intervals. Dashed black line prior to 2014 represents condition shift from turbid to clear condition based on thresholds (shown by horizontal dashed line) determined by Vitense et al. (2018). Dotted black line prior to 2018 represents a potential shift to be further monitored.

Skolte, A., C.W. Schoenebeck, and A.W. Hafs. 2022. Effects of a shallow lake condition shift on habitat, zooplankton, and yellow perch dynamics. *North American Journal of Fisheries Management* 42:659-667.

Project completed December 2021

Assessing the Dispersal and Recruitment of Stocked Walleye Fry in a Northern Minnesota Chain of Lakes

Joseph W. Amundson, Heather Marjamaa, Andrew W. Hafs, Anthony J. Kennedy, Richard W. Koch

Little is known of the dispersal habits of stocked Walleye fry, especially in a chain of lakes. Assessing the dispersal and quantifying the contribution of stocked Walleye fry is difficult, as conventional fish marking methods are inadequate due to small size of fry at the time of stocking. Chemical marking is a viable alternative, done by fry immersion in an oxytetracycline hydrochloride (OTC) solution. OTC marks are identifiable up to and even beyond four years after immersion using epifluorescent microscopy which results in a golden-yellow fluorescent mark on calcified structures. Using these marking and detection methods, marking rates of age-0 Walleyes were similar throughout the years in each of the study lakes. Within the Chain, relative abundance of OTC marked fish was highest in Andrusia each year, followed by Wolf, Cass and Kitchi (Figure 1). Pike Bay had one marked fish captured during standard sampling (2016) and Big did not have a marked fish captured (Figure 1)). Marking rates within the Chain where highest in Andrusia each year, followed by Cass, Wolf and Kitchi (Figure 1). Yearly (2016-2018) marking rates within the Chain lakes were consistent, Andrusia (96-99%) having the highest rate each year followed by Cass (80-97%), Wolf (25-39%), and Kitchi (0-24%; Figure 1). Although year class strength varied yearly within the chain, marked fish represented 71 to 79% of fish sampled. The results of this study have shown that fry stocked into Andrusia have the capabilities to disperse throughout the Chain, downstream and upstream, during the first three months of life. Subsequently, OTC marked cohorts (2016 -2018) were captured via gill nets at nearly the same marking rate as they were captured at age-0. Although there seems to be no advantages between marked and unmarked fish in growth or condition in each lake, marked fish made up the majority of each cohort. Growth modeling across distance from stocking site showed total lengths of marked fish increased as total CPUE declined (Figure 2), suggesting some degree of density-dependent growth Chain wide but it is currently unknown if those differences are biologically significant.

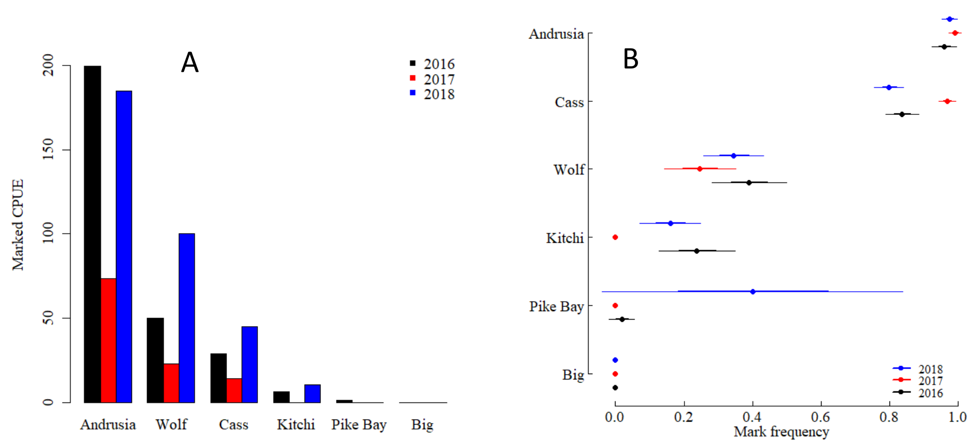


Figure 1. A) Total catch-per-unit-effort (fish/hour) of OTC marked age-0 Walleye of all study lakes, 2016-2018, during late August through early September assessment. B). Age-0 Walleye OTC marking frequency of all fish analyzed for each lake by year. Dot represents marking frequency with lines representing one and two standard errors.

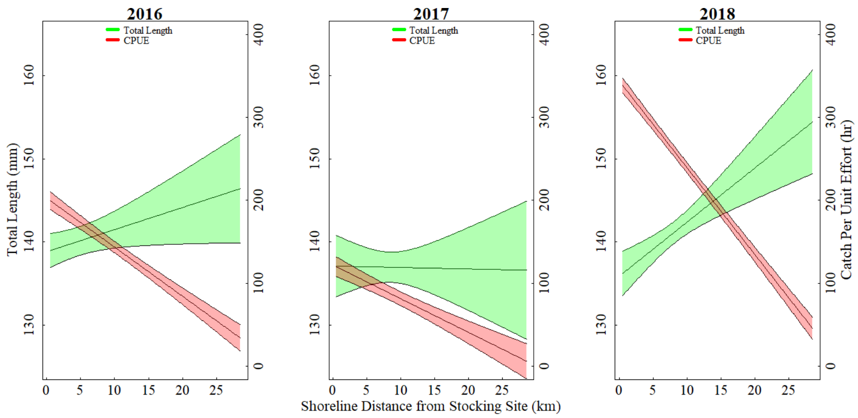


Figure 2. Predicted total length (TL) in millimeters (mm) and predicted total catch-per-unit-effort (CPUE) each year as a product of shoreline distance (km) from stocking site.

Project completed October 2021

Spatial and Temporal Variability in Post-Larval Yellow Perch Density

Steve Hauschildt, Andrew Hafs, Carl Isaacson, Debbie Guelda

Yellow Perch *Perca flavescens* are important as forage for other species and for sport fishing in many northern lakes. However, estimating post-larval Yellow Perch populations can be difficult because of many environmental factors that cause unexplained variation. The objective of this study was to help reduce unexplained variation by determining a post-larval Yellow Perch population density estimate on Blackduck Lake, MN, provide guidance to help determine the number of trawls required for trawling-based recruitment indices to achieve varying levels of precision, and test for the effects of wind speed and direction on post-larval Yellow Perch spatial variability. This study estimated a density of 0.45 fish/m^3 (0.58 SD) during the sampling period (26 Jun – 07 Jul 2017). It was determined that between 10-15 trawls produced a precise density estimate; however, trawls should be taken over multiple days in varying wind speeds to avoid over/under estimation. Trawling should also be performed in-line with wind direction to ensure non-bias estimates are calculated from both upwind and downwind sectors. This study determined wind speed and direction had a significant influence on the distribution of post-larval Yellow Perch, as more fish were caught in the downwind sector until winds reached 15 kmph. At 15 kmph, fish densities were equal in the upwind and downwind sectors of the lake. Wind did not have a significant influence though on how post- larval Yellow Perch were distributed by total length. During high wind events, more fish were found in the upwind sector of the lake, suggesting that post-larval fish are being moved out of non-towable areas. From the results of this study it appears Yellow Perch must continually relocate back into shallow areas after each high wind event moves them out of the non-trawlable areas, until they are strong enough to resist the wind.

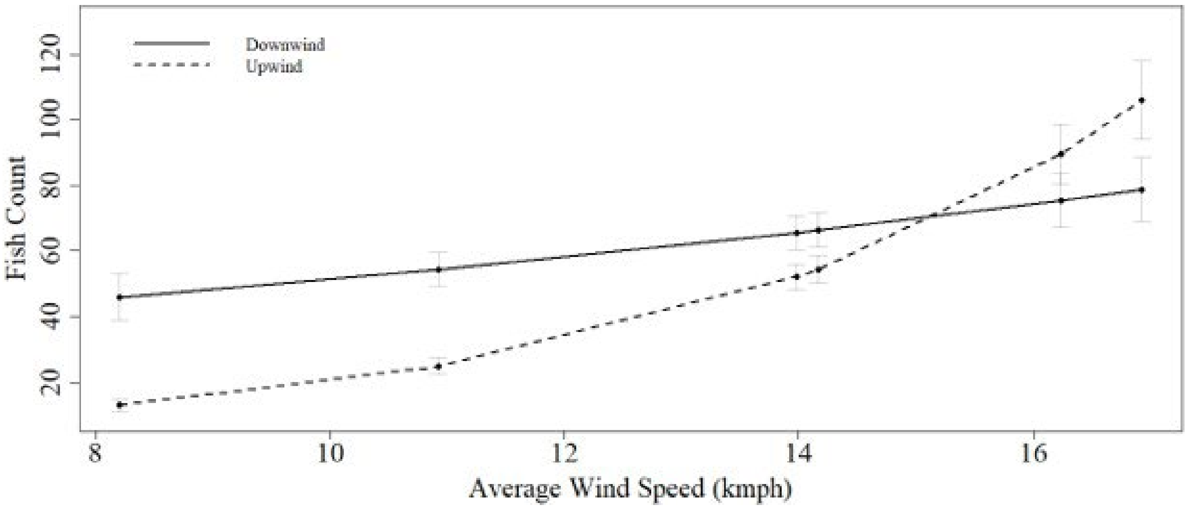


Figure 1. Change in predicted mean fish count in the upwind and downwind sectors of Blackduck Lake, as affected by varying wind speeds (kmph) during the 26 Jun – 07 Jul 17 sampling period. Error bars represent standard error.

Project completed January 2019

Michigan WTC Update

Submitted by Jason Gostiaux

Production

Life stage	Fish stocked	Number of systems
Fry	5,627,807	6
Spring fingerling	2,214,715	64
Fall fingerling	17,844	18

Research

1. A post-construction assessment of Coreyon Reef (Saginaw Bay) research has concluded. Walleye spawning was documented on the new reef. Additionally, the reef has been resisting sedimentation and overly saturated with Dreissenid mussels. Graduate student Scott Koenigbauer from Purdue has led this effort and it is expected that a manuscript will be published in the future.
2. An outgrowth of the Coreyon Reef work was to run some genetic analysis on the reef spawners and relate them to other known walleye genotypes in the Great Lakes. That work is being done by Scott and Peter Euclid who is now at Purdue also.
3. There is a Great Lakes invasive mussel work group that is coordinating new research to demonstrate the ability to clear Dreissenid mussels from rock reef habitat using molluscicides and other experimental control technologies. Two candidate locations have been selected including Tawas Reef in Saginaw Bay, and the restored reef complex in Thunder Bay. It is expected that walleye (among other species) may be the beneficiaries of such work if ever implemented on a larger scale.
4. While routine, Michigan DNR maintains numerous Walleye and Percid related surveys:
    a. Saginaw Bay fish community netting survey (since 1971)
    b. Walleye jaw tagging study and Brownie model (since 1981)
    c. Saginaw Bay (stock) of walleyes statistical catch-at-age (SCAA) model
    d. Saginaw Bay walleye population and fishery simulation model
5. USGS Great Lakes Science Center sampling in 2023 revealed the highest walleye density on egg mats in the Detroit River in their 20 years of sampling and a higher-than-average density in the St. Clair River.
6. A telemetry study in Saginaw Bay investigating sources of walleye reproduction is underway and the first year of telemetry data is being analyzed.

Management

1. An updated management plan for walleye and yellow perch in Saginaw Bay is going through internal review. Next steps include public review and approval by the fisheries chief and director of the DNR.

2. Some DNR fisheries management units are continuing to stock and evaluate spring vs fall fingerling walleye.
3. The Michigan Walleye Technical Committee held a two-day meeting earlier in January 2024 and agenda topics included:
    a. Walleye production
    b. Influence of biotic and abiotic factors on walleye recruitment
    c. Fall fingerling stocking
    d. OTC and genetic sampling
    e. Harvest regulations
    f. Implementing top priorities of the Inland Lake Walleye Management Plan

The Michigan DNR's Tribal Coordination Unit will begin implementing a long-term walleye monitoring program in 2024 focusing on seven lakes within the 1836 Ceded Territory (four in the Lower Peninsula, three in the Upper Peninsula). Currently, there is a lack of long-term data on individual inland walleye populations in Michigan and the protocols that have been established will allow the collection of long-term data over the next 20 years. The goal of this program is to examine relationships between population trends and both biotic and abiotic data to better understand walleye populations in selected lakes and apply those results to walleye management in Michigan. The surveys planned for this program include annual temperature logging, fall walleye surveys, and limnological profiles as well as walleye population estimates, Status & Trends (fish community) surveys, and water quality monitoring on a five-year rotation.

IL WTC Report, February 2024, submitted by Jason DeBoer INHS

Jeremiah Haas, Constellation Nuclear

We initiated a new RAS system for the 2023 season, instead of using the spray canal as a fish rearing pond. We had a 53% recovery rate for the 3-15000 gallon tanks (first tank thinning was at 1.75") and ultimately stocked 235,000 walleye in Pools 13 & 14.

A portion of those fish were given a liquid nitrogen freeze brand. Fall stock assessment later showed the RAS system walleyes did extremely well in the Mississippi River. They were a significant portion to the young-of-year population.

Logan Grimm, Sportfish Ecology Lab, Illinois Natural History Survey

Since 2019, the Sportfish Ecology Lab at the Illinois Natural History Survey has been collaborating with the Illinois DNR to better understand walleye, sauger, and saugeye populations in Central Illinois lakes. Our main objectives are to investigate the comparability of otolith and whole dorsal spine age estimates, validate otolith and dorsal spines through oxytetracycline (OTC) detection, and create age-length keys. To complete these objectives, we have utilized two survey methods, fyke nets, and night DC electrofishing surveys.

In the spring of 2023, fyke nets were used to survey four lakes (Dawson Lake, Lake Shelbyville, Clinton Lake, and Weldon Springs). These surveys consisted of six overnight fyke net sets. In total we captured 7 saugeye. To improve catch rates during our fall surveys, we sampled at night by DC electrofishing. These electrofishing surveys consisted of four 15-minute transects and occurred on six lakes (Lake Shelbyville, Dawson Lake, Lake Bloomington, Lake Decatur, Evergreen Lake, and Weldon Springs). Each lake was surveyed twice within the fall season. Catch totals for these surveys were 103 walleye, 9 sauger, and 81 saugeye. Regardless of survey type, length and weight were recorded and the second dorsal spine was removed for aging. Previous stocking of OTC marked fish occurred in Lake Bloomington, Lake Decatur, and Evergreen Lake. Fish within a predetermined size bin on these waterbodies were sacrificed for dissection and otolith removal.

As we begin to work through our data from this past year, we are seeing comparable age estimates between otoliths and whole dorsal spines. Currently, we are attempting to increase sample sizes to create robust age-length keys. To date, we have been unable to detect any OTC , but will continue efforts into the 2024 field season.

Nerissa McClelland, Illinois DNR

The IL Fish Hatchery system stocked 3.8 million sauger (0-2") into the upper Peoria, Starved Rock and Marseilles pools of the Illinois River in 2023.

State of Indiana Walleye Report

District 1 North West-

Wolf Lake fall electrofishing survey collected a total of 40 walleye ranging from 10.8 inches to 27 inches.

Fish Stockings *(last 5 years)*

Year	Species	Number	Average Length	Source
2023	Walleye	2,400	6.0	Perch America
2022	Walleye	2,554	5.3	DFW
2022	Walleye	2,100	6.5	Perch America
2021	Walleye	4,385	4.1	DFW
2021	Walleye	2,200	5.0	Perch America
2020	Walleye	2,200	6.0	Perch America
2019	Walleye	2,500	5.5	Perch America

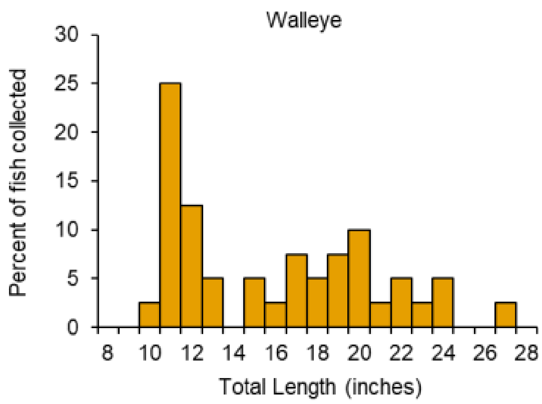


Figure 1. Walleye length frequency.

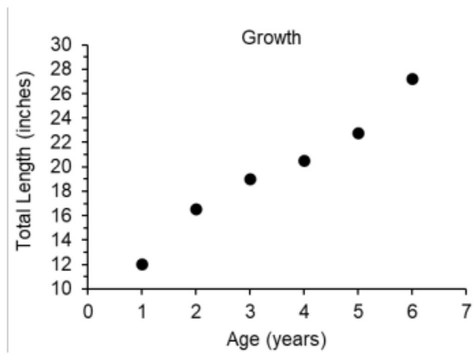


Figure 2. Walleye average length at age.

Pine and **Stone Lakes** are in Laporte County and connected via channel. Pine Lake fall electrofishing survey collected a total of 32 walleye ranging from 6.9 inches to 16.9 inches. Stone Lake fall electrofishing survey collected a total of 13 walleye ranging from 9 inches to 15.6 inches.

Fish Stockings (*last 3 years*)

Pine Lake

Year	Species	Number	Average Length
2021	Walleye	4,926	6.2
2022	Walleye	6,172	4.8
2023	Walleye	3,610	6.2

Stone Lake

Year	Species	Number	Average Length
2021	Walleye	1,215	6.9
2022	Walleye	1,312	5.0
2023	Walleye	1,062	4.3

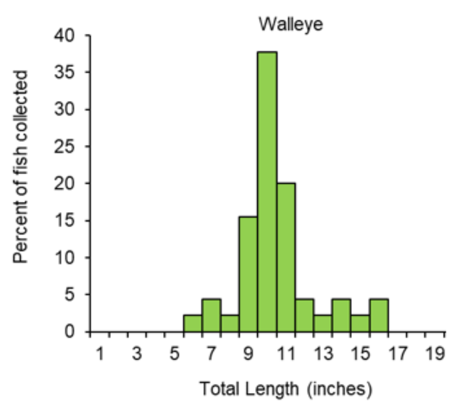


Figure 1. Walleye length frequency.

District 2 North East-

Big Turkey Lake fall electrofishing survey collected a total of 14 walleye ranging from 19.2 inches to 25.6 inches.

Big Turkey Stockings			
Year	**Species**	**Number**	**Average Length**
2019	Walleye	500	8
2022	Walleye	4,523	5.1
2023	Walleye	2,339	4.86

Pretty Lake fall electrofishing survey collected a total of 34 walleye ranging from 8.9 inches to 22.3 inches.

Pretty Lake Stockings			
Year	**Species**	**Number**	**Average Length**
2021	Walleye	1,840	7
2022	Walleye	1,852	7.63
2023	Walleye	1,472	7.5

Adams Lake fall electrofishing survey collected a total of 16 walleye ranging from 10.4 inches to 19.4 inches.

Adams Lake Stockings			
Year	**Species**	**Number**	**Average Length**
2021	Walleye	3,080	7
2022	Walleye	3,169	5.62
2023	Walleye	3,080	7

Atwood Lake fall electrofishing survey collected a total of 21 walleye ranging from 10.6 inches to 13.8 inches. First survey after initial walleye stockings in 2022.

Atwood Lake Stockings			
Year	**Species**	**Number**	**Average Length**
2022	Walleye	1,700	7
2023	Walleye	1,700	7

District 3 North Central-

Loon Lake fall electrofishing survey collected a total of 45 walleye 12.4 inches to 20.50 inches.

Loon Lake (Whitley) Stockings			
Year	**Species**	**Number**	**Average Length**
2020	Walleye	1,500	6
2021	Walleye	1,500	7
2022	Walleye	2,348	5.18

Winona Lake fall electrofishing survey collected a total of 88 walleye sizes were 7.4 inches up to 21 inches.

Winona Lake Stockings			
Year	**Species**	**Number**	**Average Length**
2021	Walleye	5,200	7
2022	Walleye	4,974	7
2023	Walleye	3,653	7

District 4 Central- nothing to report.

District 5 South Central- nothing to report.

District 6 South-

Fisheries biologists conducted a young of year walleye nighttime electrofishing survey at Patoka Lake in November. Biologists collected a total of 23 walleye ranging in lengths from 7 to 26.1 inches with the largest weighing 7.8lbs. Average length was 15.5 inches.

East Fork SFH-

248,457 Walleye fingerlings stocked 1.49in stocked at Cagle's Mill, Summit, Prairie Creek, Kokomo, Lake of the Woods, and Pike.

81,181 hybrid walleyes (Saugeye) at 1.52in stocked at Glenn Flint, Sullivan, Huntingburg and Koteewi Park.

Cikana SFH-

TABLE 2: 2023 WALLEYE FRY PRODUCTION / STOCKING

Location	Assignment	Number stocked	(Number Needed)/+Surplus
Cikana	540,000	561,650	21,650
East Fork	1,050,000	1,052,800	2,800
Driftwood	0	0	0
Brookville	10,520,000	10,546,800	26,800
Monroe	6,450,000	6,414,325	(35,675)
Patoka	6,000,000	5,238,150	(761,850)
Bass Lake	807,000	810,750	3,750
Mississinewa	488,000	493,500	5,500
Shafer	775,000	781,375	6,375
TOTAL	**26,630,000**	**25,899,350**	**(730,650)**

TABLE 3: CIKANA WALLEYE FINGERLING POND PRODUCTION 2013 - 2023

YEAR	ACRES	NUMBER STOCKED	NUMBER HARVESTED	% RETURN	% RETURN RANGE	AVERAGE LENGTH	AVERAGE DAYS IN POND
2013	9.7	730,850	285,057	39.0	0.01-69.7	1.5	39
2014	9.2	705,000	209,809	29.8	12.9-56.6	1.67	38
2015	10.1	744,550	318,321	42.8	9.4-58.3	1.44	37
2016	7.4	566,350	185,384	32.7	16.4-41.9	1.55	36
2017	6.5	487,500	180,331	37.0	11.1-55.3	1.55	37
2018	5.5	425,250	61,519	14.5	1.2-25.4	1.54	35
2019	8.4	629,850	217,854	34.6	2.1-48.7	1.4	38
2020	Cancelled due to COVID-19 (Will not be included in the 10 YR AVE.)						
2021	8.8	663,875	207,954	31.3	13.3-40.3	1.32	36
2022	6.9	517,000	115,462	22.3	1.0-44.4	1.59	36
2023	7.2	561,650	131,639	23.8	0-51.2	1.34	40
10 YR AVERAGE	**8.0**	**603,187**	**191,333**	**31.7**	**0.0-69.7**	**1.48**	**37**

Fawn River SFH-

13 ponds were drained in fall of 2023 at Fawn River State Fish Hatchery. Overall, the sizes of fish had improved from 2022, but the numbers decreased. A total of 7 lakes were stocked with these fish across the northern part of the state. In 2024, there will be continued experimentation with Fish and Wildlife ponds for minnow and possible walleye production.

Water	County	Number	Size (in)
Big Turkey	Lagrange	2,339	4.86
Crooked	Steuben	3,257	5.33
Maxinkuckee	Marshall	14,832	6.36
Pine	Laporte	610	4.33
Shriner	Whitley	1,008	4.72
Stone	Laporte	1,062	4.33
Wall	Steuben	1,290	6.39
		24,398	5.83

Year	Fingerlings	Start Size	% return	Ave-Length (in)	Total Fish	Fry	% return	Ave Length (in)	Total Fish	Total Fish
2021	157,417	1.42	16%	4.52	25,002	119,852	1.45%	6.48	1,736	26,738
2022	194,806	1.91	21.6%	5.4	42,104					42,104
2023	185,401	1.51	13.2%	5.83	24,398					24,398

Ball State University Hatchery Ponds

The Indiana DNR and Ball State University are currently working together on building a fish hatchery. This hatchery would contribute to the Advanced Walleye Program by raising fathead minnows on site, as well as helping with other rehab projects by raising other gamefish. Currently, data is being collected at possible site for hatchery ponds at Ball State. A survey will be conducted to map out entire area of site including roads, topography, and utilities to justify a budget. An in-house water quality test was completed to look at 2 wells on site and a pond near site. Parameters being tested were ph, total nitrogen, total phosphorus, alkalinity, hardness, and total dissolved solids.

Parameters	pH	TN	TP	Alk	Hardness	TDS
Unit		mg/L as N	mg/L as $PO4^{3-}$	mg/L as $CaCO_3$	mg/L as $CaCO_3$	mg/L
Well at Cooper Farm (W1)	7.7	6	1.03	115	119.7	225
Well near Bethal (W2)	7.5	10	2.99	114	119.7	200
Pond at Heron Pointe	8.0	4	0.32	120	154	200

Midwest Walleye Challenge (Indiana)

- Mobile App **MyCatch**
- New Design for 2024
  - Incentivize data for underrepresented waterbodies.
  - Implement a free option to see how anglers respond to this second option.
  - Introduce random and hidden length prize categories.
- 12 US States and 2 Canadian Provinces
- Entries from all states will compete for the grand prize.

Nebraska Walleye report for 2024 Winter Business Meeting.
Prepared by Joe Rydell

Nebraska experienced one of the worst winters in History in 2022-2023 resulting in extreme cold and record snow fall for the area. Areas that typically get 2 to 3 feet of snow a season documented over 7 feet this winter. The impacts from the winter resulted in numerous winterkill events in the Nebraska sandhills. Only one lake in the list of waterbodies with winterkill included a walleye fishery. Several of the lakes with winterkill included yellow perch fisheries. Island Lake on the Crescent Lake NWR in Garden County was the only sandhill lake that appears to be a complete winterkill, losing largemouth bass, walleye, yellow perch, crappie, bluegill, and even common carp. Most winterkill events hit the largemouth bass and bluegill populations the hardest. Most lakes had some survival of yellow perch although smaller, younger fish appeared to survive better than larger perch.

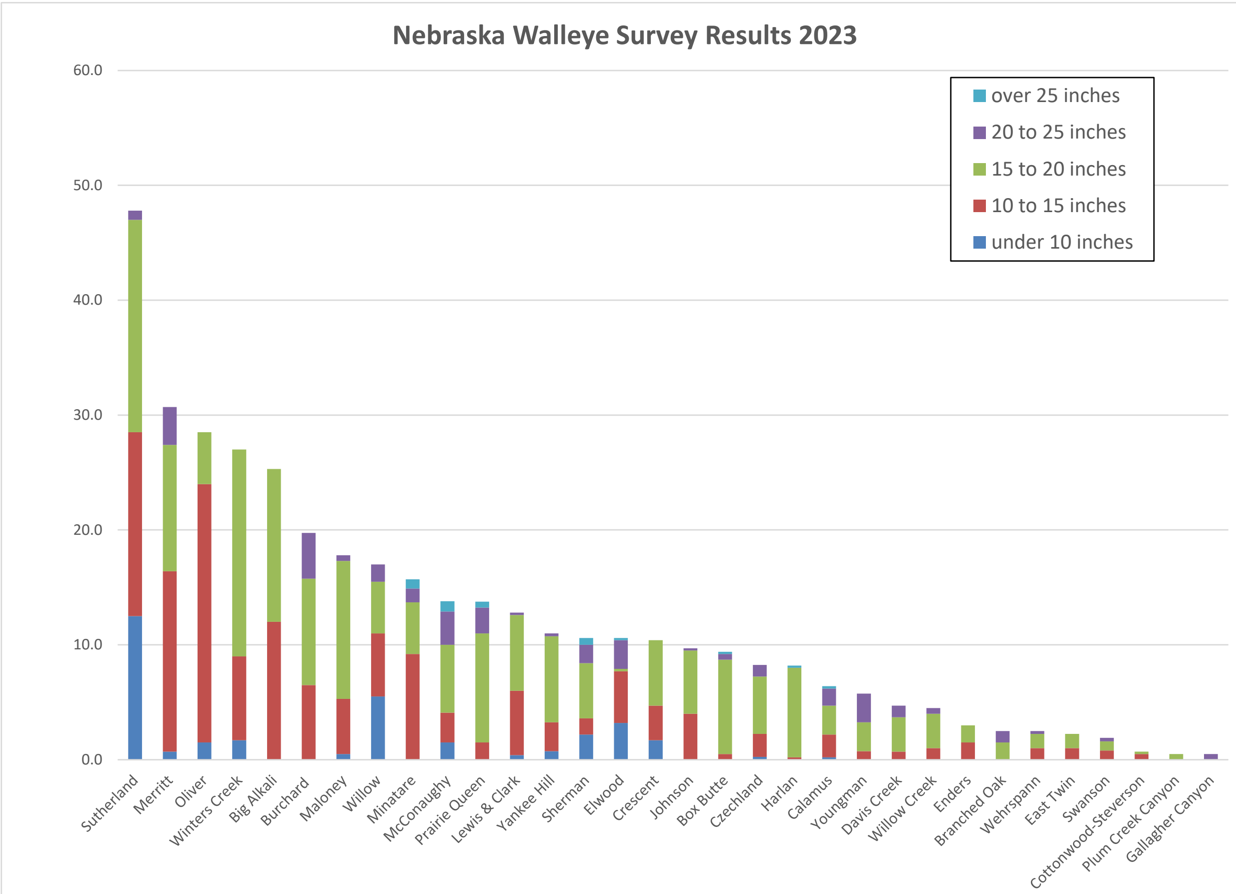
The excessive winter did appear to impact the Alewife populations in a couple of Nebraska's top walleye fisheries reducing some of the adult Alewife. Small mesh gillnets set at Lake McConaughy indicated a lower adult Alewife catch in 2023 compared to 2022. Merritt Reservoir in Cherry County and Lake McConaughy had a tremendous walleye harvest year likely as a response to declines in available prey. Overall, walleye catch and harvest appeared to be above average according to angler reports on most waterbodies.

Walleye Stockings in 2023.

Walleye production in Nebraska was another great year. Walleye, Sauger, and Saugeye were produced this year. A total of 1,137 female walleye were spawned producing 142,125,000 eggs from Sherman and Merritt in 7 days of netting. The majority of the eggs were collected at Merritt where 910 females were spawned in 4 days of effort. Hatch rates ranged from 1.4 to 1.6 quarts per female.

Walleye	
Fry Stockings	25,334,000
Fingerling Stocking (1-2")	2,602,407
Fingerling Stocking (3.5")	3,688
Fingerling Stocking (8")	35,149
Saugeye	
Fingerling (1-2")	448,786
Fingerling (3")	14,316
Fingerling (8")	13,937
Sauger	
Finglerling (1-2")	116,697

Walleye Surveys



Walleye survey results across Nebraska showed some good populations of walleye. Five lakes had catches over 20 walleye per gillnet. Sutherland Reservoir had the highest catch with two strong year-classes making up much of the population. Lake McConaughy, Minatare, Prairie Queen, and Sherman all had good catches of fish over 25 inches.

No new walleye regulations have been imposed in 2023.

Walleye Research

Lake McConaughy continues to be the highlight of walleye research in Nebraska. A creel survey was conducted on the Dam during the walleye spawn in April and May 2023. The goal of the spawn was to see if the harvest on the dam during walleye spawn was significant enough to consider closing the dam to angling pressure as requested by a group of anglers. Anglers came from 7 different states and 25 counties within Nebraska to fish the dam during the months of April and May. Most of the pressure occurred in April during the peak spawning activity. During both months, bank anglers had higher catch rates than boat anglers while harvest was similar between the two groups. Overall anglers harvested mostly smaller male walleye between 17 and 24 inches and released females.

Other research on Lake McConaughy included assessment of abundance and a diet analysis of Alewife as well as evaluating contributions of Walleye fry and fingerling stockings. Alewife were introduced into Lake McConaughy in 1986 as a supplemental forage fish and quickly became the forage for piscivores in the reservoir. Alewife can have negative influences on the ecosystem through predation of YOY fish and altering the zooplankton community. Alewife relative abundance in the nearshore areas of Lake McConaughy displayed temporal trends across the study. Alewife abundance was low in May, peaked in June, and declined again in July in both years. Over 1,800 Alewife stomachs were collected over the course of the study. There was no evidence of piscivory and Alewives almost exclusively consumed zooplankton. Given the lack of piscivory it is unlikely that Alewife predation is a factor strongly influencing Walleye recruitment. However, the degree of zooplankton consumption suggests the potential for Alewives to indirectly compete with YOY Walleye for food resources.

Looking at approximately 200 age-0 walleye in 2022 and 2023, fingerling stocked fish had the greatest contribution to the fall age-0 catch in both years. Additionally, there was higher than-average natural recruitment observed in both 2022 and 2023. There were little differences observed in total length and body condition observed between fry and fingerling stocked individuals.

Stocking assessments were also conducted on Sherman, Swanson, Box Butte, Red Willow, Merritt, and Medicine Creek. Stock contributions ranged from 46% to 98%. Fry marked with OTC were easier to identify as marked or not compared to Fingerling marked fish. Sutherland Reservoir is down stream of Lake McConaughy and no fish stocked in Sutherland were marked in 2023. However, a high abundance of YOY walleye were collected during fall surveys. A total of 100 fish were examined to see if any of the walleye YOY were marked fish from escapement from Lake McConaughy. No marks were identified in that assessment.

Walleye Technical Committee, South Dakota Update
Submitted by Mark Fincel

Value of wetlands for Walleye
Logan Cutler, Lauren Allex, Brian Blackwell, Steve Chipps, and Alison Coulter

SDSU graduate student Logan Cutler recently completed research examining how Walleye in Lake Kampeska, SD, use wetland habitats associated with the lake. Logan's project included a combination of prey surveys, diet analyses, and acoustic telemetry. Prey fish diversity and abundance were greater in wetland habitats, contributing to generally more prey consumed by Walleye inhabiting the wetland. Walleye used wetland habitats least during the spring when lake habitats were likely better for spawning. Walleye also appeared to thermoregulate by moving into the wetland when it was either a similar temperature to the lake or cooler than the lake. Diet and movement data were combined in a bioenergetics framework to examine how wetland use impacts Walleye growth. Walleye that used the wetland more in the summer and fall exhibited greater growth rates compared to fish that used the wetland less. Overall, these results show that access to wetland habitats could contribute to improved Walleye growth rates. This is likely because of a combination of increased prey abundance and diversity as well as potential behavioral thermoregulation.

Lewis and Clark Walleye Telemetry and Entrainment Project
Will Radigan

Walleye *Sander vitreus* and Sauger *Sander canadensis* are both socioeconomically important sportfish species in Lewis and Clark Lake, an interjurisdictionally-managed mainstem Missouri River reservoir fishery. Since 2011, adult catch per unit effort (CPUE) of both Walleye and Sauger has remained at approximately 50% of pre-2011 levels. A presumed reason for the suppressed CPUE of adult Walleye and Sauger is substantial entrainment of larval and adult fish resulting from the reservoir's high turnover rate (7 d). Acoustic telemetry was used to quantify adult movement and entrainment and ichthyoplankton trawls were used to assess larval entrainment. Factors driving larval entrainment through Gavin's Point Dam (GPD), abundance of age-0 fish in the reservoir, and adult movement patterns were assessed using an information theoretic approach. Variation in larval entrainment was most supported by water temperature and day of year. Age-0 Walleye abundance was most supported by mean outflow through GPD, mean annual precipitation, and delta gauge height. Age-0 Sauger abundance was most supported by adult conspecific abundance, April heating degree days, and annual precipitation. Adult movement patterns were most supported by reservoir storage and Palmer's Hydrological Drought Index. We observed that annual larval entrainment (both total including all species and Walleye and Sauger entrainment) through GPD is greater than larval entrainment through Fort

Randall Dam from 2021-2023. Further, exploitation is a substantial source of loss for adult Walleye and Sauger. Preliminary data suggests entrainment is a driving factor affecting abundances of both larval and adult Walleye and Sauger in the reservoir.

Large Fingerling Walleye Production

Matt Ward

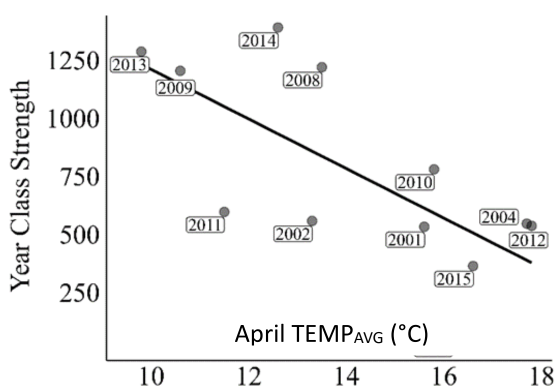
Efforts to increase production of large fingerling walleye is occurring in drainable ponds at Blue Dog State Fish Hatchery. A three-crop process in which walleye consume invertebrates through July and then receive fathead minnow forage through September has been used during the past two years. 50,000 fingerlings with a 77% survival and a size of 16 fish/lb (6 to 7 inches) were produced in 2022 and 19,000 fingerlings with a 92% survival at a size of 10 f/lb (7 to 8 inches) were produced in 2023. Walleye stocking density manipulations, forage fish production, and timing to convert walleye to piscivory are being investigated.

We certainly wouldn't have been able to achieve these results without the help of the Webster fisheries office finding and supplying minnows!

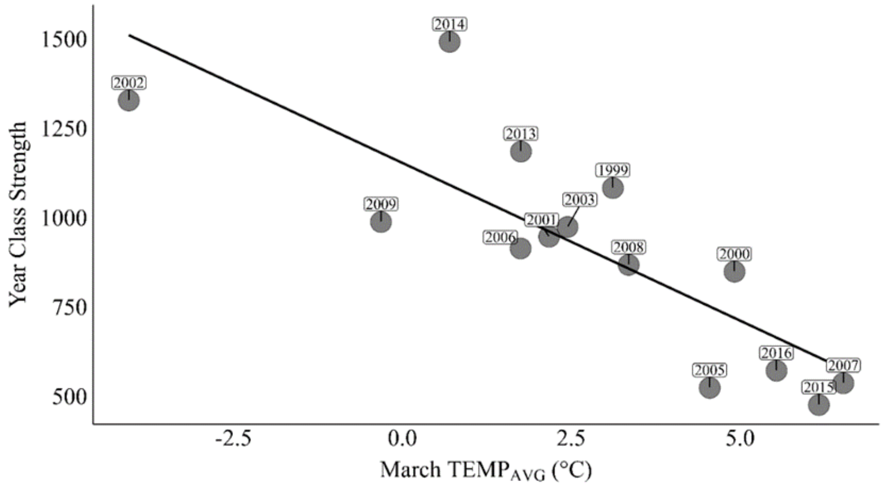
Factors affecting year-class strength of Walleye (*Sander vitreus*) populations in western irrigation reservoirs

Laurel H. Sacco, Jeremy L. Kientz[1] Gene F. Galinat[1], Jacob L. Davis[1], and Steven R. Chipps[2],

We evaluated patterns of walleye recruitment in three, western South Dakota irrigation reservoirs that included Angostura, Belle Fourche, and Shadehill. Our analysis revealed that abiotic factors, primarily temperature and hydrology, were important drivers of year class strength. Walleye recruitment was particularly limited by warming and elevated air temperatures, and spring thermal regimes were universally influential in recruitment outcomes. Although mid- to late summer and fall were also critical periods, year class strength patterns with spring temperatures and hydrology suggest that recruitment bottlenecks occur at the earliest life stages. In addition to abiotic factors in Angostura Reservoir, fingerling walleye stocking successfully augmented year class strength and was the principal driver of walleye recruitment.



Relationship between Walleye year class strength and average, April air temperature for Shadehill Reservoir, SD; (y = 2278.7 – 106.7x; r^2 = 0.43, p = 0.01). The year class strength index is labeled according to cohort year.

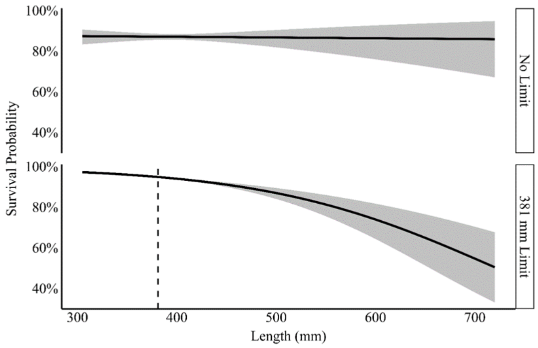


Relationship between Walleye year class strength and average March air temperature for Belle Fourche Reservoir, SD; (y = 1153.2-88.3; 5.2x; r^2 = 0.64, p = 0.001). The year class strength index is labeled according to cohort year.

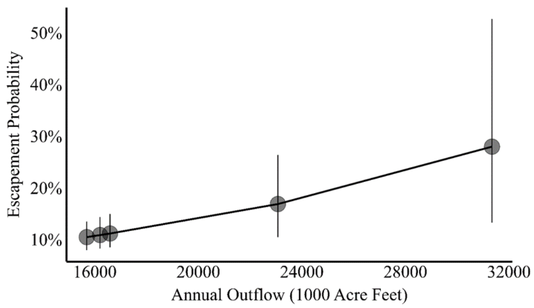
Effects of exploitation and escapement on Walleye survival in Lake Sharpe, South Dakota

Laurel H. Sacco[1], Mark J. Fincel[2], Cameron W. Goble[2], Tanner Davis[2] and Steven R. Chipps[3]

Understanding the influence of angler harvest and other sources of mortality affecting walleye survival is critical to develop effective fisheries management strategies. In 2017, we began a five-year mark-recapture study on Lake Sharpe, South Dakota using angler tag returns to estimate walleye survival and angler exploitation. Most walleye were harvested when caught and apparent survival probabilities were estimated using a Seber dead-recovery analysis that included factors associated with voluntary fish release such as length, sex, and(or) dermal lesions, as well as harvest restrictions, tagging location, and year. During the study, angler reports documented substantial walleye escapement. Using a multi-state Markov model, we estimated escapement probability in relation to walleye length, sex, and tagging location as well as annual reservoir outflow. Exploitation and escapement estimates informed interpretations of annual walleye survival. Survival patterns were explained by an interaction between walleye length and a minimum harvest length restriction. Survival was lower during months without the minimum harvest length limit and results suggest that anglers were willing to release preferred sizes when able to harvest smaller walleye. Annual exploitation ranged between 7-24%. Escapement was influenced by marking location and annual outflow, increasing with proximity to Big Bend dam and during high annual flow events. Although years with high exploitation or escapement corresponded to years with low survival, estimates did not explain the magnitude of mortality/emigration indicated by survival models. Our results suggest that harvest restrictions may maintain the fishery, but continued investigations into Lake Sharpe walleye population dynamics are needed to further inform management strategies.



Monthly survival probabilities of walleye ≥305 mm in relation to fish length during months with a 381 mm minimum harvest length limit (September-June) and months with no minimum harvest length limit (July and August). The vertical dotted line indicates the 381 mm minimum harvest length limit. The range of lengths is representative of tagged fish ≥305 mm. Gray shading represents 95% confidence intervals.



Relationship between escapement probability of walleye ≥ 305 mm and total annual discharge from Big Bend Dam. Error bars represent 95% confidence intervals.

Walleye Technical Committee
Iowa Chapter Report

Submitted 1/26/2024 by Rebecca M. Krogman, Iowa DNR

Relevant Staff Changes

- Large Reservoir Research Biologist: Madeline Lewis, madeline.lewis@dnr.iowa.gov
- Large Rivers Research Biologist: Rebecca Krogman, rebecca.krogman@dnr.iowa.gov

Ongoing and Recently Completed Research

Assessing Fry Stocking Success

Based on a recently completed report from the Large Impoundments Research team, fry stockings can be considered successful if early fall nighttime electrofishing yields at least 30 fish/hr. Quantile regression analysis indicated this catch rate equated to a 95% chance of seeing that year-class two years later as adults.

Likewise, a general rule for natural lakes is 30 fish/hr. Past research indicated fry stocking was most cost-effective, but inconsistent as has been shown in many other places. Most recently, annual summer night seining was related to fall electrofishing to yield an earlier fry assessment in natural lakes; across 13 lakes a seine catch over 25 fish/haul had a 90% probability of yielding fall electrofishing catch >50% percentile (aka, fry stocking success). This report can be expected soon, and you can get more information from Jonathan Meerbeek at Jonathan.meerbeek@dnr.iowa.gov

We have been pushing toward requisite fry assessments in order to justify and prioritize advanced fingerling stockings, especially with recent fingerling shortages, but we have not fully shifted over and continue to stock places based on requests made the winter before. Incorporation of fry indexing requirements is expected in the next update to our Walleye Management Plan.

Stocking Rates

Past observations in natural lakes indicated possible density-dependent intraspecific competition among Walleye. With that in mind, it is possible elevated stocking rates of fry do not yield large year-classes in a proportional manner. Thus, Natural Lakes Research recently evaluated Walleye catch in relation to stocking rate, and found little evidence of improved Walleye fisheries at higher stocking rates. This report can be expected soon, and you can get more information from Jonathan Meerbeek at Jonathan.meerbeek@dnr.iowa.gov

Angler Contributions to Walley Population Monitoring

Each year, the Iowa Department of Natural Resources (DNR) invests significant resources to support its walleye fishery. Collection of broodstock for hatchery production dominates the appropriate timeframe for sampling and population monitoring, thus only a handful of the stocked waterbodies are ever surveyed. Creel surveys are conducted at a limited number of fisheries. In 2022 and 2023, Iowa DNR partnered with MyCatch, an app-based tournament platform, to conduct a state wide catch-photo-release fishing tournament to determine if angler reported data could provide a reasonable overview of walleye catch rates and length distributions for waterbodies across the state.

Sampling survey data were used as a benchmark to evaluate similarity to angler derived data, and 2022 yielded promising (but limited) results. Lessons learned in 2022 – participation is a challenge, tournament data did index best with fall electrofishing data, fewer systems with adequate tournament catches than we hoped for. Changes for 2023 – more planning, acquisition of local prizes to attempt to direct effort to more locations, more outreach activities.

Results from 2023 – more anglers with catches (70 to 88), more water bodies fished (41 to 75), more fishing trips (551 to 732), more fish caught (2074 to 2782), and more fishing trips to the Mississippi River (45 trips to 3 pools up to 75 trips to 7 pools). Lessons learned in 2023 – most anglers targeted local fisheries (60% of trips less than 20 miles), while more avid anglers traveled further (26% of trips more than 50 miles); four high quality fisheries (5% of water bodies reporting catches) accounted for 60% of fish caught, likely a result of the contest for the Most Fish Caught prize; participation is still hard, over 1,000,000 emails and an extensive social media campaign did not bring on as many more anglers as hoped for.

Plans for 2024 – expanding across the Midwest with an AFWA MultiState Conservation Grant, partnering with agencies in Illinois, Indiana, Nebraska and Wisconsin. Eliminating Most Fish prize, replacing with Most Water Bodies fished prize. Bigger grand prizes, which will be awarded randomly, each fish reported is essentially a "raffle ticket" for the grand prizes. Creating free and paid categories for anglers, with more prizes for those who are in the paid category.

Attend Jeff's talk at Midwest on January 29 at 2:40pm, Meeting Room 1.

RAS Techniques

At Iowa DNR, our methods of walleye culture have been adapted to recirculation aquaculture systems with success, with exception of a deformity issue stemming from the intensive larviculture phase. Walleye eggs have been fertilized, water hardened and incubated in a partial RAS. We are evaluating the need for a biofilter to control ammonia levels. In the intensive larviculture phase, the self-cleaning larviculture tanks with a mechanical wiper arm prove to be an efficient way to maintain a clean tank with less labor. One six-foot diameter tank can rear as many as 60,000 2" fingerlings, matching the productivity of a one acre culture pond.

Our current research is focused on the larviculture phase to eliminate deformity arising during fish development. Once on the Otohime feed, fingerlings are transitioned to the Walleye grower diet, are size graded to control cannibalism, and reared to a 9 to 10 inch size for stocking. Other starter feeds have been evaluated over several years, but none have matched survival and growth rates of Otohime. Feed conversion ratios have been 1.1 during the growout phase. Before walleye are stocked to lake the deformed fish are culled out. The pilot scale RAS systems are capable of producing over 120,000 2" fingerlings while thr growout RAS can produce 12,000 10" fingerlings at a final density of 50 kg/m3.

For more information on the culture side, contact Alan Johnson, Fish Culture Research Biologist, at alan.johnson@dnr.iowa.gov

RAS Walleye Stocking Evaluation using acoustic telemetry in two Iowa Impoundments

This is a brief update on the survival of advanced fingerling Walleye reared in a recirculating aquaculture system (RAS) and Iowa's traditional Walleye rearing method. Acoustic telemetry (Figure 1 and 2) and fall electrofishing surveys (Figure 3) were used to evaluate survival of these two products. For more information, contact Lewis Bruce at lewis.bruce@dnr.iowa.gov

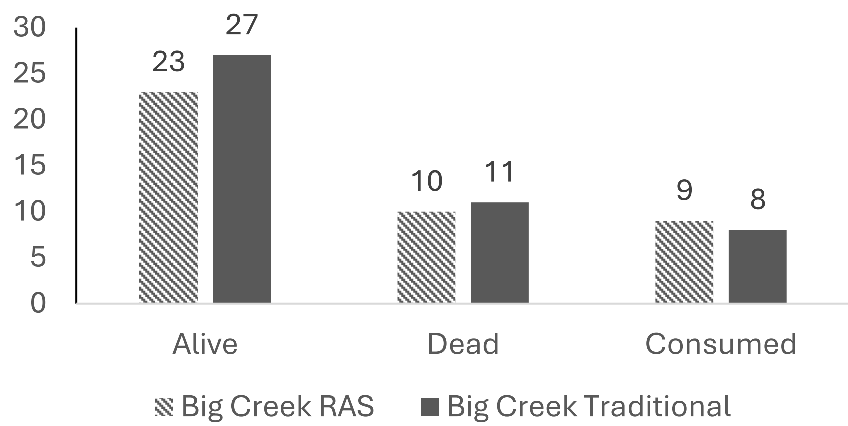


Figure 1. Survival of acoustically implanted transmitters in RAS reared and Traditional reared Advanced fingerling Walleye stocked into Big Creek Lake. Lakes were stocked November 2022 and receivers were downloaded in June 2023. Data does not include 11 questionable fish. Fate of the questionable fish will be determined when the transmitters expire.

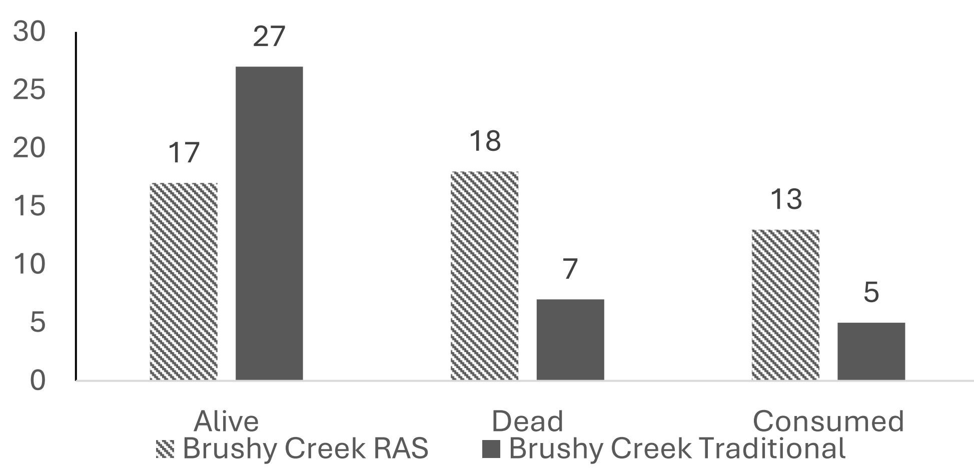


Figure 2. Survival of acoustically implanted transmitters in RAS reared and Traditional reared Advanced fingerling Walleye stocked into Brushy Creek Lake. Lakes were stocked November 2022 and receivers were downloaded in June 2023. Data does not include 12

QUESTIONABLE FISH. FATE OF THE QUESTIONABLE FISH WILL BE DETERMINED WHEN THE TRANSMITTERS EXPIRE.

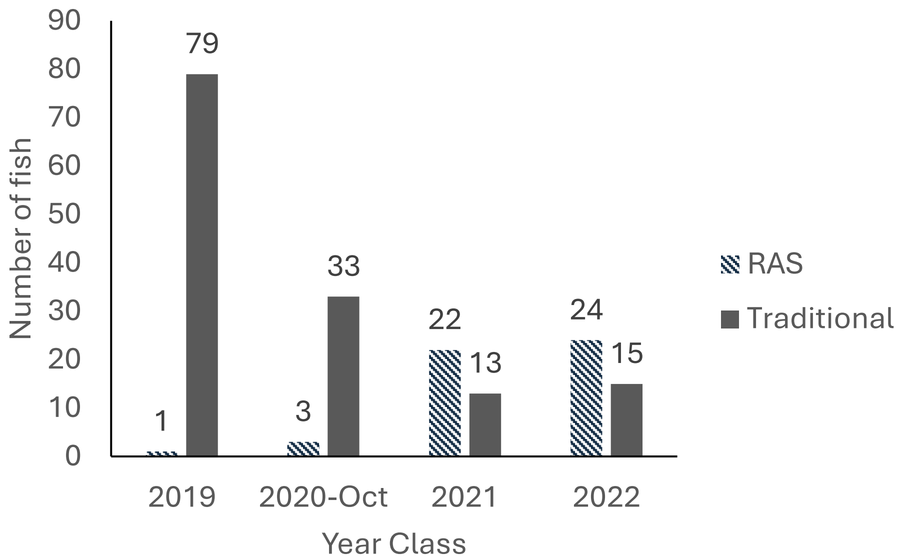


FIGURE 3. NUMBER OF RAS AND TRADITIONAL CAUGHT WALLEYE DURING FALL 2023 ELECTROFISHING SURVEYS AT LITTLE RIVER WATERSHED LAKE. EACH YEAR CLASS WAS SAMPLED 1 YEAR POST STOCKING. DEFORMED FISH WERE CULLED FROM THE RAS STOCKING IN 2021 AND 2022.

Walleye Genetic Performance in Large Reservoirs

The success of fish stocked may depend on physical and behavioral characteristics unique to the genetic strain. Lake-strain Walleye, adapted to lake and reservoir life, and river-strain Walleye, adapted to moving waters, may perform differently in different environmental conditions. A study, started in 2019, compares the two strains when stocked into reservoirs with varying physical and environmental characteristics. This was found to be true in rivers and streams, and altered Iowa DNR's stocking strategy for flowing waters.

Recent genetics results have revealed that we are not likely dealing with "river" and "lake" strain fish as we originally thought, but rather "domesticated" and "wild" stock. We are awaiting additional genetics from 2023 broodstock and fall recaptures to finalize this finding!

We are using similar techniques as Wisconsin DNR to identify not only "strain" but also track parentage, allowing us to identify study fish in lakes with potential immigration, natural recruitment, and non-DNR stocking, although we didn't expect any of those occurrences in most study lakes. We are glad we did, because we had an unsanctioned stocking occur (likely) in Don Williams during the study. The parentage information has great potential for us to guide our captive broodstock program. More on that in "Future Needs."

Contact Rebecca Krogman or Madeline Lewis for updates on this study.

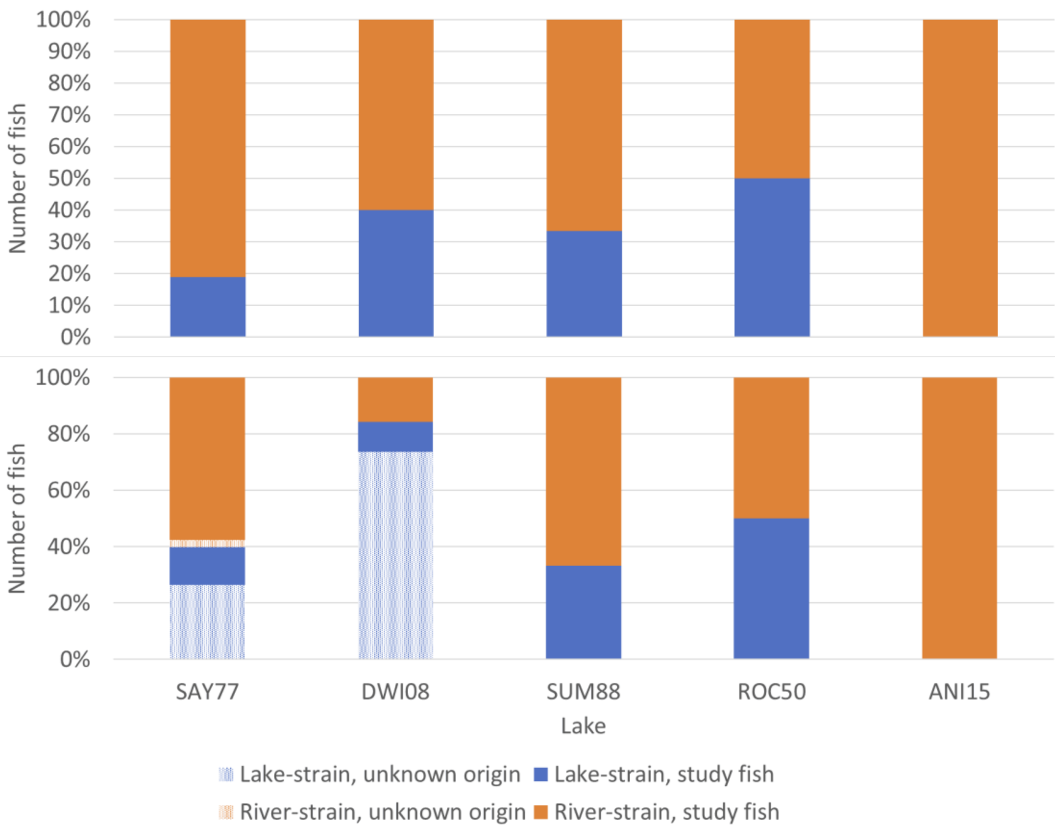


FIGURE 4. PROPORTIONAL COMPOSITION OF WALLEYE RECAPTURED FROM FIVE STUDY RESERVOIRS IN IOWA, USA, OVER THREE YEARS 2020-2022. TOP: KNOWN STUDY FISH, BASED ON PARENTAGE. BOTTOM: ALL RECAPTURED FISH, INCLUDING FISH OF UNKNOWN ORIGIN. SAY77 = SAYLORVILLE RESERVOIR, DWI08 = DON WILLIAMS LAKE, SUM88 = SUMMIT LAKE, ROC50 = ROCK CREEK LAKE, ANI15 = LAKE ANITA.

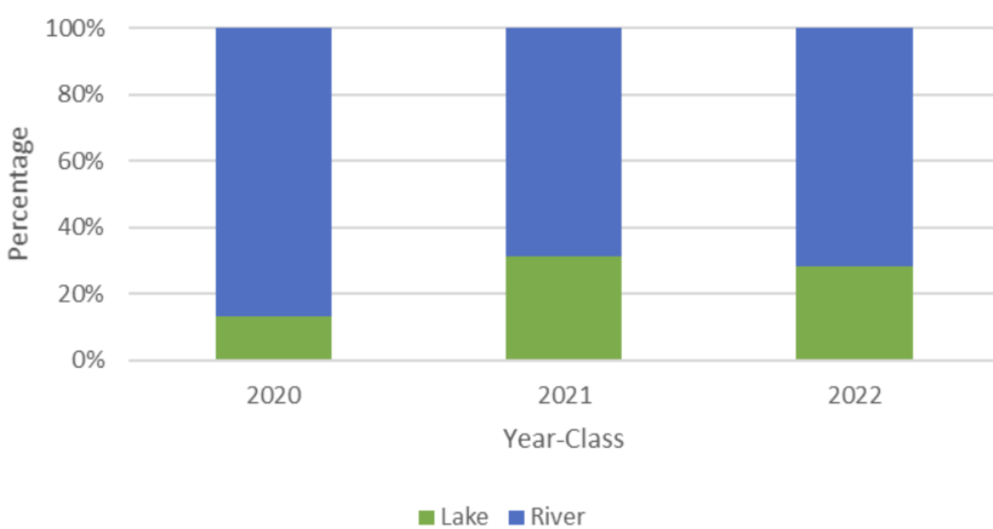


FIGURE 5. PROPORTIONAL COMPOSITION BY GENETIC STRAIN OF WALLEYE RECAPTURED DURING FALL ELECTROFISHING FROM FIVE RESERVOIRS IN IOWA, USA, OVER THREE YEARS 2020-2022.

Walleye and Sauger Population Dynamics in the Upper Mississippi River

Night electrofishing is done each October in the tailwaters of Pools 11 and 13 to measure Walleye and Sauger year class strength. High water levels have not allowed us to effectively sample the past few years. Surveys in 2016 showed weak Walleye and Sauger year classes at Bellevue (Pool 13) and Guttenberg (Pool 11); high water levels during sampling likely negatively affected catch rates. There are good numbers of 14-inch and larger Sauger available, so anglers should have good success in the tailwaters this winter and spring. The slot limit regulation appears to have been highly successful so far, yet future work on this project will continue to measure the effects of the slot limit on Walleye reproduction.

You can get more information on this study from Rebecca Krogman at rebecca.krogman@dnr.iowa.gov

Walleye Escapement at Rathbun Lake

A combined acoustic telemetry and tag return design was used to study Walleye both in the lake and in the tailrace of Rathbun Lake. The purpose of the study was to 1) estimate coarse movement and behavior patterns of Rathbun Lake Walleye and factors that may be influencing these patterns, 2) estimate fine-scale movement and behavior of Walleye near the Rathbun Dam outlet tower, 3) estimate natural mortality, exploitation, and escapement of Rathbun Lake Walleye and the factors driving these estimates, and 4) estimate survival, escapement, and movement of hatchery raised advanced fingerling Walleye released into Rathbun Lake. Results of this study will allow us to provide insight into factors regulating reservoir fish populations and the possible effects of exploitation and downstream escapement as well as providing insight into movement patterns of Walleye in altered reservoir systems. A final report was provided to the Corps in 2023.

Contact Michael Weber for more information at mjweber@iastate.edu

Figure 6. *Kernel Distribution Usage plots for Adult Walleye near the Rathbun Lake outlet tower from April 2019 - October 2021. Fifty percent usage distributions are shown during the May - February (top), June - September (middle), and October - January (bottom).*

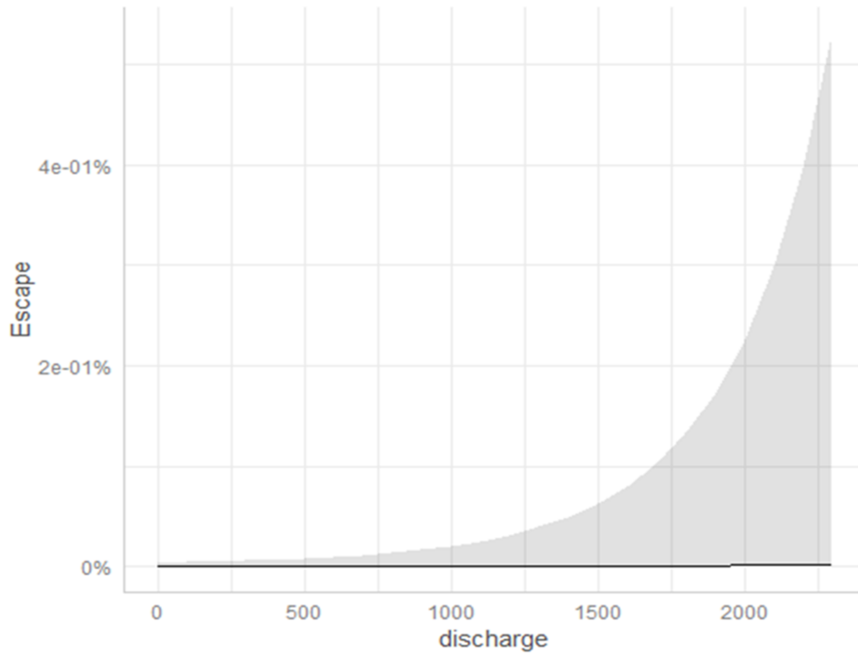


Figure 7. *Walleye in the VPS array escapement probability in relation to reservoir discharge. Black line indicates predicted value and gray shading represents 95% confidence interval.*

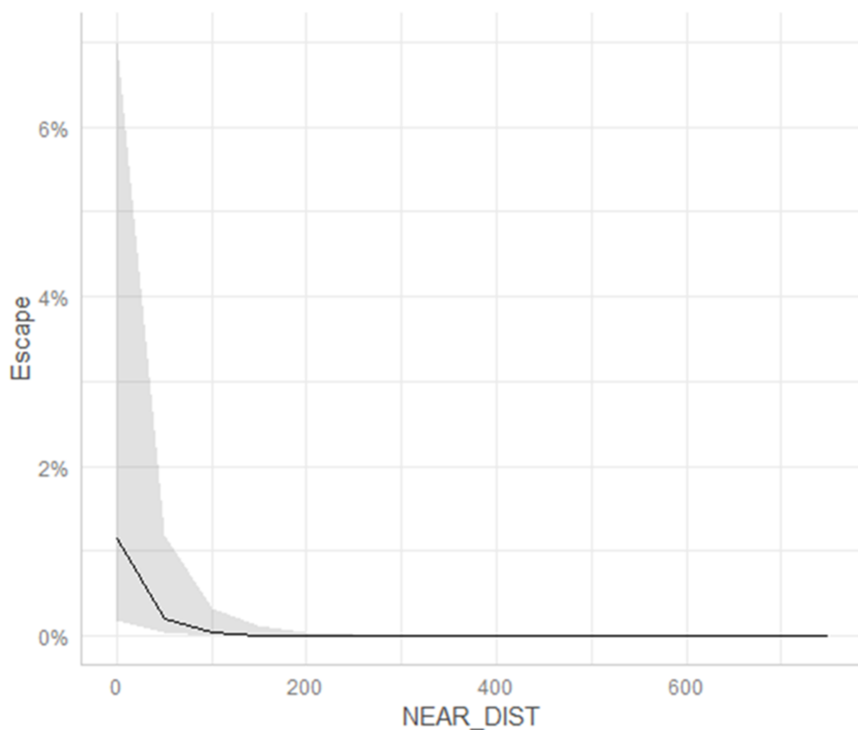


Figure 8. *Walleye in the VPS array escapement probability in relation to nearest linear distance from the intake tower. Black line indicates predicted value and gray shading represents 95% confidence interval.*

Future Walleye Research Needs of the Iowa DNR

- Determine ideal product(s) needed to support each Walleye fishery
  - Identify lakes and impoundments that can be supported entirely by fry stocking
  - How often can a successful fry stocking be expected?
  - How often is a year class needed to maintain these fisheries?
  - If a successful fry stocking is not documented for X years, what actions should be taken?
- For lakes and impoundments that are not fry friendly, can advanced fingerlings be used to maintain a quality Walleye fishery?
  - How often should these systems be stocked (e.g., smaller annual stockings versus larger stockings every 3-5 years)?
  - Stocking rate needed to maintain a quality fishery?
  - Cost:benefit of these fisheries (i.e., cost per Walleye returned to the creel)
  - For systems where advanced fingerlings are stocked (to amend fry stocking), what portion of the overall population is attributable to these stocked fish?
- Finish out the genetics study and its implications for impoundments (and possibly pivot)
  - What factors are driving the difference in survival? (e,g., is it a superior strain or is it just more diverse than the populations in our traditional broodstock sources)
  - Use this information to develop a Walleye Broodstock Management Plan for wild and captive broodstock sources – substantial change to our broodstock collection strategy
- Expand the walleye movement study to better assess large-scale movement risk through dams and hydropower systems – How often does it happen, do they survive, and how far do fish go downstream?

Many of these items will likely lead to a Walleye Management Plan revision.

State Report for North Dakota at the 2024 Winter Walleye Technical Committee Meeting.

The walleye population in Devils Lake is doing well. There are many age-classes of walleye in the lake and some of the fish can become quite old, as fish up to 21 years old have been encountered.

We conducted our Standard Adult Sampling on Devils Lake in July. Results showed the overall CPUE of walleye was 32.4 walleye/net-night in our 125' variegated gill nets. This year's catch was down a little from last year's record high (35.3 walleye/net-night). Another impressive result was that the catch rate of Q-P sized walleye was up again to 12.4/net-night this year, which set another record high. The northern pike were below the long-term average again, while yellow perch numbers were a bit below average. White bass numbers were still above average. Many of the large white bass are from the strong hatch that occurred in 2015, and they are mostly about 15 to 17 inches long now, although a fair number of younger fish were sampled as well. About 298,000 fingerling walleye were stocked in the eastern, more saline portion of the lake in 2023. We observed good results from our young of the year netting survey in September, with about 29 young walleye being caught per net, which a little above the average of about 25. Overall, we've observed 8 good year classes of walleye in a row now, so the future is promising for walleye in Devils Lake.

One of our other large lakes, Stump Lake is doing well too. We conducted our Standard Adult Sampling there in late June. The walleye population appears to be doing very well, as our catch rate set a new record high at about 31 walleye per net, which is well above the long-term average of about 19 walleye per net. There were a record number of walleye over 20" captured as well, at about 8.5/net-night. The northern pike were below their long-term average, whereas yellow perch and white bass numbers were above average.

In the Northeast District of the state, some of our most impressive walleye waters continue to be new fisheries that were formerly duck-marsh type habitats. Some of these waters are also able to produce good numbers of walleye over 24" long.

Across the rest of the state, the good old days of walleye fishing, and fishing in general, continue to be right now. However, the winter of 2022-2023 was very long and harsh, and about 80 waters experienced some degree of winterkill. Statewide, there are about 450 waterbodies that are being managed for fishing. This is a great increase from only about 175 managed fisheries in the early 1990's. Since 1997 we added over 100 new walleye fisheries. State-wide there are currently about 230 waters that have walleye populations. One of the few places where walleye are currently not doing as well is in the North Dakota portion of Lake Oahe and the Missouri River between Lake Oahe and Garrison Dam. Ongoing drought has worsened forage conditions in this fishery resulting in poor walleye condition, growth, and size structure.

Our state record for walleye was broken again in 2021. In March, a 33-inch-long walleye weighing 16 pounds 6 ounces was caught in the upper portion of Lake Oahe. This fish bested the previous record of 15 pounds 13 ounces that was caught in 2018.

Our department stocked walleye fingerlings in 145 lakes in 2023. About 8 million fingerlings were stocked by our department. The fingerlings were generally about 30 days old and were around 1.25" long. About 10 million fry were also stocked in 22 waters, and advanced fingerlings were stocked in 7 waters.

Known zebra mussel populations exist in the Red River, Lake Ashtabula and the lower Sheyenne River, Lake LaMoure, the lower James River (downstream from Lake LaMoure), Twin Lake and Lake Elsie. In December, Zebra mussels were discovered in the lower end of Lake Oahe in South Dakota. There were no other new zebra mussel discoveries in 2023.

Missouri State Walleye Report for 2023

Recent Publications –

Berkman, L.K., Titus, C.L., Thomas, D.R. *et al.* Genetic differences among the Interior Highlands walleye (*Sander vitreus*) with mitochondrial and nuclear markers indicate the need for updated stocking practices. *Conserv Genet* **24**, 347–359 (2023). https://doi.org/10.1007/s10592-023-01504-7

Black River Strain Walleye – 2023 Update

The Black River Basin (includes Black, Current, and Eleven Point rivers) supports a distinct Walleye genetic strain, hereafter called the Black River Strain (BRS) (Figure 1). Recent research across the Walleye native range has shown that the BRS Walleye are part of a group of Walleye known as the Eastern Highland or New River strain (Berkman, L.K. et al.). Due to the unique genetic makeup, the Department of Conservation have taken extra care to protect these Walleye.

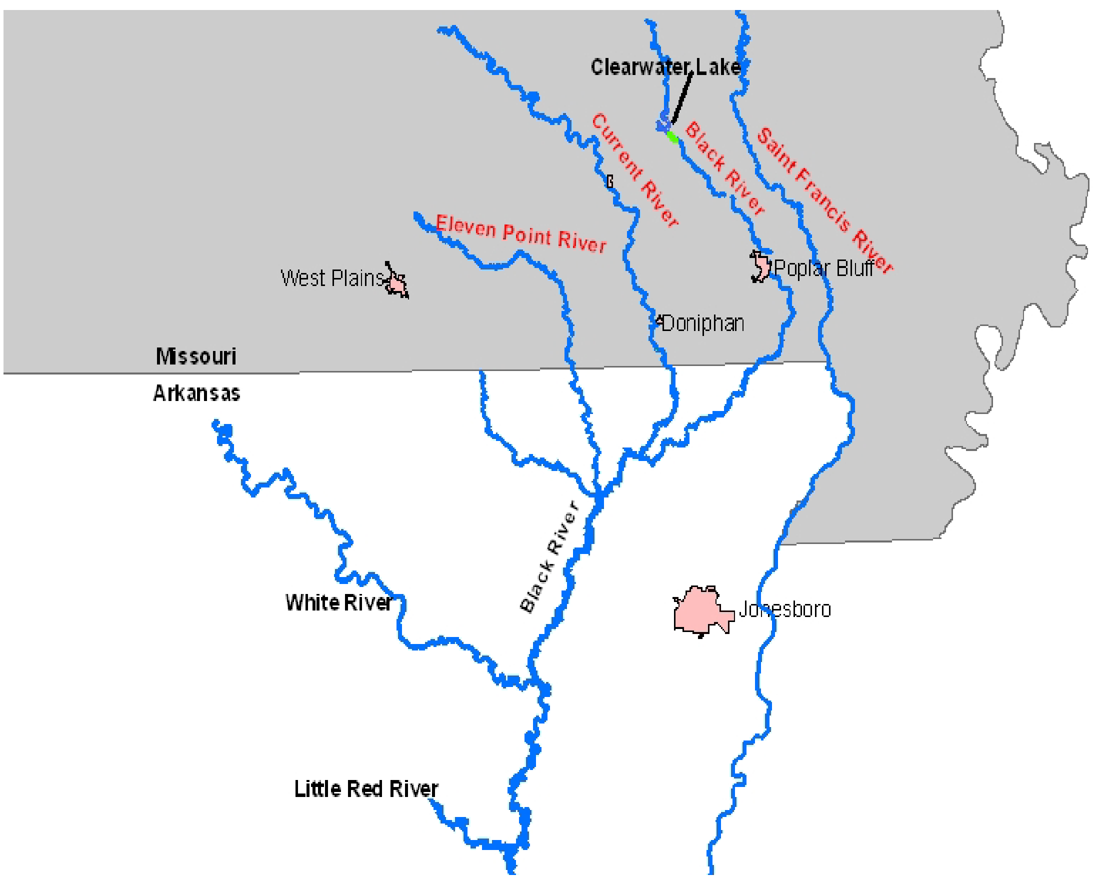


Figure 1. Missouri Rivers with the Black River strain walleye.

The Black River downstream of Clearwater Lake supports a high-quality Walleye population (Figure 2). BRS male and female Walleye have significantly different growth rates and size structure (Figures 3, 4, & 5). Female Walleye grow faster and reach a much larger size. In the Black River, female Walleye greater than 10 pounds are fairly common. In contrast, male Walleye rarely exceed four pounds. The Black River Walleye dataset is comprised primarily of male Walleye. This is because male Walleye are more susceptible to electrofishing during the spawning season. Male Walleye reside on shallow shoals for a month or longer waiting for the female Walleye to show up to spawn. Female Walleye tend to reside in deeper water where electrofishing gear is not as effective. Female Walleye will spend one night on a spawning shoal before heading downstream. In general, 80% of the Walleye captured by MDC staff are male. In the Black River, the Walleye minimum length limit (MLL) is 15”. Both female and male Walleye reach this size in just over two years. In the Current and Eleven Point rivers, the Walleye MLL is 18”. Female Walleye generally reach this length by age-3. Male Walleye don’t reach this limit around age-5.

Figure 2. Fourteen-pound Black River walleye captured on February 21, 2023

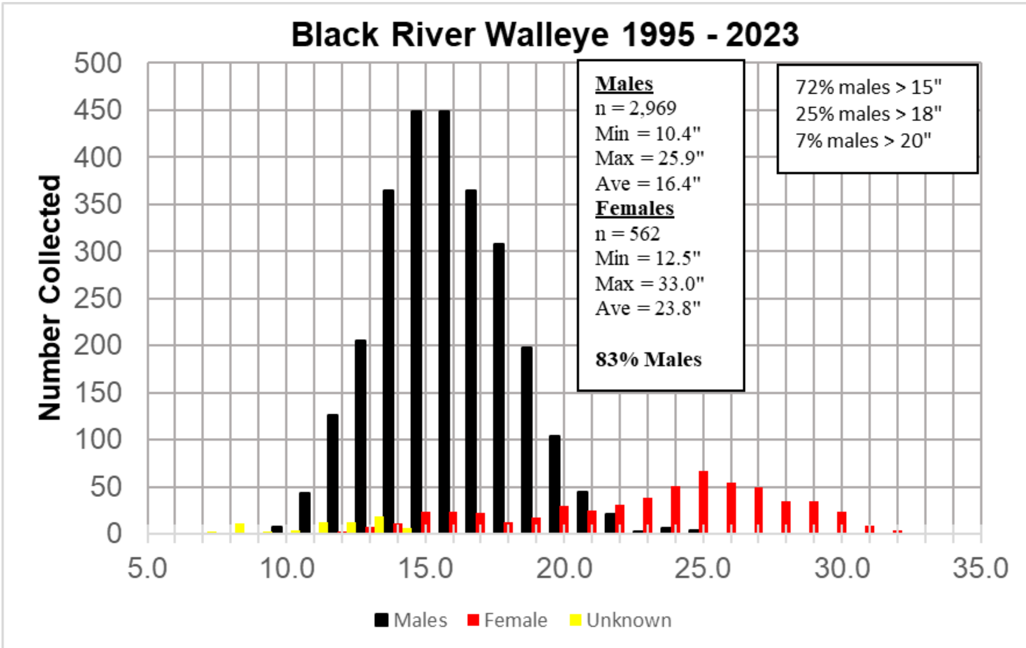
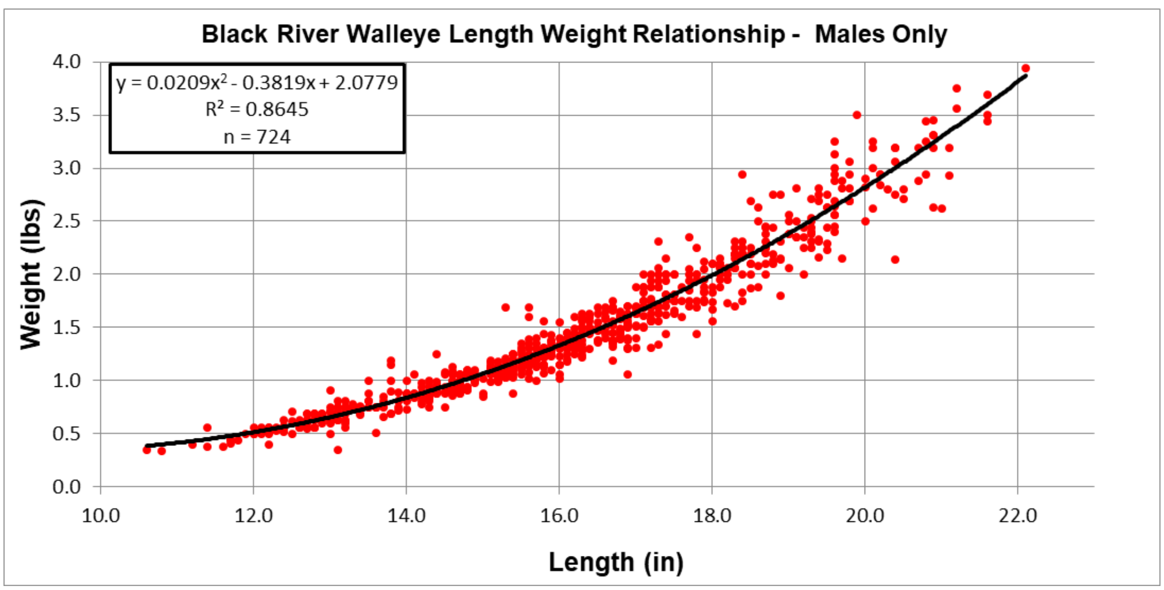


Figure 3. Walleye length frequency from the Black River, MO.



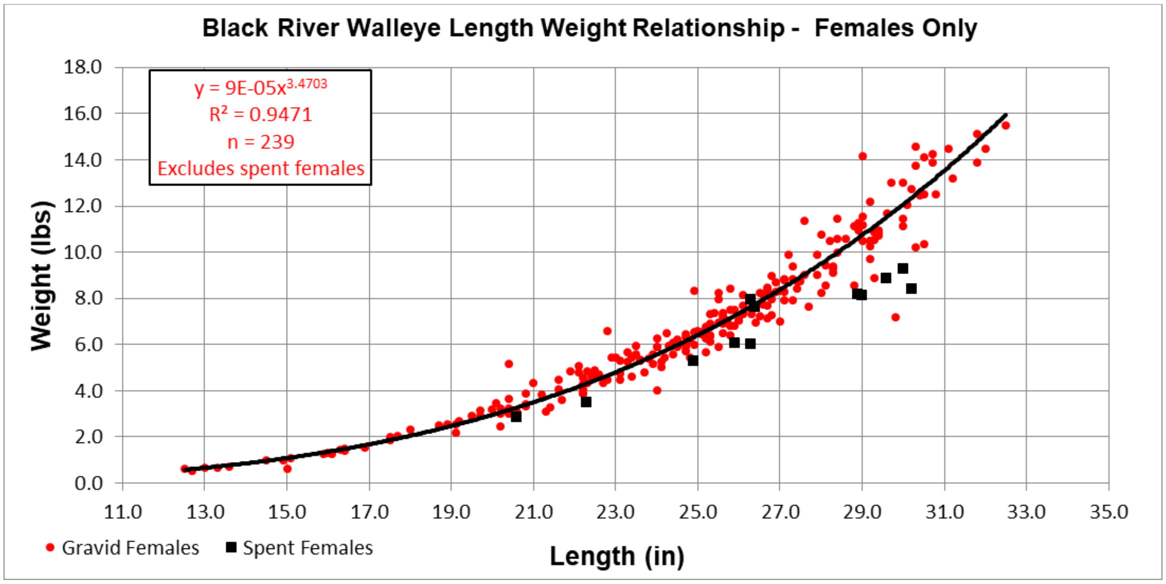


Figure 4. Walleye length weight relationship from the Black River, MO.

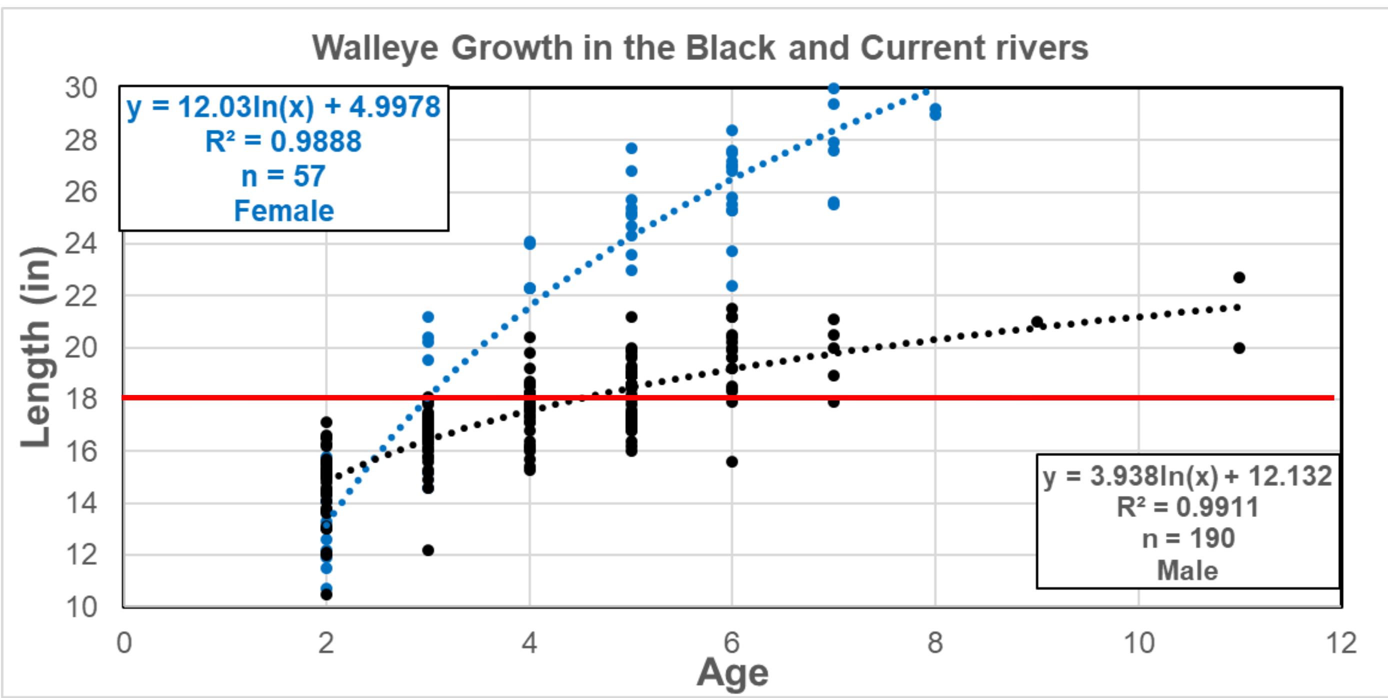


Figure 5. Walleye growth rates in the Black and Current rivers.

For the past fifteen years, Fisheries staff have collected ~10 female and 30 male Walleye each spring from the Current or Black rivers for hatchery propagation purposes. These fish are used to produce fingerlings that are stocked into the Black, Current, Eleven Point, and St. Francis rivers. Stockings are rotated between the rivers, so each river is stocked on a four-year cycle. In 2023, winter water temperatures were much higher than normal. In late February, the Black River was 51^0 F to 54^0 F. At that time of the year, the river is generally 45^0F. Do to warmer than normal water temperatures, brood stock collection was moved forward a week and done on February 28th. We captured 12 female Walleye between 4.5 and 11.5 pounds. Ten female and 32 male Walleye were transferred to the Lost Valley Fish Hatchery. All Walleye were verified as Black River Strain before spawning. These fish produced 1,019,800 eggs. On March 13th, 360,000 fry produced from these eggs were stocked into three production ponds at Blind Pony Fish Hatchery. Ponds were only 42^0 F at the time of stocking. The weather continued to deteriorate, and the ponds were ice covered soon after. No fingerlings were produced in 2023.

In 2022, a Walleye exploitation study on the Lower Black River was approved. The study called for staff to collect 300 Walleye in the spring for two consecutive years (600 total tags). Due to the differences in sex specific size structure, 100 tags each year should be placed on female Walleye. This will allow for sex specific harvest estimates. A combination of high ($75) and low ($25) value reward tags will be used. The use of high value tags is essential for calculation angler compliance. Twenty five percent of the tags will be $75 reward tags and the remaining 75% of the tags will be worth $25. Carlin dangler tags will be used for this project. Tags will be placed below the dorsal fin and each tag contains a unique tag number and contact information (Figure 6).

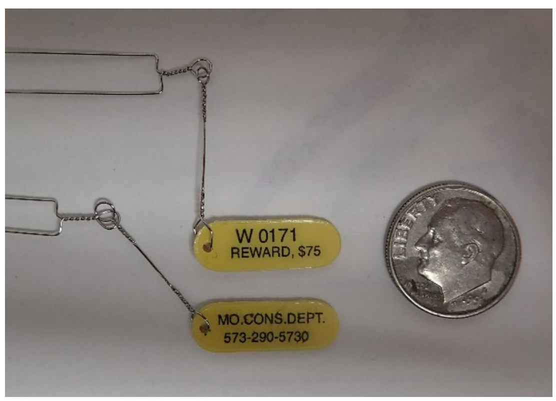


Figure 6. Carling tag (upper photograph) and tag location (lower photograph).

In 2022, tagging efforts started on February 10th. Three additional trips were completed before high water forced us to postpone the exploitation study. A total of 41 Walleye were tagged (Table 2). Thirty-seven (99%) were male and four were female. Anglers reported catching seven male Walleye within one year of tagging. Six were harvested and one was released. The harvest rate for males was 15% without adjusting for angler compliance and tag loss. These adjustments will be included at the end of the study.

The 2023 tagging efforts started on January 10th and ended on March 1st. A total of 358 Walleye were captured of which 275 Walleye were tagged (Table 1). Of the tagged Walleye, 216 were male and 59 were female (21%). Of note, nine large female Walleye were not tagged because they were used for hatchery broodstock. As of January 1st, harvest rate for males was 9% and 10% for female without adjusting for angler compliance and tag loss. These adjustments will be included at the end of the study.

Angler tag returns from previous exploitation studies indicated that Walleye travel between the Black, Current, and Eleven Point rivers. To quantify these movements, MDC staff in 2019 began implanting VEMCO acoustic tags in walleye. To track these fish, MDC staff have set up VR2 receiver stations in the Black River Basin at the following locations:

Station 1 - Black River - 1 mile downstream of Clearwater Dam (river mile 257)
Station 2 - Black River - Markham Springs (18 miles from Station 1)
Station 3 - Black River - Highway 67 Bridge (29 miles from Station 1)

Station 4 - Black River - Highway 62 Bridge near Corning, AR (105 miles from Station 1)
Station 5 - Current River - 2 miles upstream of the Black River (164 miles from Station 1)
Station 6 - Spring River - 2 miles upstream of the Black River (189 miles from Station 1)
Station 7 - Eleven Point River - near Myrtle Access (232 miles from Station 1)
Station 8 - Eleven Point River - Highway 160 Bridge (246 miles from Station 1)
Station 9 - Current River - Deer Leap (220 miles from Station 1)

Stations 7, 8, and 9 were set up in October 2023. Station 2 was deployed in December 2023.

Prior to 2023, 24 Walleye had been tagged and released in the Black River. Twenty tags have been placed in female Walleye and six tags in male Walleye. Three Walleye have never been detected since tag implantation, so we presume they did not survive surgery. Twelve additional Walleye (2 in Black River, 3 in Current River, and 7 in Eleven Point River) have been recently tagged and have not been located yet.

Our study has shown definite Walleye movement patterns in the Black River basin. Six of the 21 tagged Walleye traveled 100 plus miles down the Black River into Arkansas (29%). It appears that these Walleye are spending the summer months in the Current River. In November, these Walleye move out of the Current River and by January are near their Black River spawning areas. Male Walleye will move on to the spawning riffles in late February and stay for about 30 days. Female Walleye are at the spawning riffles for only 1 or 2 days in early March. After spawning, they quickly move downstream. Multiple male and female Walleye have shown 30-mile downstream movement within 24 hours. One female walleye traveled 30 miles downstream in 11 hours. See Table 3 for the movement pattern of a male walleye.

Table 1. Walleye exploitation estimates for the Black River as of January 1, 2024.

		Total Number Tagged	Number Returned (1 year)	Number Returned Harvested (1 year)	Number Returned Released (1 year)	HR*	CR*
2022	All walleye	41	7	6	1	15%	17%
2023	All walleye	275	36	26	10	9.5%	13.1%
	Males	216 (79%)	28	20	8	9.3%	13.0%
	Females	59 (21%)	8	6	2	10.2%	13.6%
2024	All walleye	17	2	1	1		
	Males	6	1	0	1		
	Females	11	1	1	0		

not corrected for non-reporting or tag loss

Table 2. Walleye #31509 movement patterns.

Ultrasonic tag 31509	Anchor Tag (grey) #442 18.2 Male	Comments
3/10/2020	released in paddlefish pool below dam	
3/11 - 30/2020	pool below paddlefish pool 6,626 hits	
	spawn 2020	
4/12/2020	Hwy 62 Bridge - Corning Ark 9 hits	moving downstream
	No Current River VR2 station - Installed August 2020	
10/31/2020	**Current River** in Arkansas 16 hits	coming out of Current River
11/7/2020	Hwy 62 Bridge - Corning Ark 12 hits	headed upstream
11/12/2020	Hwy 67 Bridge - 29 hits	headed upstream
11/17/20 - 12/3/20	pool below paddlefish pool 401 hits	headed upstream
1/26/2021	in paddlefish pool	
1/31/21 - 4/3/21	pool below paddlefish pool 16,135 hits	
	spawn 2021	
4/9/2021	Hwy 62 Bridge - Corning Ark 9 hits (6 minutes)	moving downstream
4/10/2021	**Current River** in Arkansas vr2 28 hits	going into Current River
11/16/2021	**Current River** in Arkansas vr2 8 hits (5 minutes)	coming out of Current River
11/20/2021	Hwy 62 Bridge - Corning Ark 13 hits (10 minutes)_	headed upstream
11/29/2021 -12/1/2021	Hwy 67 Bridge - 126 hits	headed upstream
12/7/2021	pool below paddlefish pool 60 hits	
1/12/2022	paddlefish pool	
2/15/2022	pool below paddlefish pool 17 hits	
2/17 - 19/22	Hwy 67 Bridge - 43 hits	big flood moved downstream for 2 days
3/5/22 - 4/11/22	pool below paddlefish pool 32261 hits	
	spawn 2022	
4/12/2022	Hwy 67 Bridge - 1 hit (15 hours traveled 30 RM)	moving downstream
4/16/2022	Hwy 62 Bridge - Corning Ark 3 hits	moving downstream
4/18/2022	**Current River** in Arkansas vr2 15 hits	going into Current River
12/4/2022	Hwy 67 Bridge - 1 hit	headed upstream
1/21/23 - 2/4/2023	in paddlefish pool above B island	
2/10 - 4/2/2023	pool below paddlefish pool 831 hits	
2/23/2023	captured with EF gear Shoal 1 (Reward Tag W0666)	19.1" at this time
	spawn 2023	
4/10/2023	Hwy 62 Bridge - Corning Ark 1 hit	moving downstream
7/21/2023	harvested in Current River at Carter County line	234 river miles from Shoal 1

References

Berkman, L.K., Titus, C.L., Thomas, D.R. *et al.* Genetic differences among the Interior Highlands walleye (*Sander vitreus*) with mitochondrial and nuclear markers indicate the need for updated stocking practices. *Conserv Genet* **24**, 347–359 (2023). https://doi.org/10.1007/s10592-023-01504-7

2023 Missouri Walleye Production:

Our staff stocked a total of 2,292,038 fingerlings and 1,984,037 fry into fifteen reservoirs and two river systems in 2023. They also stocked an additional 12,682 advanced fingerlings into two reservoirs. Black River Strain Walleye did not survive to fingerling stage in grow out ponds and therefore were not stocked in Missouri in 2023. However, Missouri did provide Arkansas with fry that produced 8,990 fingerlings. Thes fingerlings were stocked in the Eleven Point River in Arkansas. Overall production for non-Black River Strain Walleye was excellent with all of our production and surplus requests completed. An additional 403,378 surplus fingerlings were stocked. (see individual hatchery reports below).

2023 Lost Valley Hatchery Walleye Production Report

Lost Valley Hatchery's 2023 walleye production was successful meeting and exceeding production requests. Staff successfully produced both the Black River strain of walleye fry and the Lake of the Ozarks strain fingerlings this year.

Black River fish were spawned in early March with the genetics being verified prior to spawning. Staff took 1,019,800 eggs resulting in 454,207 fry. Of the hatched fry, 365,744 were transferred to Blind Pony Hatchery and 88,463 were shipped to Mammoth Springs Arkansas for extensive culture.

Lake of the Ozark strain brood fish produced 7,097,550 eggs, hatching at 59%, which resulted in 4,181,869 fry. Staff transferred 1,041,311 fry to ponds at Lost Valley for extensive fingerling culture. Staff sent fry to Blind Pony (915,320 fry), and Hunnewell (241,201 fry) hatcheries as well. An additional 1,984,037 surplus fry were stocked into Lake of the Ozarks.

Lost Valley's walleye extensive pond culture efforts produced 485,110 fingerlings. Fingerlings were distributed to the following requested lakes; Stockton Lake (168,704 fingerlings), Lake of the Ozarks (170,238 fingerlings), Longview Lake (18,637 fingerlings), Lake Jacomo (19,400 fingerlings), and Mozingo Lake (30,842 fingerlings). Additional fingerlings were distributed and stocked against approved surplus requests; Stockton Lake (44,159 fingerlings), and Mozingo Lake (22,917 fingerlings).

An additional 10,213 fingerlings were held back for intensive production at Lost Valley for additional growth. Blind Pony also provided 11,532 fingerlings for this effort. These fish produced 6,029 3" fish which were stocked into Mozingo Lake as surplus. Staff stocked 6,653 fish into Thousand Hills State Park – Forest Lake as part of the requested stocking. These fish averaged 4.6".

2023 Walleye Production Report
By
Brad Russell

Objective

1. Produce at least 1,560,000 walleye fry to stock 13 one-acre hatchery ponds each with 120,000 fry. Chesapeake request is to stock 384,000 fingerlings into Bull Shoals Lake and 176,000 into Norfork Lake.

Bull Shoals Walleye Production

Brood stock walleye are not kept at Chesapeake Hatchery and must be collected during the spring spawning run. In 2023, collection took place on 3/20/23 at Bull Shoals Lake and Chesapeake received 12 females and 75 males. Bull Shoals Lake was 48 degrees F. After all brood was collected and transferred to the hatchery, the females were weighed, and egg samples were staged. 45 females from LOZ were also transferred to Chesapeake to make up for the small amount of Bull Shoals females. All females that were green were injected with HCG at a rate of 0.25cc/lb., while those close to spawning were not injected. Spawning took place over the next few days and was completed on 3/27/23. Chesapeake ponds were stocked with 1,571,254 fry.

Females

	Bull Shoals	Lake of the Ozarks
Collected	12	45
Injected	6	45
Spawned	11	45
Bloody or clumpy eggs	1	0
Dumped	0	0
Spent	1	0
Average female weight	3.95 lbs.	3.93 lbs.
Average # of quarts/female	0.85 qts.	
Average # of eggs/quart	137,818	
Original # of eggs collected	6,563,203	
# of eggs after dumping or sucking	5,488,038	
# of fry hatched	Estimated 4,088,588	
Original # of quarts taken	47.4 qts.	
Quarts left to hatch after dumping or sucking	40.4 qts.	
Percent hatched	Estimated 65.0%	

Hatchery ponds 2-14 were utilized for walleye production. All ponds are one acre in size. The ponds had been filled during late January to help avoid algae treatments and leaves in the ponds. Ponds were filled with solar pond water. The ponds were fertilized with alfalfa meal to stimulate plankton growth. No vegetable oil was applied to the ponds for insect control. Grass carp were not used in the ponds for additional algae control. Fry were stocked at 212 fry per gram. Dissolved oxygen levels were monitored twice a day after fry were stocked. Air lift pumps or paddlewheels were turned on at the time of fry stocking and run throughout the grow-out period to keep the water mixing,

add some aeration, and breakup the water surface tension. Refer to chart below for fertilization and treatment totals.
Chesapeake hatchery stocked out 1,070,452 walleye this season. A surplus of 510,452 walleye were stocked out of Chesapeake hatchery this year. It was a good year for walleye production. The pond temperatures being near 60 degrees had a big impact and average pond return was 68.1%. It was difficult collecting females from Bull Shoals so the rest came from Lake of the Ozarks. We will get all brood stock from Lake of the Ozarks next season.

Recommendations for 2023 walleye culture:

- Fill ponds halfway with solar pond water to seed the pond, then use spring water.
- Fill ponds with filter bags to keep green sunfish out of the ponds.
- Start fertilizing ponds mid-March.
- Keep walleye ponds empty until late January or February to reduce growth of algae and leaves.
- Check walleye brood stock for flowing at 7 AM, 2 PM, and 10 PM.
- Place no more than 3 egg jars per aquarium to hatch. This will provide more room in each aquarium for fry and keep the hatch time close.
- Clean egg jars twice a day by siphoning off dead eggs and/or fungus. Do not treat with formalin unless the need arises.
- Determine average fry per gram before stocking to be more accurate.
- Collect brood stock from Lake of the Ozarks
- Stock fry around 2 days post hatch.
- Temper tubs at pond stocking time to get the pH close to pond ph.
- Make two trips to each pond when stocking and tempering.
- Turn on air lift pumps and paddlewheel aerators as soon as the fry are stocked into the ponds.
- Turn off paddlewheels when harvesting the ponds. If you leave them on it weakens the fingerlings and results in death upon transport.
- Switch water over to Solar water before pond harvest takes place
- When draining ponds, drain down 3 steps the first day, then bring down to 18 inches on day 2. Harvest on day 3.
- Use socks on aerators when hauling walleye fingerlings.

2024 Walleye Technical Committee Winter Meeting

2023 Wisconsin Report – submitted by Lawrence Eslinger (WDNR; WTC Rep)

1. **Wisconsin Walleye Management Plan Efforts** – submitted by WDNR Biologists Lawrence Eslinger and Max Wolter

   In 2023, WDNR and partners made progress on a number of efforts in alignment with goals and objectives identified within Wisconsin's updated 2022 Walleye Management Plan. Below are brief summaries on a couple of those efforts.

   - New walleye regulatory options made available within management regulation toolbox.
     1. 12" minimum, 1>15" or 13" minimum, 16-24" protected slot, 1>24"; replaced previous no-minimum, no-minimum, 1>14" and no-minimum, 14-18" protected slot, 1>18" options within high density/slow growth scenarios.
     2. 18" minimum, 22-28" protected slot, 1>28" (1 bag); added "rehabilitation" regulation option.
     3. Catch and release; added "rehabilitation" or "special opportunity"/ "biomanipulation" option.
   - Resist-Accept-Direct (RAD) Summit – July 24-25 meeting in Stevens Point, with goal of producing the following deliverables:
     1. Potential actions within each RAD category to apply to Walleye waters
     2. Definition of "bright spot" walleye waters with an associated list of waterbodies
     3. A list of waters where additional rehabilitation actions may be desired (e.g., Walleye Lakes of Concern)
     4. Resources and template for future rehabilitation plans using Walleye Lakes of Concern plan as model

2. **WDNR Hatchery Walleye Production** – submitted by WDNR Biologist, Ryen Kleiser

   Hatchery walleye production numbers in 2023 associated with State of Wisconsin walleye stockings. These numbers include surplus fish sourced from our hatcheries, as well as fish the state purchased from vendors towards active work quotas. They do not include fish purchased from private funds, nor do they include independent tribal stockings.

WI DNR 2023 Walleye Stocking		
Age Class		
Fry	Small Fingerling	Large Fingerling
28,040,585	1,453,253	610,939

3. **Walleye Regulation Changes for upcoming 2024 fishing season –** provided by WDNR Policy Specialist, Meredith Penthorn

   Rules that have been approved for implementation this upcoming 2024 fishing season include:

   - The statewide walleye inland bag limit reduction to 3 in total (for waters with a daily bag limit of 5 currently). Statewide Walleye/Sauger daily bag limit of 3 per day on all inland waters - Bag limits for Great Lakes (including Green Bay) and Wisconsin-Iowa, Wisconsin-Minnesota, and Wisconsin-Michigan boundary waters would remain unchanged, as would any water with a bag limit currently lower than 3.
   - Lake Wissota and associated waters walleye - Daily bag limit of 3 fish and a minimum length limit of 13 inches for walleye, 16 – 24" protected slot, only one Walleye greater than 24 inches may be kept per day on the following waters and connected tributaries up to the first dam (Chippewa, Eau Claire, Price, Rusk, Sawyer and Taylor counties).
   - St. Croix River Game Fish Regulation Changes (St. Croix Falls dam downstream to Prescott)—Walleye/sauger: Daily bag limit of 4 in total, 15" minimum length limit for walleye and none for sauger, only 1 walleye/sauger over 20" may be kept per day
   - Wilke Lake (Manitowoc Cty) regulations: Walleye minimum length limit of 18", daily bag limit of 3

Wisconsin DNR Office of Applied Science – Fisheries Research Program – Walleye Research 2023 – submitted by WDNR Program Supervisor, Dr. Greg Sass

- **Walleye genetic pedigree analysis of the Sanford and Escanaba Lake, WI walleye populations**. Beginning in 2016, WDNR fisheries research has collaborated with Dr. Wes Larson and Dr. Jared Homola of the Wisconsin Cooperative Fishery Research Unit at UWSP to genetically link age-0 and age-1 walleye with individual parental walleyes and spawning habitat. Post-doctoral researcher at UWSP (and now Assistant Professor at Northland College), Dr. Bobby Davis and his co-authors have a manuscript provisionally accepted in Evolutionary Applications.

  Davis, R., L. Simmons, S.L. Shaw, G.G. Sass**,** N. Sard, D. Isermann, W. Larson, and J. Homola. Analyzing demographic patterns in reproductive success of walleye (*Sander vitreus*) in Escanaba Lake, Wisconsin. Evolutionary Applications (provisionally accepted).

- **Does woody habitat addition increase walleye production?** Beginning in 2015, a long-term study was initiated to test whether the addition of trees to a lake increases fish production, including the production of walleye. Pre-manipulation monitoring of the fish community and aquatic ecosystem has been completed and 160 trees were added to Sanford Lake in June 2018. Fish and aquatic ecosystem monitoring is ongoing to test for responses to the habitat addition. Preliminary results suggest that whole-lake fish community productivity has quadrupled in Sanford Lake after adding the trees. Species-specific production increases have primarily been observed in bluegill, rock bass, and largemouth bass, which may not bode well for walleye given known influences of centrarchids on walleye natural recruitment. Water quality, aquatic macrophytes, and benthic invertebrates within the lake have not changed since the initial round of tree drops. Total zooplankton has declined, likely in response to increases in centrarchid recruitment. Another round of tree drops is scheduled on Sanford Lake for fall 2024. Former M.S. student on the project, Quinn Smith, currently has a manuscript provisionally accepted in the North American Journal of Fisheries Management detailing fish behavioral responses to the coarse woody habitat addition.

Sass, G.G., S.L. Shaw, T.P. Rooney, A.L. Rypel, J.K. Raabe, Q.C. Smith, T.R. Hrabik, and S.T. Toshner. 2019. Coarse woody habitat and glacial lake fisheries in the Midwestern USA: knowns, unknowns, and an experiment to advance our knowledge. Lake and Reservoir Management 35(4):382-395. DOI:10.1080/10402381.2019.16305309.

Smith, Q.C., G.G. Sass, T.R. Hrabik, S.L. Shaw, and J.K. Raabe. 2021. Sportfish behavioral responses to a littoral coarse woody habitat addition in a north-temperate lake. Ecology of Freshwater Fish 31:454-468. https://doi.org/10.1111/eff.12643.

Sass, G.G., S.L. Shaw, C.C. Fenstermacher, A.P. Porreca, and J.J. Parkos. 2022. Structural habitat in lakes and reservoirs: physical and biological considerations for implementation. North American Journal of Fisheries Management https://doi:10.1002/nafm.10812.

Smith, Q.C., J.K. Raabe, S.L. Shaw, T.R. Hrabik, **G.G. Sass**. Movement of sport fish in response to a littoral coarse woody habitat addition. North American Journal of Fisheries Management (provisionally accepted).

- **Walleye comparative recruitment study**. Beginning in summer 2017, a 7-year comparative walleye recruitment study was initiated with Great Lakes Indian Fish and Wildlife Commission biologists. The project aims to measure within-lake and watershed characteristics from a suite of lakes throughout northern Wisconsin with stable walleye recruitment and in those where natural recruitment has declined over time. The goal of this study is to test for differences between the lake types and to identify management actions that could be applied to improve walleye natural recruitment. As of 2024, we have 7 years of data on 53 lakes and data collection has ended. Results suggest that water clarity, zooplankton, and the availability of thermal-oxygen-optical habitat did not differ between populations with stable or declining recruitment. No differences between lake types were observed for measured habitat variables (i.e., shoreline development, spawning habitat, coarse woody habitat), except for percent area coverage (PAC) of aquatic macrophytes. Declining recruitment lakes had significantly higher PAC of aquatic macrophytes. Centrarchid relative abundance was greater on declining recruitment lakes compared to stable recruitment lakes. Results of the study are currently being written up for peer-reviewed publication.

Shaw, S.L. and G.G. Sass. 2020. Evaluating the relationship between yearling walleye, *Sander vitreus*, electrofishing catch per effort and density in northern Wisconsin lakes. Fisheries Management and Ecology 27:544-549. DOI:10.1111/fme.12449.

- **Hatchery reared walleye sex ratios.** In 2021, OAS research scientists in collaboration with WDNR Fish Management Veterinarians and WDNR and Tribal Hatchery Managers initiated a project to investigate the sex ratios of extended growth walleye fingerlings. This project was initiated after preliminary reports of sex ratios favoring females from one hatchery in 2019 (n=50 fish) and three hatcheries in 2020 (n=50 fish/hatchery)[Sass et al. 2022 citation below]. The project initiated in 2021 has ended. Primary objectives include 1) documenting age and size of sexual differentiation for both males and females; 2) evaluating the environmental factors that may influence sexual differentiation both natural (e.g., temperature, pH, rearing density) and chemically induced (e.g., endocrine disrupting or mimicking compounds and hormone profiles); and 3) evaluating temporal trends in adult sex ratio of lakes stocked with different hatchery products (i.e., fry, small fingerling, and extended growth) as well as wild population sex ratios. Histology results from 2021, showed that males (confirmed via presence of early stage sperm) were not generally present at time of stock out in September and October (3 males observed out of 727 total samples). Samples at stock-out included confirmed female fish and undifferentiated fish (which had no primary stage gametes present) which is consistent with the literature that suggest female Walleye differentiate first. Males became more apparent in over-winter samples (held indoors for repeated monthly sampling from October through January). January 2022 sample n = 25 Females, 21 males, 4 undifferentiated. Walleye that had spent any time in lined ponds during rearing tended to have a higher female sex ratio, range 51% - 100% female, whereas Walleye raised in earthen ponds, indoor raceways or the wild sample had sex ratios closer to 1:1 or were dominated by undifferentiated fish, range 18% - 54% female. Water chemistry sampling of lined ponds did not directly indicate any endocrine disrupting chemicals or hormones present in the rearing water that were consistent with observed female dominated sex ratios. However, we tested bisphenols and alkylphenols only and did not test for phthalates or other endocrine disrupting chemicals. Water temperature and pH were significantly higher in lined ponds relative to earthen ponds, indoor raceways, and the wild sample. Both water temperature and pH are known to influence sexual differentiation in some fish species but there is little information about the effects of these factors on Walleye. Evaluation of the potential effects of rearing conditions (temperature and pH) on sex ratio is ongoing as well additional analysis related to trends in adult sex ratios of stocked and wild populations. Results of the study are currently being written up for peer-review publication.

Sass, G. G. et al. 2022. Female sex ratio bias in extended growth hatchery Walleye fingerlings produced in Wisconsin. North American Journal of Aquaculture DOI: 10.1002/naaq.10237.

- **Whole-lake bullhead removal to test for walleye recruitment responses**. In 2019, a whole-lake bullhead removal study was initiated on Howell Lake in Forest County, WI. After a year of baseline fish community monitoring in 2019, over 800,000 (adult and age-0) bullhead have been removed from Howell Lake. A review of previous bullhead removal studies in Wisconsin was published by Sikora et al. (2021) in a special issue of the North American Journal of Fisheries Management based on the 3rd International Catfish Symposium proceedings. Previous bullhead removals have shown major shifts in fish community structure favoring percids. Population demographics of bullhead in Howell Lake was also published in 2022. Currently, post-bullhead removal fish community monitoring is continuing. Preliminarily, the bullhead removal resulted in a large year class of black crappie, high relative abundances of yellow perch, and walleye natural recruitment persists at low levels.

  Sikora, L.W., J.A. VanDeHey, G.G. Sass, G. Matzke, and M. Preul. 2021. Fish community changes associated with bullhead removals in four northern Wisconsin lakes. 2021. Proceedings of the Catfish 2020; 3rd International Catfish Symposium. North American Journal of Fisheries Management 41:S71-S81. DOI:10.1002/nafm.10594.

  Sikora, L.W., J.T. Mrnak, R. Henningsen, J.A. VanDeHey, and G.G. Sass. 2022. Demographic and life history characteristics of black bullheads *Ameiurus melas* in a north temperate USA lake. Fishes doi.org/10.3390/fishes7010021. (Editor's Choice Article)

- **Depensation in Wisconsin walleye populations**. Depensation, or elevated age-0 mortality rates at low adult stock size, was tested for in about 80 Wisconsin walleye populations. Results suggested that about half of the walleye populations examined showed depensatory recruitment dynamics. This suggests that a critical adult density threshold exists such that reductions in stock size below this level will result in failed recruitment without intervention. This study was published in Fisheries in 2021 by WDNR fisheries research scientists, Dr. Greg Sass, Dr. Zach Feiner, and Dr. Stephanie Shaw. A current study and manuscript led by Dr. Colin Dassow of the WDNR examining abiotic and biotic covariates of walleye depensation has been published in Fisheries Research. Dassow et al. (2023). Depensation for walleye was best predicted by climate, land use change, proportion of the fish community being centrachids, and a consistent interaction with largemouth bass.

  Sass, G.G., Z.S. Feiner, and S.L. Shaw. 2021. Empirical evidence for depensation in freshwater fisheries. Fisheries 46(6):266-276. **DOI:**10.1002/fsh.10584.

Dassow, C.D, G.G. Sass, S.L. Shaw, Z.S. Feiner, C. Nieman, and S.E. Jones. Depensation in fish recruitment driven by context-dependent interactions with another predator. Fisheries Research 262 (2023) 106675.

- **Walleye spawning phenology related to climate change**. WDNR fisheries research scientist, Dr. Zach Feiner, has an ongoing study testing for the influences on climate change on walleye spawning phenology and subsequent recruitment responses. In addition, a collaboration among WDNR fisheries research and UW-Madison, Center for Limnology scientists is examining the influence of high ice off variability on walleye recruitment. A perspective on climate change phenological effects on aquatic ecosystems and walleye was published in the Canadian Journal of Fisheries and Aquatic Sciences, showing shifts toward earlier ice off and walleye spawning in spring, but also that ice off and walleye spawn timing was becoming increasingly unpredictable and variable over time. Extreme ice-off years (either early or late) were related to poor recruitment in Escanaba Lake.

  Feiner, Z.S., H.A. Dugan, N.R. Lottig, G.G. Sass, and G.A. Gerrish. 2022. A perspective on the ecological and evolutionary consequences of phenological variability in north-temperate lakes. Canadian Journal of Fisheries and Aquatic Sciences doi.org/10.1139/cjfas-2021-0221.

  A follow-up paper analyzed patterns in walleye spawning phenology and recruitment across ~250 lakes in Wisconsin, Minnesota, and the Upper Peninsula of Michigan. Both ice-off and walleye spawn timing was shifting earlier and becoming more variable across all lakes, however, walleye spawn timing was shifting at only about half the rate as ice-off, suggesting increasing risks of trophic mismatches for newly hatched walleye. Walleye recruitment was negatively related to the degree of mismatch (measured as the deviation of spawn timing in a given year from the average timing for that lake) in the majority of lakes, suggesting that increasing variability in spawn timing will likely increase the frequency of poor walleye year classes. Lastly, lakes that were stocked exhibited different phenology patterns (shifting to spawn later in the year) than non-stocked populations (shifting to spawn earlier in the year), although this phenomenon requires further study to understand possible mechanisms.

  Barta, M.E., G.G. Sass, J.R. Reed, T.A. Cichosz, A.D. Shultz, M. Luehring, and Z.S. Feiner. Lagging spawning and increasing phenological extremes jeopardize walleye (*Sander vitreus*) in north temperate lakes. Limnology and Oceanography Letters (provisionally accepted).

  Finally, an ongoing project is seeking to use walleye spawn timing to uncover critical periods for larval and juvenile walleye survival in Wisconsin lakes. Initial results suggest that temperature in the month before spawning is the dominant trigger for walleye spawning. Few clear critical periods for larval or juvenile walleye survival to the fall have been discovered, which may suggest that critical periods vary year to year based on environmental conditions. This work is preliminary and will continue in 2024.

- **Restoring walleye populations in rainbow smelt invaded systems**. In 2019, baseline research was conducted between UW-Madison, Center for Limnology Ph.D. student, Joe Mrnak, and WDNR fisheries research to restore walleye in a rainbow smelt dominated lake. Restoration is being attempted by stocking cisco, yellow perch, and adult walleye, while subsequently removing rainbow smelt during spring spawning. This research is ongoing and cisco were stocked into Sparkling Lake in fall 2020 and 2021. A review of invasive rainbow smelt effects on fish communities and the theory behind this research project were published in Reviews in Fisheries Science and Aquaculture in 2022. Results of the study are currently being written up for peer-reviewed publication.

  Mrnak, J.T., L. Sikora, M.J. Vander Zanden, and G.G. Sass. 2022. Applying panarchy theory for aquatic invasive species management: a case study on invasive rainbow smelt *Osmerus mordax*. Reviews in Fisheries Science and Aquaculture https://doi.org/10.1080/23308249.2022.2078951.

- **Fish community productivity**. Walleye production because of poor natural recruitment has declined over time in Ceded Territory of Wisconsin lakes. Determination of fish community production distribution in lakes with stable walleye natural recruitment versus those where natural recruitment has declined over time will be used to inform applied management actions to rebalance fish community production to favor walleye natural recruitment. A M.S. graduate student at UWSP (Max Wilkinson) will continue this study in 2023-2025.

- **Evaluation of the Wisconsin Walleye Stocking Initiative**

  Walleye *Sander vitreus* are culturally and recreationally important in Wisconsin, USA and have experienced population declines in some lakes due to reduced natural recruitment over time. In 2013, the Wisconsin legislature implemented the Wisconsin Walleye Stocking Initiative, a statewide rehabilitation effort to help declining Walleye populations by stocking fall fingerling Walleye (150-250 mm). An evaluation of stocked fish survival and cost to harvestable age is important for assessing the program's goals. Our objectives were to: (1) test for differences in natural mortality (*M*) of stocked Walleye among stocking densities (12.4, 24.7, 37.1 fish/ha), lake recruitment status, and lake conductivity; (2) estimate cost of survival to a harvestable age; and (3) test for differences in predicted adult Walleye abundance (resulting from stocking) among lakes across various stocking densities. We found significant differences in *M* among recruitment status, lake conductivity, and stocking density. Natural mortality was lower in lakes with some some natural recruitment, with medium-low and high conductivities, and stocked at 24.7 fish/ha. No estimates of survival resulted in stocked Walleye populations reaching densities of natural reproducing populations (≥7.4 adult Walleye/ha) or that of a "fishable" population (≥3.7 adult Walleye/ha) following one stocking event. No conditions resulted in the naturally reproducing population density standard to be met after multiple stockings. Two to four stocking events were required to achieve the "fishable" population standard, depending on lake conditions. When estimating cost to harvestable age, lakes stocked at 24.7 fish/ha had the lowest cost to age-4 ($17.70 - $35.41/fish). Lakes stocked at 12.4 fish/ha had the highest cost to age-4 ($91.17 - $182.34/fish). Our results suggest that the stocking density to reduce juvenile Walleye *M* from age-0 to age-1 was dependent on lake conductivity and recruitment status, with lakes stocked at 24.7 fish/ha providing the lowest cost to age-4. This manuscript was published in Fisheries Research in 2023.

Elwer, B.M., J.A. VanDeHey, S.L. Shaw, L.W. Sikora, J.T. Mrnak, and G.G. Sass. 2023. Post-stocking evaluation of mortality and cost to age-4 of fall fingerling walleye *Sander vitreus* in northern Wisconsin lakes. Fisheries Research 266(2023) 106758 https://doi.org/10.1016/j.fishres.2023.106758.

- **Walleye Angler Effort Dynamics**

This objectives of this new FY24 SFR fisheries research project are: 1) test whether walleye angler effort has changed in the Ceded Territory of Wisconsin during 1990-2025; 2) if walleye angler effect has changed in the Ceded Territory of Wisconsin over time, test whether angler effort has changed for other non-walleye sportfish over time; 3) test for predictors explaining variability in walleye and non-walleye sportfish angler effort dynamics over time; and 4) evaluate spatial and temporal dynamics of walleye and non-walleye sportfish angler effort dynamics in the Ceded Territory of Wisconsin over time. Given natural recruitment, adult abundance, and productivity declines in some Ceded Territory walleye populations, this projects intends to better understand angler responses to declines in walleye productivity.

- **Creel Survey Efficiencies**

This new FY24 SFR fisheries research project aims to identify potential efficiencies for existing point-intercept Wisconsin creel surveys. The project will examine long-term creel survey data to understand whether modeling may allow us to predict angler effort, catch rates, and harvest rates on more lakes with limited data. Further, the project aims to identify when species-specific creel surveys may be most important for estimating exploitation.

4. Minocqua Chain Walleye Rehabilitation – Submitted by WDNR biologists Nathan Lederman, Lawrence Eslinger and Royce Zehr

A partner group implemented a rehabilitation plan in hopes of restoring a self-sustaining walleye population across the Minocqua Chain of Lakes. Effort included walleye stocking, closure of angler and tribal harvest, increased monitoring and habitat alterations (TWG 2016). Adult walleye abundance has increased but sufficient young of year recruitment still lacks. This past year, multiple life stages of walleye began to be stocked within the same year in hopes of improving walleye survival and to identify where the bottleneck may be occurring. Approximately 77,000 eggs were manually fertilized and placed onto prime walleye spawning grounds in the beginning of May by the Great Lakes Indian Fish and Wildlife Commission (Lenz 2023). Approximately 3.2 million walleye fry were raised by Headwaters Basin Chapter of Walleyes for Tomorrow in a portable hatchery on the shore of Minocqua and released at three sperate deep water locations within Minocqua at the end of May (WFT 2023). XXXXX large fingerling walleye (average length 6.3 inches) were stocked in the middle of September after the fall electrofishing surveys. Tissue samples from the parents used in all spawning and stocking events were collected allowing for parentage assessments. Previous parentage analysis of small individuals captured during the 2022 monitoring indicated that 0/5 walleye from Kawaguesaga and 2/2 walleye from Minocqua were from the portable hatchery. The 2023 egg and fry stockings do not appear to have survived to appreciable levels as evidenced by the fall electrofishing age-0 relative abundance estimate of <0.2 age-0 per mile across the chain. Stocking of multiple life stages is planned to occur for a couple more years. Contributions of each stocking life stage will be assessed in the future as these cohorts mature and recruit to the adult life stage in 3-5 years.

Lenz, K. 2023. Assisted reproduction: An alternative to fish hatcheries on Minocqua Lake. Mazinaigan: A Chronicle of the Lake Superior Ojibwe.

Technical Working Group (TWG). 2016. Minocqua Chain Walleye Rehabilitation Plan. Madison, Wisconsin.

5. **Assisted reproduction: An alternative to fish hatcheries on Minocqua Lake**
By Aaron Shultz (Great Lakes Indian Fish and Wildlife Commission)

Ogaawag (walleyes) are threatened by warming waters due to climate change, human activity on spawning grounds, invasive species, and overfishing. This is of special concern for the Anishinaabeg people, for whom ogaawag are not only an important food source but also a close relative. They believe their relationship with relatives (natural resources) should be maintained for the next seven generations and that each successive generation should make decisions with this in mind.

A decline in the number of adult and young ogaawag was observed in the Minocqua Chain of lakes in the Ceded Territories of Wisconsin in the Upper Midwest. In response, an ogaa rehabilitation plan was initiated with goals of increasing adult abundance and reestablishing natural recruitment. As part of that effort, an assisted reproduction project was started in 2023 with the goal of increasing the number of young ogaawag in the Chain of Lakes. This effort included the Great Lakes Indian Fish and Wildlife Commission in collaboration with the Wisconsin Department of Natural Resources, Lac du Flambeau tribe, and Walleyes for Tomorrow.

To accomplish this task, Walleye were captured using fyke nets placed near spawning grounds throughout the lake. Captured fish were removed from the holding tank, measured, and weighed. The ventral posterior area of the female fish was dried with a towel to avoid activating the eggs which become sticky when wet. Researchers expressed the eggs into a sterile container.

Next, the researchers dried off the ventral posterior area of a male walleye and expressed the milt (sperm) into a different container. Milt from at least two other male walleye went into the same bowl. The milt and eggs were mixed for one to two minutes before being dispersed onto prime spawning grounds. One of the primary causes for egg mortality is lack of gas and nutrient exchange to the eggs due to their cohesive nature. Manually spreading the eggs decreases the occurrence of these fatalities. Cameras were placed near the egg distribution sites to monitor egg predation by other fish species.

The team took fin clips from each fish so that parentage of any offspring can be determined. This will be an ongoing effort for the next three years with hope that environmental conditions will be favorable for young ogaa survival in at least one of the three years.

6. **Hooking Mortality Study on Tenderfoot Lake in the 1842 Ceded Territory in Wisconsin**

By Mac McPherson, University of Illinois Urbana-Champaign in association with the Great Lakes Indian Fish and Wildlife Commission

Ogaawag (walleyes) are an important relative of the Anishinaabeg people and a food source throughout the year. Anishinaabeg people also share a strong spiritual connection with this being. Changing environmental conditions, harvest, and nonnative beings are putting ogaawag at risk in many lakes throughout the Ceded Territories in Michigan, Wisconsin, and Minnesota.

Hook and line fishing is very popular throughout the Midwest, especially northern Wisconsin. Anglers of all ages come from all over the world to experience what it’s like to catch a walleye. Anglers may choose to harvest an ogaa, or they may voluntarily or be compelled to release the fish depending on regulations for a given lake. Angler behavior while catching and releasing a fish can increase or decrease survival. For example, taking a photo while holding the fish out of the water increases air exposure and can negatively influence survival.

This project aims to estimate the post-release mortality of ogaawag across a range of temperatures in Tenderfoot Lake in northern Wisconsin. The Great Lakes Indian Fish & Wildlife Commission (GLIFWC) led this project in collaboration with the University of Illinois Urbana-Champaign, Wisconsin Department of Natural Resources, and Minnesota Department of Natural Resources. Once a fish was hooked, the following variables were recorded: fight time, hook location, air exposure, and handling time. A series of reflex tests (equilibrium response, eye-tracking, bite reflex, vibration response, and the release score) were administered when the fish was caught and put in the livewell. These tests were scored on a quarter system from 0 to 1, with 0 being not impaired and 1 to be severely impaired. The fish were then put into holding pens and closely monitored with an underwater camera for five consecutive days. After five days, the fish were examined for any injuries, the number of mortalities were noted, and the surviving ogaawag were released back into the lake.

Additionally, data collected over the past year shows a relationship between temperature and handling time. Once the water temperature is ~ 73 degrees Fahrenheit, it was noted there was a greater chance that a caught and released ogaawag would not survive. Moreover, preliminary analyses suggest an increase in ogaawag handling time and air exposure may also decrease survival rates.

A follow-up study will be conducted this year that aims to estimate hooking mortality without the use of holding pens. For more information, please contact the GLIFWC Inland Fisheries Biologist Aaron Shultz (aaronshultz@glifwc.org) or Mac McPherson (msm16@illinois.edu).

7. **Green Bay Management Update –** submitted by WDNR Biologist, Jason Breeggemann

Green Bay Walleye Reward Tag Study:
Green Bay supports a high quality walleye fishery that is growing in popularity. Results from annual creel surveys estimate that anglers are now harvesting over 100,000 walleyes each year from Green Bay and its tributaries. In recent years, anglers have expressed concerns that walleye harvest is too high and more restrictive regulations should be put in place to reduce walleye harvest to ensure the sustainability and quality of this fishery. While results from creel surveys provide estimates of the number of walleyes that are harvested, the exploitation rate remains unknown. To get an estimate of annual walleye exploitation rates on the Green Bay system, we plan to start a reward tag study in the spring of 2024. The goal of this study is to tag 5,000 walleyes each spring during electrofishing surveys. Two hundred of these walleyes will receive a red reward tag. Anglers that report catching or harvesting a reward tagged walleye and have proper confirmation (can present the physical tag or have picture evidence of the tag in a walleye and a verifiable tag number) will receive a $100.00 reward. The study will run for 3-5 years depending on variability in tag reporting rates and will provide us with an exploitation rate as well as correction factor for angler non-reporting that will be used to better manage the Green Bay walleye fishery in the future.

8. **Shawano Lake and Surrounding Waters (Loon, Washington, Wolf River Pond and Shawano Outlet Channel Walleye Rehabilitation) -** submitted by WDNR Fisheries Technician, Elliot Hoffman

Wisconsin Department of Natural Resources along with Walleyes for Tomorrow began working together to address the walleye population decline in Shawano Lake, Shawano County in 2011. Annual survey data showed no young of year recruitment since 2002. A naturally reproducing population had been present in Shawano Lake in the past, population estimates averaged five per acre. Beginning in 2011, stocking quotas were requested for 30,000 (5/acre) large fingerlings every other year. Over a period of 4 stockings, through 2017, these fish were fin clipped to denote year classes. Beginning in 2012, a stakeholder group, Walleyes for Tomorrow, began using a walleye wagon to stock back into Shawano Lake, they also marked with oxytetracycline. On average 4 million fry have been stocked back into Shawano Lake annually. While there had been several reports of smaller walleyes being caught by anglers since rehabilitation began, the first documented year class was in 2016. These 13 fish were confirmed to have originated from the walleye wagon. Since rehabilitation measures have begun 3 population estimates have been calculated. The most recent population estimate in 2023 has shown just over 0.8 adult walleye per acre. Over the course of the 3 population estimates there has been increase in the population. An ongoing study is being conducted using PIT tag arrays around Shawano Lake and the surrounding waters to better understand the spawning areas of the walleyes. Historically most of the effort in sampling for walleye has been focused near a small island in the southwest part of Shawano Lake. During 2023 sampling good numbers of walleye were captured in Loon and Washington Lakes. Over 30% of the adult walleyes captured throughout the surveys had fin clips from previous state hatchery stockings. The current study will be used to determine potential habitat improvements and usage of waterbodies by adult walleyes. Along with tracking movements to better understand walleye wagon fry movements vs large fingerling hatchery stocked fish.

9. **Molecular Conservation Genetics Laboratory; Wisconsin Cooperative Fishery Research Unit; University of Wisconsin – Stevens Point**
   Submitted by Dr. Jared Homola

   Over the past year, the Molecular Conservation Genetics Laboratory at University of Wisconsin – Stevens Point has led a project to characterize stock structure of Lake Superior walleye. To date, we have genotyped walleye from 13 spawning aggregates in Lake Superior and its tributaries and four out of basin broodstock sources. We have found substantial genetic structure throughout Lake Superior as well as evidence of a moderate effect of stocking on spatial genetic structure, particularly around the Keweenaw peninsula. Upcoming work will include genotyping approximately 10-14 more spawning aggregates, providing a more complete understanding of stock structure. We have also continued to advance efforts in parentage-based tagging (PBT) as a walleye management tool throughout Wisconsin and neighboring states. PBT involves genetic assignment of wild caught walleye back to a reference database containing genetic information for broodstock previously used in hatchery production. This process provides a means of differentiating naturally produced from hatchery-reared walleye for informing stocking assessments and assessing stocking success as a function of factors such as broodstock source, recipient waterbody, or specific hatchery practices.

10. **Wisconsin Cooperative Fishery Research Unit; University of Wisconsin – Stevens Point**
    Submitted by Dr. Dan Isermann & Dr. Dan Dembkowski

Yellow perch recruitment and zooplankton availability in northern Wisconsin lakes with different walleye recruitment histories

Some northern Wisconsin lakes that previously supported natural walleye recruitment have exhibited recruitment declines over the last few decades. Previous research suggested that a recruitment bottleneck was occurring at or before mid-July in lakes with declining walleye recruitment. Recent research indicates that walleye and yellow perch recruitment may be influenced by similar environmental factors, but the current status and historical trends of perch recruitment in Wisconsin are unknown. To better understand factors influencing both walleye and yellow perch recruitment, the objectives of this study were to determine if: 1) differential trends in age-0 perch abundance occurred between lakes with different walleye recruitment histories (sustained or declining); 2) catch per effort (CPE) of larval and post-larval fish predicted perch year-class strength indexed as age-0 CPE in fall electrofishing; and 3) zooplankton densities and spatial and temporal trends in these densities differed among lakes with different walleye recruitment histories. Broadly, results suggest that lakes with declining walleye recruitment are capable of producing age-0 yellow perch year classes that are similar to year classes observed in lakes with sustained walleye recruitment. Furthermore, densities of zooplankton and spatial and temporal trends in these densities were generally similar between lakes with different walleye recruitment histories. Larval yellow perch were an important diet item of larval walleye, and the lack of zooplankton of larval walleye diets is likely not due to low zooplankton densities. M.S. thesis led by AnaSara Gillem is complete and manuscript is in preparation.

Spawning locations, movements, and potential for stock mixing of walleye in Green Bay, Lake Michigan

Effective fishery management in large systems relies on understanding how individual stocks contribute to the fishery over spatial and temporal scales. The current conceptual model for Walleye *Sander vitreus* management in Green Bay designates Walleye in the northern and southern parts of the bay as distinct stocks, with little mixing between the northern and southern fisheries and assumes Walleye in both northern and southern Green Bay primarily spawn in tributaries as opposed to shoreline or offshore reef areas. We used acoustic telemetry to test this conceptual model for Walleye management in Green Bay. Telemetry indicated that the majority of Green Bay Walleye use tributaries for spawning. However, many individuals were assigned to open water spawning locations in consecutive years in both northern (26%) and southern (21%) Green Bay, suggesting that open water spawners may represent a larger proportion of the Walleye stocks than previously thought. Differential movement was observed between northern and southern portions of Green Bay, with 56% of Walleye tagged in northern Green Bay crossing south compared to only 19% of Walleye tagged in southern Green Bay crossing north. Walleye typically transitioned across these boundaries in summer and fall, suggesting that stock contributions to the fishery in each zone may differ seasonally. Differential movements of northern Green Bay Walleye may be influenced by broad-scale differences in habitat and prey availability, which are likely related to the differential effects of dreissenid mussel invasion in Green Bay. Our results suggest that adjusting monitoring efforts to account for open water spawners may provide a more complete picture of stock status. Additionally, more research examining potential food web effects of northern Green Bay Walleye moving into southern Green Bay may be needed to determine how these movements might influence other important species. This study was published in the North American Journal of Fisheries Management (Izzo et al. 2023) and we are continuing to analyze walleye telemetry data with a focus on tributary use during spawning and non-spawning periods.

Izzo, L.K., D.J. Dembkowski, T. Hayden, T. Binder, C. Vandergoot, S. Hogler, M. Donofrio, T. Zorn, C.C. Krueger, and D.A. Isermann. 2023. Spawning locations, movements, and potential for stock mixing of walleye in Green Bay, Lake Michigan. North American Journal of Fisheries Management 43:695-714.

Supply and demand dynamics associated with using stocking to maintain walleye fisheries in the face of climate change

The objective of this study was to evaluate stocking success of Walleye Sander vitreus in lakes and reservoirs across the midwestern United States to inform stocking practices for state agencies. Demand for walleye stocking may increase if climate change limits the potential for natural recruitment in lakes. Consequently, the strategic distribution of walleye stocking may be needed to maximize fishing opportunities. We synthesized data from 2226 Walleye fry and fingerling stocking events on 653 lakes in the Midwestern USA (based on contributions from researchers and managers in IL, IN, IA, MI, MN, NE, OH, SD, and WI) and used random forest algorithms and mixed-effects linear models to identify abiotic and biotic factors related to walleye stocking success. Latitude and year explained relatively little variation in stocking success relative to within lake variation. Relative abundance of Largemouth Bass Micropterus salmoides was an important indicator of Walleye stocking success for fry and fingerlings, with stocking success generally decreasing with increased bass abundance. An interaction between lake size and growing degree days demonstrated that in large systems fingerling and fry stocking success was not related to growing degree days. The models we developed did not accurately predict exact levels of Walleye stocking success, but were 92-94% accurate in predicting whether stocking success of both fry and fingerlings would be at or above the 50th percentile. These findings may help inform the management and stocking allocation of Walleye and suggest that future increases in growing degree days and Largemouth Bass abundance could limit the effectiveness of stocking in some lakes. Paper led by Bobby Davis (WICFRU and now Northland College) and is in review.

Using parentage analysis to investigate the dynamics of walleye at Escanaba Lake, Wisconsin

Harvest in walleye *Sander vitreus* fisheries is size-selective and could influence phenotypic traits of spawners; however, contributions of individual spawners to recruitment are unknown. We used parentage analyses using single nucleotide polymorphisms to test whether parental traits were related to the probability of offspring survival in Escanaba Lake, Wisconsin. From 2017-2020, 1339 adults and 1138 juveniles were genotyped and 66% of the offspring were assigned to at least one parent. Logistic regression indicated the probability of reproductive success (survival of age-0 to first fall) was positively (but weakly) related to total length and growth rate in females, but not age. No traits analyzed were related to reproductive success for males. Our analysis identified the model with the predictors growth rate and year for females and the models with year and age and year for males as the most likely models to explain variation in reproductive success. Our findings suggest that interannual variation (i.e., environmental conditions) likely plays a key role in determining the probability of reproductive success in this population and provide limited support that female age, length, and growth rate influence recruitment. Paper led by Bobby Davis (WICFRU and now Northland College) and accepted for publication in Evolutionary Applications.

Evaluating walleye thermal-optical habitat preferences in northern Wisconsin lakes

Declines in preferred thermal-optical habitat (TOHA; the fraction of a lake considered suitable for walleye in terms of both temperature and light conditions) has been implicated as a factor contributing to declines in walleye recruitment throughout the upper Midwest. However, current models describing TOHA and expected walleye use of TOHA are mostly observational in nature and lacking empirical support. Advances in fish tagging and tracking technology allow abiotic and biotic measurements experienced by individual fish to be transmitted or recorded, thereby providing an opportunity to empirically assess walleye use of model-predicted TOHA and whether lakes with declining walleye recruitment have less TOHA than lakes with sustained recruitment. The objectives of this study are to use acoustic transmitters and archival tags to determine if TOHA use by walleyes varies among lakes or in relation to season and fish size and if previously-used TOHA models accurately define TOHA use for three Wisconsin lakes with different trends in walleye recruitment. Furthermore, results can be used to provide a roadmap for future TOHA studies by determining the data resolution and cost-effectiveness of acoustic telemetry vs. archival data storage tags. We implanted acoustic transmitters into 40 walleye and archival data storage tags into 136 walleye during spring 2022. Tags were distributed among three sizes of walleye and across three lakes with different trends in walleye recruitment. Thermal and optical profiles were measured at each lake periodically during 2022 and archival tag recovery and acoustic detection processing occurred during 2023. This portion of the project is led by MS student Ben Vasquez at UWSP and is part of a broader project to investigate walleye recruitment bright spots in a changing climate. Other team members include personnel from Wisconsin Department of Natural Resources, the USGS National Climate Adaptation Science Center, University of Minnesota, and Center for Limnology at University of Wisconsin-Madison. M.S. thesis is in preparation.

Effects of centrarchid removal on percid populations

The Wisconsin Cooperative Fishery Research Unit at UW-Stevens Point, in collaboration with the Center for Limnology at UW-Madison and with Wisconsin Department of Natural Resources, completed the two years of post-removal monitoring at McDermott Lake where over 280,000 centrarchids were removed during 2018-2021 with goal of assessing effects of large-scale centrarchid removal on walleye recruitment and yellow perch population dynamics and demographic, among other things. During spring 2022 a single larval walleye was captured, representing the only evidence thus far of a walleye recruitment response to manipulation. However, no juvenile walleye were captured in subsequent summer or fall sampling. Yellow perch abundance appears to have increased following centrarchid removals and further research is occurring to determine conditions associated with the observed increase (i.e., if a single or multiple years classes of perch). Project led by M.S. student Becca Henningsen at UWSP and thesis is in preparation.

Identifying walleye and lake whitefish spawning habitat below De Pere Dam to inform habitat improvements for lake sturgeon

Previous work indicates that lake sturgeon recruitment is extremely limited in the Fox River below De Pere Dam. Lack of available spawning habitat and the location of that habitat (nearshore) could contribute to low recruitment. Adding spawning habitat in the form of offshore reefs could provide a potential means to increase lake sturgeon recruitment. However, spawning habitat for other species must be considered in the planning process to ensure that restoration efforts for lake sturgeon do not result in loss of spawning habitat for other species. Specifically, the Fox River below De Pere supports significant spawning runs of native walleye (spring) and lake whitefish (fall) that contribute to important recreational and commercial fisheries in Green Bay. Specific spawning locations for walleye and lake whitefish in the Fox River remain unknown, but previous telemetry and available habitat suggest that many of these fish may spawn in the area shown on the map below. The goal of our project is to use intensive egg sampling to improve our understanding of where walleye and lake whitefish spawn in the Fox River below De Pere Dam to inform placement of the reef designed to improve lake sturgeon spawning habitat so that loss of spawning habitat for walleye and whitefish can be minimized. The first field season of this project focused on the lake whitefish spawning period in fall 2023 and future sampling (spring 2024 and spring 2025) will focus on specific spawning locations for walleye. Project is led by M.S. student Braden Lensing.