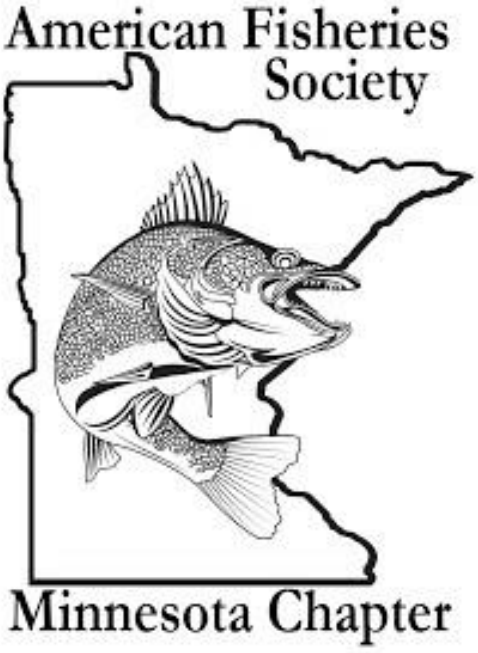
Minnesota Chapter of the American Fisheries Society Annual Meeting – Abstract Book



Reconnecting With the Resource

January 31 & February 1-2 2023

St. Cloud, Minnesota

Concurrent Sessions 1 (Room: Ballroom East)

Large-scale common carp (*Cyprinus carpio*) removal impacts on native fish abundance in Lake Allegan, Michigan

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Common carp (*Cyprinus carpio*) is one of the most invasive aquatic species in Midwestern waterways. Currently, there are very few well-documented impacts of large-scale carp removal on native fish species. Here we report on the preliminary results of a long-term carp removal program and associated changes in native fish community in Lake Allegan, a reservoir on the Kalamazoo River in Southwestern Michigan. We used baited box nets, a selective strategy which targeted carp feeding aggregations, to remove carp in Lake Allegan for the past 5 years. From 2018 to present, over 150,000 carp (approximately 80% of the population) has been removed from the reservoir. As carp biomass declined, macrophyte communities began to increase signaling a shift in lake ecology. Fish community assessments were conducted by WSP USA Environment & Infrastructure Inc. in the spring of 2019 and 2022 to assess potential impacts of removal on native species. Sampling methods, consistent between years, included boat electrofishing, small and large-mesh trap netting, beach seining, and gillnetting. From 2019 to 2022, there has been an overall increase in native fish catch per unit of effort (CPUEs) values across most sampling gear, as well as improvements in age class distribution and Index of Biotic Integrity (IBI). The total number of native individuals captured increased from 1,863 in 2019 to 10,698 in 2022. Most notably, gillnet CPUE for adult yellow perch increased 14 folds from ~3 to 46 per net. Also, small-mesh trapnet CPUE of young-of-year smallmouth bass and largemouth bass increased by two orders of magnitude. Future surveys will determine if these cohorts recruit into the population. These results, although preliminary, signal potential changes in the native fish community as a result of carp removal. Carp management can be an important tool not only in improving water quality, but also in restoring native fish communities throughout the Midwest.

Can mechanical removal of invasive cattail benefit fish communities in Minnesota lakes?

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Nearshore aquatic vegetation in lakes provides crucial habitat for spawning adult fishes, nursery habitat for larvae and juveniles, and habitat for prey. The structural complexity and heterogeneity of plant communities that include a mix of floating, emergent, and submergent plant types tends to benefit fishes, including sportfishes like walleye, bass, pike, and sunfishes. Over the last 50 years, invasive narrow-leaf and hybrid cattail (*Typha angustifolia* and *Typha* x *glauca*, hereafter cattail) have moved into lake littoral zones across Minnesota and displaced native vegetation. Expansion of cattail has altered littoral zone habitats by forming dense, homogenous stands that change environmental conditions, displace native vegetation, and may have detrimental effects on fishes. Localized mechanical control and suppression (stand fragmentation or channelization) of cattail may benefit littoral zone ecosystems by improving water quality and increasing plant and fish diversity. The goals of our study are to 1) understand the ecological impacts of cattail on nearshore fish communities, 2) determine if small-scale cattail removal can positively affect fish abundance and diversity, 3) compare regional effects of cattail removal on nearshore lake ecosystems across Minnesota. To determine the before and after effects of cattail removal on nearshore fish communities, we established 1-2 sets of paired sites at 9 study lakes. Following sampling and mechanical harvesting of cattail in one of two paired sites in each lake in 2021, we resampled all sites during summer 2022 to determine if the ecological variables differed in cattail removed sites compared to cattail retained sites. With cattail removal we found changes in water quality, increases in plant diversity, and some changes in fish communities. Results from this study will inform researchers, policy makers, and managers about the effectiveness of mechanical cattail removal as a restoration method in cattail invaded nearshore areas.

Aquatic Invasive Species: Is an ounce of prevention worth a pound of cure?

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Efforts to prevent the spread of aquatic invasive species (AIS) have been widely implemented on local and regional scales to mitigate the economic and environmental harm associated with these organisms. Watercraft inspection and decontamination, along with boater education and outreach, are popular prevention strategies; however, few studies have investigated the effectiveness and cost effectiveness of these approaches. In this study, we aim to fill these knowledge gaps to inform management decision-making by providing more nuanced information about watercraft inspection effectiveness and by using program cost data to estimate prevention benefits for specific monetary investments. We estimated effectiveness of AIS prevention strategies by evaluating boaters and watercraft inspectors during experimentally controlled boat inspections. During these inspections we realistically staged a boat with fresh macrophytes and dead and preserved AIS. Participants were asked to inspect and remove any items as they would after a typical outing on a lake. Both the types of organisms and amount removed from the boat were used to estimate effectiveness for any one inspection. Results suggest that inspectors are significantly more effective than boaters and removal effectiveness differs by type of AIS. In addition, costs of all evaluated prevention strategies have been determined by reviewing existing literature and interviews with AIS managers. Ultimately, these data will be incorporated into the online decision support tool, AIS Explorer (www.aisexplorer.umn.edu) to guide future management decisions.

Optimizing eDNA for Multiple AIS

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Aquatic invasive species (AIS) threaten lake ecosystems and the economies around them. In Minnesota, there are over 800 waterbodies infested with one or more AIS. However, this number is likely an underestimate due to the lack of a widespread AIS monitoring plan. Traditional monitoring for AIS requires significant expertise, different gear for different species, and is expensive on a large scale. eDNA has the potential to alleviate these issues, but many questions persist about how managers can get the most “bang for their buck” (i.e. get the highest probability of detecting an AIS for the cheapest cost). To optimize eDNA sampling for the maximum probability of AIS detections, we sampled 21 lakes over the course of the open water season for common carp and rusty crayfish eDNA. We used qPCR to quantify copy numbers of the target AIS with species-specific assays. Using multi-scale occupancy models, we quantify the effects of seasonality and physical and chemical lake characteristics on detection probability. Our results and recommendations will provide guidance to stakeholders and managers interested in using eDNA as an AIS monitoring tool for the sake of managing aquatic ecosystems.

Zebra mussel induced food web shifts and increased mercury concentrations in walleye and yellow perch

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Zebra mussels (*Dreissena polymorpha*) are invasive species that clear water columns and shift energy resources from pelagic to littoral areas. Walleye (*Sander vitreus*) and yellow perch (*Perca flavescens*) are culturally and economically important fish species in Minnesota that may be negatively affected by zebra mussels, although impacts are variable across populations. The resilience of walleye and yellow perch relies in part on the capacity to access littoral resources following invasion. However, such food web shifts may result in changes in mercury concentrations in fish tissue. To assess the effects of zebra mussel invasions on walleye and yellow perch populations, we evaluated stable isotope ratios (δ15N and δ13C) and total mercury concentrations in fish from 12 zebra mussel invaded and 9 uninvaded Minnesota lakes. Preliminary results suggest zebra mussel induced food web changes led to increased mercury incorporation in walleye and yellow perch diets. Walleye and yellow perch in lakes invaded with zebra mussels demonstrated an increased littoral reliance, spurring elevated methylmercury diet incorporation. Increased littoral reliance and mercury concentration highlight challenging fisheries management decisions and public health concerns that couple in the presence of zebra mussels

Concurrent Sessions 1 (Room: Ballroom West)

Patterns of isotopic niche size in fish communities across Minnesota lakes

David J. Gallagher, Sara M. Kangas, Dylan J. McNulty, Payton E. Johnson, Brian R. Herwig, David F. Staples, Kyle D. Zimmer

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Anthropogenic stressors on fish communities have increased the importance of identifying food web factors that generate ecosystem stability. Theory predicts that species with larger trophic niches may have greater capacity to stabilize food webs through enhanced trophic redundancy, but patterns across lakes and fish species remain poorly known. We sampled 12 fish species across 14 Minnesota lakes and used the stable isotopes δ13C (littoral carbon use) and δ15N (trophic position) to estimate isotopic niche size for each species in each lake. We then performed two analyses. First, does mean niche size across all species vary between lakes? If so, can we identify lake factors influencing niche sizes? Second, is fish niche size within lakes driven by species identity or food web position? Results showed mean lake niche size varied four-fold and was inversely related to lake volume. Lake volume increased trophic position variation but decreased littoral carbon use variation more strongly, indicating fish populations increase omnivory in response to more specialized habitat use as lake volume increases. For our second analysis, species varied over three-fold in mean niche size. Bluegill (*Lepomis macrochirus*) and Yellow Perch (*Perca flavescens*) exhibited the largest niches, while niches were smallest in Walleye (*Sander vitreus*) and two minnow species. Niche size was also negatively related to trophic position, likely due to a wider range of pelagic-littoral carbon use and enhanced omnivory at lower through intermediate trophic levels of fish. Species was a better predictor than trophic position, but our strongest model included both variables, indicating the importance of trophic position in determining niche size. Overall, our study demonstrates how isotopic niche sizes change predictably across lakes and within food webs of individual lakes, an important step for understanding food web stability and how species interactions may shift in the future.

Fish communities exhibit predictable multispecies shifts in trophic position, littoral carbon use, and habitat coupling across Minnesota lakes

Sara Kangas, David Gallagher, Dylan McNulty, Payton Johnson, Brian Herwig, David Staples, Kyle Zimmer

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Food web characteristics can influence the stability of lake ecosystems. Three important factors include a) high trophic position that increases energy integration across trophic levels, b) specialization in energy use (either pelagic or littoral) that increases community niche size, and c) habitat coupling (defined as equal use of pelagic and littoral carbon) that integrates two major energy pathways for lake food webs. To date, it is unknown whether these three variables differ among fish species (species effects) and/or systematically change across fish species among lakes (lake effects). We used stable isotope analysis to estimate trophic position, littoral carbon use, and habitat coupling in 15 fish species in 14 Minnesota lakes and tested for both species and lake effects. Results showed significant species effects on all three variables. Walleye and Muskellunge had the highest trophic position, Cisco specialized on pelagic energy, Banded Killifish specialized on littoral energy, and Northern Pike and Walleye exhibited the highest habitat coupling. Given their combination of both high trophic position and habitat coupling, Walleye may be particularly important for stabilizing food webs. Lake effects were assessed using six species found in all 14 lakes, with lake as a fixed effect and species as a random effect. Surprisingly, all three variables differed significantly among lakes. Additional analyses showed trophic position in all six species was positively related to hypolimnetic dissolved oxygen, hypolimnetic water temperature, and fish size. Further, littoral carbon use was highest in lakes with zebra mussels and low phytoplankton abundance, while habitat coupling was maximized in lakes with the largest mean fish size. Taken together, our results indicate fish communities exhibit shifts in important food web properties, which likely influence food web and ecosystem stability.

Trophic niche overlap of Lake Superior nearshore fishes

Jessie Hanson, Joel Hoffman, Cory Goldsworthy, Nicholas Peterson, Thomas Hrabik, Valerie Brady, Ryan Lepak, Morgann Gordon

Presenter: Jessie Hanson, jessie1414hanson@gmail.com
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My study area, the nearshore region along the north shore of Lake Superior's Western Arm, which includes three fisheries management zones overseen by MN DNR, is occupied by a highly diverse group of native and introduced salmonids. The main objective of this research is to delineate the trophic relationships among the nearshore salmonid complex and other nearshore predators to provide new insight into interactions among these potentially competing species, including native lean lake trout and walleye, relative to introduced steelhead, brown trout, and other salmon species. Our hypothesis was (1) there will be trophic differences among species, (2) the size of the species will be a significant factor; however, sex will not be a significant factor, and (3) fisheries management zone (MN1-MN3, WI2) in which they were caught will be a significant factor. Within the collections, zone differences in species composition, sex, and size were not apparent (though the sample varied among zones). Among species, the nitrogen stable isotope ratio (δ15N) range was large, >5‰, indicating that our study species occupy ~2 trophic positions: omnivores (e.g., Steelhead *Oncorhynchus mykiss*, Coho *Oncorhynchus kisutch*) and piscivores (e.g., Siscowet Lake *Trout Salvelinus namaycush*). The carbon stable isotope ratio (δ13C) range among species was consistent with a mix of pelagic and benthic diet habits. Combined, the δ13C and δ15N values revealed some species have a relatively distinct trophic niche (e.g., Siscowet Lake Trout) whereas other species form an overlapping complex of species that occupy similar trophic niches (e.g., Walleye *Sander vitreus* and Lean Lake Trout or Steelhead and Chinook Salmon *Oncorhynchus tshawytscha*). We conclude that the overlapping trophic niches indicate strong potential for resource competition among some non-native salmonids and native nearshore predators, but also among some native fishes, as well.

Prey-resource partitioning among Brook Trout *Salvelinus fontinalis*, Brown Trout *Salmo trutta*, Rainbow Trout *Oncorhynchus mykiss*, and Coho Salmon *Oncorhynchus kisutch* in the Bois Brule River, Wisconsin

Daniel McCann, Thomas Hrabik, Joel Hoffman
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Affiliation: University of Minnesota-Duluth

Over the past century, intentional introductions of Brown Trout (*Salmo trutta*), Rainbow Trout (*Oncorhynchus mykiss*), Coho Salmon (*Oncorhynchus kisutch*), and Chinook Salmon (*Oncorhynchus tshawyscha*) into Lake Superior and its tributaries has resulted in a diverse assembly of resident and migratory salmonid species in the Upper Bois Brule River, Wisconsin. The introduced species listed above, along with native Brook Trout (*Salvelinus fontinalis*), occupy similar niches, and compete for resources such as food and space in the Upper Brule River. The first objective of this project was to compare prey selectivity among salmonids and determine if interspecific competition between species is reduced through resource partitioning. The 9-mile study reach included six sampling sites, each encompassing a riffle-pool habitat series. Gut contents were collected from 415 fish among 8 total trips between 2021 and 2022. Benthic and drifting invertebrates were collected at each sample site with a hess sampler, kick nets, and drift nets. Prey items sampled in the diets and environment were enumerated and identified to taxonomic order. Overall, 36% of all prey items consumed consisted of Trichopteran larvae and 21% Diptera larvae, while the proportions of those prey items found in the benthos were 28% Trichopteran larvae and 33% Diptera larvae. Brown, Rainbow, and Brook trout preyed most upon (>30%) Trichopteran larvae, while Coho Salmon preyed most on Diptera larvae(>30%). Seasonal proportions of prey items in diets and environment will be reported during the presentation, along with Manly-Chesson's Index of prey selectivity and Schoener's index for diet overlap. An updated insect survey and dietary analysis of salmonids will benefit the current understanding of prey availability and habitat requirements for Brule River salmonids, while aiding in future management decisions within the Upper Bois Brule River system.

Environmental influences on the growth of inland Cisco populations in three Minnesota Sentinel Lakes

Edward Carlson, Casey Schoenebeck, Beth Holbrook, Andrew Hafs

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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. To investigate how different factors were affecting inland Cisco populations, 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. Additionally, metrics that described the pelagic oxythermal habitat and food availability 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 95% 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 age-0 recruitment ($p < 0.01$. $R2 = 0.41$). 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; $p = 0.022$, $R2 = 0.29$). The results from this study document the importance of zooplankton prey and oxythermal habitat on Cisco and provide fisheries managers with further knowledge to help closely monitor these populations.

Concurrent Sessions 2 (Room: Ballroom East)

Does Walleye spatial segregation during spawning persist throughout other seasons?

Claire Rude, Rick Bruesewitz, John Kempe, Michael J. Weber

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Understanding spatial distribution of fish can provide insights into their behavior, population structure, and habitat importance. For instance, fish spatial distribution during spawning and the degree of site fidelity can be indicators of quality spawning areas. After leaving spawning locations, spatial differences in spawning movements may persist throughout other seasons or fish may intermix and use similar habitats throughout the rest of the year. Yet, how intraspecific population differences in spawning movements translate into habitat use during other seasons is not well understood. Our objectives were to use acoustic telemetry to assess the spatial distribution of Walleye *Sander vitreus* in Big Sandy Lake, Minnesota during the spawning season, determine spawning site fidelity between years, and compare home ranges of spatially segregated spawning groups outside the spawning season. We tagged and released 60 Walleye (303-615 mm TL) in autumn 2020 and 2021, passively tracked these fish from October 2020–October 2022, assessed their presence during the spawning period in two tributaries (Sandy and Prairie rivers) compared to those remaining within the reservoir, and assessed spawning site fidelity across years. In 2021, only 29% of Walleyes traveled into tributaries during the spawning season while 71% remained in the reservoir whereas during 2022, 49% traveled into tributaries and 51% remained in the reservoir. Spawning site fidelity between 2021 and 2022 was 91%. Walleye occupying different locations during spawning appear to mix throughout the reservoir during other parts of the year with some slight differences in which areas of the reservoir are preferred. Our results provide information on annual variation in Walleye preferences for reservoir tributaries versus lacustrine habitats during spawning and indicate Walleye spawning in different locations may use similar habitats during other seasons.

Mussel shell use by crevice spawning fishes: reflections from citizen and university scientists on a cooperative study

Molly Fuentes, Jake Wiebe, Gracie Mertes, Mark Hove

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Native freshwater mussels provide a variety of ecosystem services, and while some of these have been described in detail, others are still poorly understood. We explored anecdotal evidence of fish use of mussel shells as spawning habitat. Our research objectives were to describe the proportion and species of mussel shells with evidence of attached fish embryos, identify fish species using shells as nurseries, and share volunteer and university scientists' experiences on this collaborative study. We collected data from several Rice Creek reaches at Locke County Park, Anoka, MN between May and September 2022. Empty mussel shells were photographed for shell identifications, length measurements, and embryo counts. We collected fish embryos for genetic analysis from 18 nests, ≈7% of all shell nurseries observed during the study. Embryo DNA was sequenced at a mitochondrial barcode region (COI) and compared with the NCBI nucleotide database to identify the closest species match based on percent pairwise identity. Preliminary analyses showed evidence of fish embryos in empty mussel shells beginning late May with shell use peaking at ≈40% in late June. The shells of most medium and large mussel species showed evidence of attached embryos. We found that *L. siliquoidea* (Fatmucket) shells used as spawning habitat were significantly larger than unused *L. siliquoidea* shells. Fish embryos collected from shells were identified as *Etheostoma nigrum* (Johnny Darter). Volunteer participation through the Minnesota Master Naturalist program and student citizen scientists from Avail Academy were integral to the success of this study. Citizen scientists greatly increased sample size, broadened sampling methods, and increased participants' passion for this ecosystem. This study demonstrates for the first time that a significant portion of stream mussel shells are used as spawning habitat for crevice spawning fish species.

Dietary Habits of an Underperforming Walleye (*Sander vitreus*) Population in a Northern Minnesota Reservoir

Katherine Bruesewitz, Donn Branstrator, Heidi Rantala, Thomas Hrabik

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Affiliation: Minnesota Department of Natural Resources, University of Minnesota Duluth

Walleye (*Sander vitreus*) are a predatory fish that are highly desired by Minnesota anglers. Previous management surveys conducted by the Minnesota Department of Natural Resources (MNDNR) on Island Lake Reservoir (ILR) near Duluth, Minnesota, have found that walleye size at age has declined the last 30 years. The MNDNR speculates that food limitation is one factor influencing the walleye size structure. Notably, ILR is infested with spiny water flea (*Bythotrephes cederstroemi*) which have been associated with slower growth rates of young of year walleye in Minnesota lakes. This study aimed to characterize the dietary habits of ILR walleye during summer 2021 and identify important prey items. This dietary assessment coincided with the implementation of new harvest regulations and cisco (*Coregonus artedi*) stocking conducted by the MNDNR. Walleye for this study were collected by gill net, fyke net, electrofishing, and angling. Diet composition was assessed by direct microscopic observation of stomach contents. ILR walleye dietary habits were compared with other regional walleye diet data from the literature as well as previous walleye diet data from ILR during 2006 and 2007. This study will help inform future fisheries management decisions.

Concurrent Sessions 2 (Room: Ballroom West)

The trials and tribulations of acoustic conditioning in common carp (*Cyprinus carpio*)

Rebecca Bullers, University of Minnesota; Przemyslaw Bajer, University of Minnesota; Allen Mensinger, University of Minnesota-Duluth

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Affiliation: University of Minnesota

Acoustic conditioning can prove to be a useful tool in common carp (*Cyprinus carpio*) management. Bait and removal strategies have proven to be effective in carp removal, however, there are limitations in the number of carp that can be caught at once due to carp feeding at different times. The efficacy of these strategies may be significantly increased by using acoustic conditioning to ensure that carp aggregations at the bait are more synchronized and that more carp are attracted to the bait from larger areas. During the summer of 2022, we tested if common carp can be conditioned to associate sound with bait in a natural lake setting. Carp responded positively to baiting in the study lake, however, they were unable to be acoustically conditioned using that specific protocol. Currently, we are working on a lab study that will continue to focus on acoustic conditioning in common carp as well as test different reinforcement methods of the acoustic cue in hopes to prolong the extinction of the learned behavior. We hope to apply what we learn about individual fish responses to the acoustic cue in our protocol for the 2023 field season. If successful, acoustic conditioning could accelerate carp management and reduce associated costs.

Effects of Channelization on Fish Communities in Northwest Minnesota Red River Basin Streams

Amanda Craft, Richard Koch, John Sandberg, Andrew Hafs

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Channelization has been historically prominent in Minnesota's Red River Basin in attempts to mediate flooding issues due to agriculture and developmental practices. The straightening of stream channels has assisted in removing water quickly and reduce local flooding of crop fields but has the potential to profoundly influence stream quality and biota. This study compares fish communities between channelized and natural streams in the Red River Basin to assess impacts of stream modifications on local and regional fish communities. Fish metrics included a normalized fish index of biological integrity (FIBI), species richness, species diversity, total abundance, and total biomass. All metrics were significantly higher ($p<0.01$) in natural stream reaches compared to channelized reaches. Watershed FIBI was negatively correlated ($p<0.01$, $R2=0.133$) with percent channelization upstream. Our data provides evidence to suggest there are negative influences that stream channelization has on fish communities.

Concurrent Sessions 3 (Room: Ballroom)

Updates from City of Eagan Neighborhood Fishing Program

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The City of Eagan is a suburb Saint Paul, in the Twin Cities metro area of Minnesota. Over 69,000 residents call Eagan home, with even more folks visiting to work or play. With over 30 small lakes and over 1000 bodies of surface water, Eagan has its own full time Water Resources staff division within Public Works. Jessie Koehle is one of these staff, helping to manage neighborhood fisheries, engage the public, and monitor & protect Eagan lake water quality. Program updates this year include a rotenone treatment for goldfish, recent in-lake alum treatments, lake impairment de-listings, updated fishing programs, new Water Resources Manager on staff, and ongoing discussions on equity and sustainability.

Leveraging approaches for early detection monitoring of invasive fish introductions to the Great Lakes

Joel C Hoffman, Greg S Peterson, Anett S Trebitz, Chelsea I Hatzenbuhler, Jared T Myers, Jason E Ross, Sara L Okum, Erik M Pilgrim

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Assessing relative performance of different sampling methods used for early detection monitoring (EDM) is a critical step in understanding the likelihood of detecting new, previously undetected non-indigenous species (NIS). Typically, EDM performance metrics are based on the probability of detecting established NIS or rare indigenous species; however, detection probability estimates for these proxies may not accurately reflect survey effectiveness for newly introduced NIS. We used data from three different EDM survey approaches for invasive fish monitoring that varied by targeted life-stage (adult–juvenile versus ichthyoplankton), media (physical fish versus environmental DNA), and taxonomic method (morphology-based versus DNA-based taxonomy). The goal was to explore relative detection sensitivity for recently introduced white bass (*Morone chrysops*) and gizzard shad (*Dorosoma cepedianum*) in the Port of Duluth-Superior, a NIS introduction hot spot within the Laurentian Great Lakes. Detection efficiency, measured by the effort (number of samples) required to achieve 95% probability of detection, differed by EDM approach and species. Also, the detection rate of each survey approach differed by species. For both species, detection in surveys using DNA-based taxonomy was generally as good or better than the adult–juvenile survey using morphology-based taxonomy. While both species appear to have been detected at early stages of invasion, white bass were likely present up to 5 years prior to initial detection, whereas gizzard shad may have been detected in the first year of introduction. We conclude that using complimentary sampling methods can help to balance the strengths and weaknesses of each approach and provide more reliable early detection of new invaders.

Steroidal sex pheromones likely determine when and where invasive carps spawn

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Spawning, or the coordinated release of sperm and eggs, is arguably the most important event in the lives of fishes. This event is complex because gametes take months to develop, with final maturation occurring in just 12 hours, and once released, gametes are only viable for minutes. Tight physiological and behavioral synchrony between sexes is key to success. In fresh water, this event is complicated because environmental cues vary greatly in the spring. To address this challenge, fishes commonly rely on pheromones, or chemical signals that pass between members of the same species, to coordinate male-female endocrine systems and spawning. Decades of research have shown that the pheromones are usually comprised of hormonal derivatives and can have both physiological and/or behavior function. They are well understood in the common carp, *Cyprinus carpio*, for which a mixture of 3 steroids including the maturation inducing-steroid, 17,20□-dihyhroxyprogesterone (1720bP), is released 12 hours proceeding spawning to promote spermiation and ovulation. These pheromones are detected by carp at picomolar concentrations (grams in billions of liters). Ongoing studies of the olfactory sensitivity of bighead (*Hypophthalmichthys nobilis*) and silver carp (*Hypophthalmichthys molitrix*) are now describing similar pheromone systems. Briefly, electrophysiological recording from the olfactory systems of these carps show that of 223 steroids tested, silver carp detect only 7, and bighead carp, just 5. Further, like common carp, these carps are extremely sensitive to waterborne 1720bP as well as its gluronidated and sulfated conjugates. However, these species also detect cortisone sulfate, while the silver carp is highly sensitive to 5a-pregnan-3a-17,20b-triol. Extreme sensitivities in the picomolar range fulfill the criteria for pheromones although tests using mature wild fish are needed. These findings show how pheromone systems have evolved in Cyprinidae, and could be useful

Piscivore Diets in Minnesota Lakes

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

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Muskellunge, Northern Pike, Walleye, and Largemouth Bass are popular sport fish throughout Minnesota that often co-occur in aquatic systems, either naturally or through stocking. 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. We used gastric lavage to examine piscivore stomach contents in 12 Minnesota lakes. Diets were quantified for each species by lake, and niche overlap was calculated using Pianka's index. Across lakes, Muskellunge consumed a wide range of prey, whereas Northern Pike and Walleye diets consisted primarily of Yellow Perch and centrarchids in most lakes. Largemouth Bass consumed more invertebrates, especially crayfish, but centrarchids were also important prey in some systems. Diet overlap tended to be highest between Northern Pike and Walleye across systems, while Muskellunge generally had low levels of diet overlap with other predators. Patterns in predator diets across the state were also explored using multivariate analyses. While ordinations indicated shared prey use among all species, permutational multivariate analysis of variance indicated diets were significantly different between species with one exception, as Northern Pike and Walleye diets were statistically similar. Furthermore, predator diets were correlated with several lake-scale habitat variables. These results provide additional evidence that Muskellunge can co-exist with other predators in a variety of lakes with varying physical and biological properties while offering additional insight to resource managers regarding likely diet patters and potential for competition among species.

Influence of conditions in Lake Superior and Bois Brule River on returning migratory rainbow trout

Hrabik, T.R., K.W. Olson, T.J. Kaspar, M.E. Sierszen and B.G. Matthias

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Rainbow trout were introduced to Lake Superior in the late 1800's and exhibit a potamodromous life history and exhibit high variability in reproductive success. We examined reproductive variability in the Bois Brule River, WI (Lake Superior), through analyses of returns of wild maiden spawning adults. We used classification and regression tree analyses to identify in-stream and in-lake (western Lake Superior) sources of variability, and to identify the environment (stream or lake) that was most influential to the returns to each river. Among in-stream influences, high discharge rates in the spring period (March – May) during a pre-smolt's first stream year were the strongest source of variability and were negatively correlated with returns. High discharge during the fall period from September to November in the pre-smolt first stream year was also negatively correlated with numbers of maiden returning steelhead from that year class. When variables associated with Lake Superior were considered, maiden returns were positively correlated with higher lake surface temperatures in Lake Superior. Returns were negatively correlated with the abundance of adult rainbow smelt and bloater suggesting a possible competitive interaction among those species. Finally, we also observed a conditional (minor) positive effect of age-0 smelt abundance indicating the importance of this prey for juveniles in colder years in western Lake Superior. Taken together, our findings indicate that stream and within lake variables influence fish in their first year in each environment. However, spates in the spring and fall appear to highly influence returns. This information may be useful in explaining future variability in the number of returning adult rainbow trout in this system.

Concurrent Sessions 4 (Room: Ballroom)

Parallel trophic responses in predators across lakes: support for the ecosystem size and accessibility hypotheses

Kyle Zimmer, Mary Thelen, David Gallagher, Payton Johnson, Sara Kangas, Dylan McNulty, Alexandra Morrison, Brian Herwig, and David Staples

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Understanding similarities and differences in trophic ecology of top predators in ecosystems is crucial given their importance for stabilizing food webs. Ecosystem size has been shown to influence trophic characteristics of predators, but the degree to which habitat quality alters ecosystems size -trophic relationships is less clear. Walleye (*Sander vitreus*) and Northern Pike (*Esox lucius*) are top predator species, but differences in their trophic ecology across lakes are poorly know. We sampled both species in 14 Minnesota lakes and used δ13C and δ15N to estimate littoral carbon and trophic position, respectively. We also used littoral carbon and trophic position to estimate isotopic niche size of both species and niche overlap between species in each lake. Trophic ecology was distinctly different between the two species across lakes, with northern pike using more littoral carbon, having lower trophic position, a larger isotopic niche, and having greater niche overlap on walleye than vice versa. However, each species showed pronounced variability across lakes. Subsequent analysis showed the two species differed but paralleled each other across lakes as littoral carbon use, trophic position, variability in littoral carbon and trophic position, and niche size were all positively related between species across lakes. The parallel responses across lakes were driven by presence of zebra mussels increasing use of littoral carbon, warmer and more oxygenated hypolimnion increasing trophic position, and lake size reducing niche size in both species. Our results provide evidence key factors can drive similar trophic responses in top predators, suggesting ecosystem features may influence ecosystem function by influencing multiple top predators in a similar way. They also support the habitat accessibility and ecosystem size hypotheses for trophic position, where unfavorable habitat conditions can reduce trophic position and alter ecosystem size-trophic position relationships.

Everything Stays the Same, until it Changes: Documenting Fish Community Changes through Historical Records.

Jeff Reed

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Ecological processes are constant and over time create system change. However, management activities often fail to recognize this simple, yet foundational concept of ecology. For example, shifts from percid-dominated to centrarchid-dominated fish communities are a common concern among stakeholders and fisheries managers. Attempts to maintain Percid communities through stocking of Walleye fingerlings often results in poor returns to the creel and does little to alter fish community structure. These efforts can also produce unrealistic expectations from stakeholders. Historical records can provide insights into system changes over time thereby giving managers opportunities to discuss ecological changes with stakeholders. Using historical photos, guide records, and oral histories collected over the last 145 years from various historical archives, I been able to document changes in angler preferences and catches. Furthermore, combined with water quality changes documented from paleolimnological surveys, archival and historical evidence suggests fish communities have also changed, sometimes dramatically, over the same time. Using this knowledge, fisheries managers can help stakeholders understand ecological processes and ultimately temper expectations of management actions designed to counter system change.

Trout community response to dam removal in a small forested watershed

Amy Schrank, Paul Webb

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Dam removal is becoming more commonplace and necessary as smaller, aging dam structures become unstable and outlive their utility. There is an increasing willingness to remove dams as the importance of connectedness in rivers for ecosystem health is better understood. One of the challenges in assessing the success of dam removal is the need to monitor habitat and fish communities both before and after removal. However, this intensive monitoring often does not occur. We assessed fish communities both before and after dam removal in a small (168 mi2/435 km2) watershed in northern Lower Michigan. The Maple River has a relatively undeveloped, forested watershed with high quality native brook trout habitat in the upper reaches, and rainbow and brown trout populations in the lower reaches. The Maple River was dammed and impassable to fish moving upstream from the late 1800s until 2018 when the dam was removed. We collected fish community data before and after dam removal. We also monitored fish community change post dam removal at stream sites that were created after the former reservoir was drained. We observed that dam removal did not significantly decrease trout abundance downstream of the dam site. We continue to observe increasing numbers of brown trout at sites upstream of the former dam location. This has important implications for brook trout populations in upstream reaches as brown trout can outcompete brook trout when the two species are sympatric. Our five year post dam removal assessment is planned for summer 2023. The results of our study will inform future dam removal projects in the region.

Are Minnesota lakes warming? When, where and what does it mean for lake processes and aquatic community composition?

Casey Schoenebeck, Tim Martin, and Will French

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Water temperature is an important metric for the long-term monitoring of lake ecosystems as it can affect most lake biological, chemical, and physical processes. As such, the Sentinel Lake Program spearheads an effort started in 2008 to monitor for changes that may be occurring in lake temperature with the help of MNDNR Fisheries Areas, using continuous water temperature loggers placed either singly or as a logger chain in all 25 Sentinel Lakes. We explored trends in water temperature using two analyses. The first analysis looked at the monthly means for the shallowest available depth for each time period on each lake to explore if monthly means have changed across years. The second analysis looked at how annual growing degree days (GDD) patterns have changed across years for each lake. Trends in water temperature over time in the Sentinel Lakes differed by month. Increasing water temperature trends were stronger in June than the other months. There was also a difference in the rate of change between ecoregions. Overall, there has been a slight increase in GDD across the years but there does not appear to be an ecoregion effect on the rate of increase for GDD. There is a high degree of annual variability in water temperature data making it difficult to elucidate trends. The strongest trend was the consistent increase in June mean monthly temperatures in all Sentinel Lakes which could have an effect on a number of lake processes such as the strength of lake stratification, life-history of organisms, autochthonous production, and dissolved oxygen depletion rates.

Poster Session

Assessing bubbled CO2 as a fish repellent: While a diverse group of fishes avoid spending time in high concentrations of CO2, many fish including 4 species of invasive carp do not avoid crossing into it

Frank Savage, Colin Pillai, Natalie Windels, Jane Feely, Gabe Berken, and Peter Sorensen

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Invasive bigheaded carp (*Hypophthalmichys spp*.) are advancing up the Mississippi River through its locks and dams (LDs), threatening to damage ecosystems and native fisheries in Minnesota. If sensory stimuli that specifically and immediately deter carp could be identified and applied to LDs, this invasion could be greatly delayed. One promising possibility is a bioacoustic fish fence (BAFF) in which a stream of air is created in front of locks into which powerful cyclic sounds are projected. While laboratory tests show a BAFF can be up to 98% effective (Feely and Sorensen 2023), ongoing field tests in deep waters are now describing efficiencies of 60-70%. One way to increase this value might be to inject CO2 into the BAFF because many fishes are known to avoid spending time in CO2. However, whether CO2 also functions as a contact repellant is not yet known. To test the possibility, we tested the behavioral responses of 9 species of fish including 4 carps and 5 natives to CO2. Groups of 4 fish were placed into a laminar-flow flume while either nothing was added, compressed air was bubbled across its midline (control), or CO2 was bubbled instead. Ten groups of each species were tested and the number of times that fish crossed the air/CO2 stream noted, as was their location for 30 minute pretest and test periods. No species responded to the air curtain but all responded to the CO2, albeit in different manners. While all species except for Lake Sturgeon avoided spending time in CO2 waters, only Largemouth Bass, Golden Shiner, Rainbow Trout and Catfish avoided crossing into it- Carp did not ($P<0.05$). We conclude that CO2 has little potential to increase the efficiency of a BAFF and because it is also repulsive to many native fishes, its utility in invasive fish management unclear.

Factors Driving Isotopic Niche Size and Niche Overlap in Yellow Perch (*Perca flavescens*)

Dylan McNulty, David Gallagher, Sara Kangas, Payton Johnson, Brian Herwig, David Staples, Kyle Zimmer

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Understanding patterns of trophic niche overlap in fish communities is important because trophic redundancy stabilizes food webs. Stable isotopes δ13C and δ15N can be converted into percent littoral carbon and trophic position, respectively, and used to estimate isotopic niche size of species A, niche overlap of species A on other species, and niche overlap of other species on species A. Our previous work showed Yellow Perch (*Perca flavescens*) have the largest isotopic niche overlap on other species and the second largest niche size of all species tested. However, perch niche size varied ten-fold and niche overlap threefold among lakes. We hypothesized niche overlap of perch on other species is positively related to perch niche size. We also hypothesized that perch niche size is driven by ontogenetic changes in diet, such that populations with greater range in body size would exhibit the largest niches. Alternatively, perch niche size could be driven by food web effects such as average trophic position. We studied 14 Minnesota lakes and results showed perch niche overlap on other species was positively related to perch niche size. Perch niche size, however, was unrelated to mean, range, or standard deviation of perch length. Instead, niche size was inversely related to perch mean trophic position. Lastly, perch mean trophic position was positively related to hypolimnetic dissolved oxygen levels. Yellow Perch niche size and niche overlap on other species is thus driven by lake effects on food webs, and not by ontogenetic changes in perch foraging. Therefore, lake physical environments can influence patterns of fish trophic overlap and food web stability.

The Effect of the Initial Infestation of Zebra Mussels in Red Lake, MN, on Freshwater Drum Diets

Marissa Pribyl

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Freshwater Drum, *Aplodinotus grunniens* are known to consume bivalves, including zebra mussels, *Dreissena polymorpha*, and physidae using pharyngeal teeth, the molar-like grinders in the back of their throats. Zebra mussel larvae were first found in the Red Lake system, located in Beltrami County, in 2019, but adult zebra mussels have yet to be documented. The purpose of this research is to examine freshwater drum diets after their initial infestation to identify any presence of adult zebra mussels and to determine their effect on drum diet and bioenergetics. Freshwater drum stomachs were extracted and dissected to determine the presence of adult zebra mussels as well as document other species that were consumed to better understand what drum choose to feed on. No evidence of adult zebra mussels were found in the diets of the freshwater drum collected. The majority of the diets were comprised mostly of larval midges like Chironomidae. This research suggests the initial infestation of zebra mussels has little to no effect on freshwater drum diets and bioenergetics. Freshwater drum prefer other sources of nutrients like Chironomidae compared to zebra mussel adults if present. These results provide baseline data for Red Lake DNR to use in future research on zebra mussel infestation.

Genetic Structure of Yellow Perch in Minnesota

Megan Boche, Andrew Hafs, Michael Hamann

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Among the aquatic organisms native to Minnesota, little is known about the population structure of yellow perch *Perca flavescens*. A multitude of equipment is available to physically observe the species population structure, however, using molecular techniques to monitor microsatellite variation can provide more accurate results. Microsatellite variation represents segments in the DNA sequence that are used as polymorphic markers for studying variation patterns. The information from those patterns makes it applicable for measuring bottlenecks, local adaptations, allelic fixation index values, and gene flow. The objective of the present study was to describe the genetic variation within and among yellow perch populations throughout Minnesota's basins using microsatellite DNA markers. Sixteen microsatellites developed for percid, walleye *Sander vitreus* and yellow perch, were evaluated to test the null hypothesis that there is genetic homogeneity among yellow perch groups throughout Minnesota's basins. The genetic patterns were compared to those of lakes within and among basins. The presence of a genetic pattern among the populations in the basins would be consistent with reproductive isolation caused by limited movement of individuals or fidelity to natal sites. The results are pending and are expected to show where reproductively isolated populations are occurring.

Establishing Baited Remote Underwater Video Survey (BRUVS) Watching Program to Aid in Conservation of Sharks in The Bahamas

Briana Davis, Steve Kessel, Lynn Waterhouse

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In recent decades, the global demand for shark products, in combination with unsustainable bycatch levels, has created widespread declines in shark populations globally. These declines have the potential to affect not only the function of ocean ecosystems but also risk economic failures from the loss of associated fishing and tourism. Baited remote underwater video systems (BRUVS) and their stereo-video counterparts (stereo-BRUVS) have grown increasingly popular and proposed as a novel, standardized, non-extractive methodology for estimating the relative abundance and diversity of demersal fishes and other marine megafauna. The use of BRUVS as a methodology can aid in realizing the potential of conservation efforts while also ensuring our actions as scientists and researchers are not harmful or counterproductive in preserving members of crucial lineages. Using BRUVS paired with quantitative modeling approaches, there is the opportunity to collect data on abundance, diversity, length-frequency distributions, along with behavioral studies and inter- and intra- species interactions. BRUVS data can capture both changes in population metrics and uncover a more in depth analysis of biodiversity in a given region, all of which can be utilized to make more informed policy and management decisions. With these benefits and opportunities in mind, the goal of this project is to design a remote, volunteer-based BRUVS watching program with the intent to produce a streamlined protocol to utilize when annotating the BRUVS footage. BRUVS analysis is a time and attention intensive task and upon attaining many hours of footage, there needs to be a system in place to analyze that footage and document findings in a timely manner. Developing a BRUVS watching program can give those who seek to employ BRUVS as a research methodology or those who are already utilizing this method a reliable, repeatable, and accessible way to annotate their footage using freely available online tools.

Influence of Relative Predator Size on Schooling Behavior

Tanner Fossum, Andrew Hafs

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Forming shoals and schools is a common defense mechanism of prey species of fish. This includes minnows, freshwater sunfishes, yellow perch (*Perca flavescens*) and many game fish species during their early life stages. When placed in a container with a potential predator, young-of-year (YOY) yellow perch have been observed forming schools and distancing themselves from the predator as much as the container allows. This study observed members of Cyprinidae put in five-gallon containers and measured how predator gape limit and total length influenced schooling behavior. Data collection was done by placing ten groups of ten minnows of the same species in equal sized containers before introducing varying sized yellow perch that were approximately large enough to prey on the minnows. Video was taken of each group over a period of twenty-five minutes. Frames were taken in intervals of five minutes and used to measure the area of the schools. Pending results will provide valuable information relative to predator prey dynamics in aquatic ecosystems and fisheries.

An Analysis and Description of Walleye Dentition

Matthew D. Kvam, Andrew W. Hafs

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An individual's ability to procure food is a significant factor in the success of a species. Teeth are an important part of the food gathering strategy of many organisms; however, they are often ignored in research. Teeth have been found to be especially important among piscivores, many of which support economically important fisheries. Walleye *Sander vitreus*, is one such species, and are an iconic game species in much of their range. Therefore, the objective of this study is to lay the groundwork for future research by assessing the variation and abundance of walleye teeth, particularly those of the pre-maxillary and dentary patches. To accomplish this, walleye heads from fish ranging from 400 to 499 mm were collected from gillnets deployed in Namakan Lake, Minnesota. All teeth > 1.00 mm were counted and measured. Total tooth abundance ranged from 29 to 45 with an average of 37.91 (SD = 4.86). Tooth length had a mean of 2.14 mm (SD = 0.80) and ranged from 1.00 to 4.78 mm. Head length was a poor predictor of tooth abundance ($p = 0.14$), however, it was a good predictor of tooth size ($p = 0.01$). Examination revealed that walleye do not exhibit bilateral symmetry in tooth arrangement as other fishes do. Future studies should strive to elucidate walleye tooth development and seek to explore possible advantages of this lack of uniformity in relation to other advanced fishes and the environmental history of the walleye.

Larval Fish Densities in Near Shore Habitats

Bryan Larson, Andrew Hafs

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The reproduction, growth, and recruitment of gamefish is very important in relation to management practices. The recent zebra mussel invasion of Lake Bemidji could influence larval fish densities and growth rates. The objective of this study is to estimate the larval fish densities and growth within the near shore habitats of Lake Bemidji. Quatrefoil light traps were used from 9 PM to 12 AM. Three traps were set and pulled each hour for three samples per hour. The pending results of this study could be used to determine how zebra mussels are affecting the larval fish communities of Lake Bemidji in the future. This study will be compared to data from a recent Leech Lake study on larval fish growth rates in 2017.

Interactions between Rusty Crayfish invasion and Yellow Perch population dynamics

Kendra Fink, Kamden Glade, Brian Herwig, Bethany Bethke, Andrew Hafs

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In recent years there have been changes in percid populations in Minnesota, likely due to combined effects of invasive species, shoreline development, and changes in local climate. New sampling techniques are being used to better assess changes in these populations, though it is still unknown to what extent each of these variables affect fish population dynamics. Yellow Perch *Perca flavescens* are an important game fish and prey species for many piscivorous fish like Walleye *Sander vitreus* and Northern Pike *Esox lucius.* They spend much of their post-larval life in littoral areas, where they consume small fish and invertebrates and use benthic structures for shelter and reproduction. Rusty Crayfish are a regulated invasive species and have the potential to outcompete native crayfish and decrease macroinvertebrate and small minnow populations though predation and habitat destruction. These changes to vegetation and prey assemblages in aquatic systems can lead to shifts in energy flow and, subsequently, altered growth, condition, and maturity of native fish species. It is unknown the degree of impact Rusty Crayfish have on Yellow Perch population dynamics. In this study, we investigated potential effects by sampling 150 Yellow Perch from 14 lakes across north central Minnesota. Of those lakes, half are infested with Rusty Crayfish and all support healthy Yellow Perch populations. Total length, weight, sex, and age of sampled perch will be documented. Hypothesized interactions include an increase in growth and condition of Yellow Perch populations in lakes infested with Rusty Crayfish compared to populations in lakes without Rusty Crayfish. This could be driven by an increased availability of a nutrient-rich, and relatively easy, prey source to perch who exceed gape limitations.

A fish tracking study shows that few fish pass Lock and Dam 5 except via its lock suggesting that it is a suitable location to stop invasive carp by installing a lock carp deterrent

Sorensen, Peter, Hatch, Jay, and Berken, Gabe

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Silver (*Hypophthalmichthys molitrix*) and Bighead Carp (*H. nobilis)* from Asia escaped into the Mississippi River in the 1970s, established, and started invading other regions of the river. These carps are filter-feeders, grow rapidly to large sizes and reproduce, rendering them a significant threat to ecosystems and native fishes. A reproductively-active population of Silver Carp is now found in Iowa and mature adults routinely make their way into Pool 8 near Winona. One way to stop these carp might be to block passage at locks and dams. Lock and Dam 5 (LD5) has been hypothesized to be a suitable site because its spillway gates open rarely, meaning that few fish presumably pass it except via its lock. A numeric model based on the presumption that its passage is low (~15-20%; Zielinski and Sorensen 2021), suggests LD5 could block 98-99% of all carp if a deterrent system were added to its lock. The present study tested this. We captured fish upstream of LD5, tagged and released them below it, and tracked their movements using 15 archival receivers. In 2021, 7/31 Common Carp (*Cyprinus carpio*) passed LD5 with all passing via the lock (22%). Similarly, in 2022, 57/65 Common Carp swam initially upstream with 55 entering the lock with 17 passing (26%) and no carp passing via another route. A Silver Carp entered the lock 10 times but never passed. 10 Bowfin swam upstream with 9 entering the lock and 1 passing (10%). No Redhorse passed LD5. 6/10 Drum swam upstream with all entering the lock and 3 passing (30%). River discharge ranged between 98,800-13,000 cfs, so LD5's spillway gates did not open. In conclusion, LD5 appears to function as a block for fishes with few passing except via its lock, which could house an acoustic carp deterrent and native fish passage system.

Using eDNA for comprehensive fish community assessments in broad-scale inland lakes

Chelsea Hatzenbuhler, Joel Hoffman, Courtney Larson, Greg Peterson, Erik Pilgrim, Aubree Szczepanski, Anett Trebitz

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There is potential to obtain biological community composition data from environmental DNA (eDNA) samples to supplement traditional methods. However, eDNA community assessments are not typically included in standardized surveys because eDNA methods do not fit well with existing protocols. We aim to develop practical, scalable methods for eDNA based fish community surveys in lakes with varying complexity and diversity. Our 2021 study comprised nine Minnesota lakes in the Northern Lakes and Forests ecoregion for which recent physical fish catch data were available. Lakes were divided into three classes based on shoreline complexity, total surface area, and fish richness. We expanded on the design used by EPA's National Aquatic Research Survey (NARS) to include random depth stratified stations to evaluate how eDNA-based fish composition relates to sampling intensity and lake characteristics. Each lake also had several fixed sites - boat ramp, inlets, outlets, and deepest point. We collected water quality metrics, habitat data, and three 250 mL surface water samples at all sites. Additional near bottom samples were collected at a random subset of open water sites. In total, 1131 samples were collected from 315 sites over nine lakes. Water samples were filtered and three pooled PCR replicates from each sample were metabarcoded using two complementary fish genetic markers (Am12S, Ac16S). Fish species assemblage data obtained from these eDNA samples was compared to physical fish catch data from the Minnesota Department of Natural Resources (MNDNR) standard and targeted surveys. We expect results to provide insight on how to efficiently incorporate eDNA sampling into existing broad scale lake surveys to increase the probability of detecting new invaders and native fish species that may be missed by traditional methods.

Watershed Health Assessment Framework for Lakes

Paul Radomski, Kris Carlson, Jeff Reinhart, Kevin Krause, Beth Knudsen

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The Minnesota Department of Natural Resources is now providing assessments of lake health for thousands of Minnesota lakes. Available online, these assessments are based on water quality, biology, and hydrology. Users can view graphics on these components, as well as find data on basic lake characteristics and lake stewardship. This information will help citizens think about lake health and guide local government decisions about lake protection and restoration.