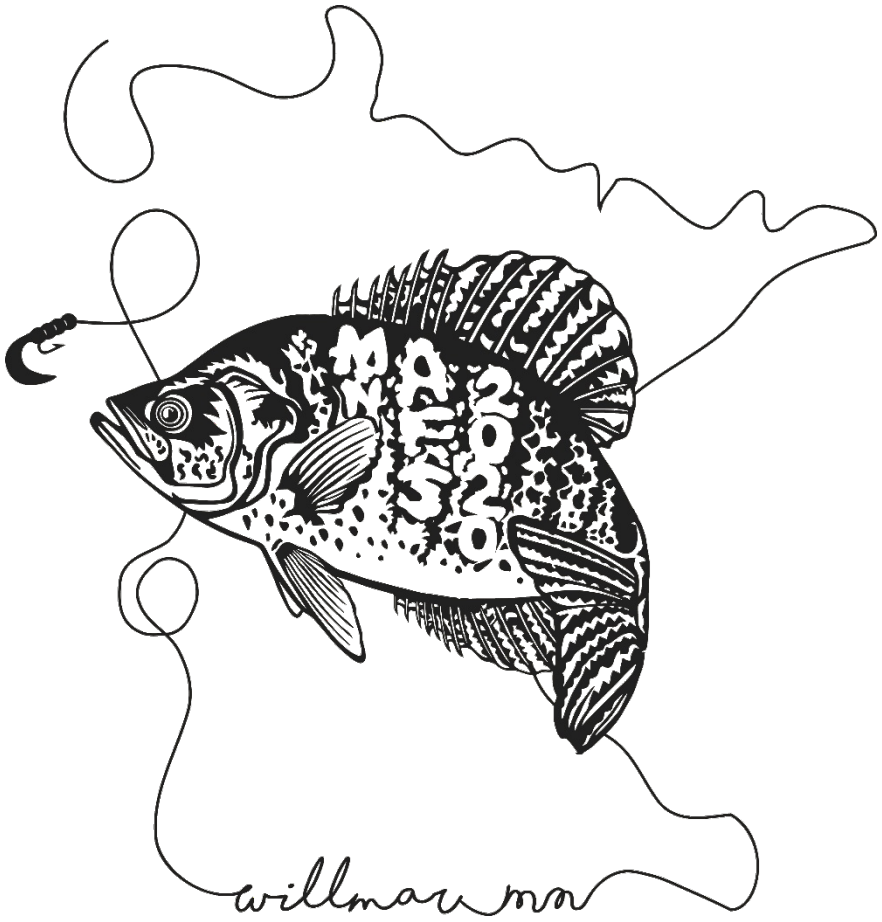
Minnesota Chapter of the American Fisheries Society 2020 Annual Meeting



Leaving a Conservation Legacy

Concurrent Sessions 1 (Gallery 3&4:)

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

Joseph W. Amundson, Andrew W. Hafs, Tony Kennedy

Presenter: Joseph W. Amundson, joseph.amundson@live.bemidjistate.edu
Affiliation: Bemidji State University

The dispersal of stocked Walleye *Sander vitreus* fry in the Cass Lake Chain located in Northern Minnesota had not been previously evaluated because of the difficulty in differentiating between stocked and naturally produced fish. As part of Minnesota's Walleye egg take policy, 10% of eggs taken for hatchery purposes are stocked back into the donor lake. This policy can result in elevated fry densities (mean: 7,000 fry/littoral acre, typical range: 500-1,000 fry/littoral acre) in Lake Andrusia. In 2016-2018 fry were mass-marked by immersion in oxytetracycline (OTC) prior to stocking into Andrusia (donor lake). Age-0 walleyes were sampled throughout the chain each fall (2016-2018). Each year, age-0 fish were widely distributed by late August. Marking rates in each lake in the chain ranged from 0 to 99% (median = 73%). The chain was previously thought to be largely self-sustaining with put-back stocking considered a social aspect of management rather than contributory to the Walleye population, which was clearly demonstrated. The stocked fish ability to disperse throughout the chain helped suppress density dependent effects, although, total length (mm) increased as distance from stocking site to collection site increased.

Patterns of baitfish use and release by Minnesota anglers

Meg McEachran, Nicholas Phelps

Presenter: Meg McEachran, thom4412@umn.edu
Affiliation: University of Minnesota

The release of live baitfish by anglers has been identified as a potentially high risk pathway for aquatic invasive species due to the potential for inadvertent release of invasive fish, invertebrates, or pathogens along with the fish. Release of live baitfish is consequently illegal in Minnesota, but little is known about compliance rates or motivations for illegal release. We administered a mailed survey questionnaire (n=4000) to anglers who held a 2018-2019 annual Minnesota fishing license. We received 669 responses for an adjusted response rate of 17%. 489 (73%) respondents reported that they used live baitfish and of those, 99 (20%) reported that they release their leftover live baitfish into the water at least some of the time. We also conducted intercept surveys (n=305) at water accesses around the state asking anglers about the current day's behaviors and found that 59 (19%) were using live minnows on the day they were surveyed and of those, 11 (18%) released their leftover minnows into the water. Reasons given for release included convenience and a misperception that released fish benefit the recipient ecosystem. Given the many millions of fishing trips that occur every year, the current rate of illegal bait release results in many chances for invasive species introduction. However, there is also significant opportunity for management interventions aimed at changing perceptions and providing convenient disposal alternatives to illegal release to reduce the risk presented by this pathway.

Assessing the Effects of Double-crested Cormorants on Walleye and Yellow Perch Populations in Leech Lake, Minnesota

Cody F. Coyle, Andrew W. Hafs, Douglas W. Schultz, Carl A. Pedersen, Steve Mortensen

Presenter: Cody F. Coyle, cody.coyle@bemidjistate.edu
Affiliation: Bemidji State University

Accurate estimates of natural mortality in sub-adult fish is beneficial to fisheries managers for setting specific harvest regulations on complex aquatic systems. Restoration of Double-crested Cormorants *Phalacrocorax auritus* throughout much of their native range has sparked interest in the impact this piscivorous bird may have on sportfish populations. The current colony on Leech Lake, Minnesota has been managed since 2005 due to concern of negative effects on Walleye *Sander vitreus* and Yellow Perch *Perca flavescens*. Fish consumption was estimated using a bioenergetics model and Monte Carlo methods, with Yellow Perch (61%) and Walleye (4.8%) comprising 65.8% of all diet contents. Walleye and Yellow Perch abundance and instantaneous mortality rates for select cohorts were estimated during pre- and post-cormorant management time periods and compared to species-specific estimates of consumption by cormorants. Cormorant diets were dominated by age-0 and age-1 fishes, but fish as old as age-3 were observed. A better understanding how cormorants effect recruitment of fish cohorts beyond maturity will lead to better management of the fishery.

Tracking the Burbot of Bad Medicine Lake Using VEMCO Positioning System

Tyler Robinson, Andrew Hafs, Shannon Fisher, Andrew Carlson

Presenter: Tyler Robinson, Tyler.Robinson@live.bemidjistate.edu
Affiliation: Bemidji State University

Applications of acoustic telemetry aid in analyzing behavior and migration of fish throughout a system. More specifically, acoustic telemetry helps fisheries biologists understand spawning behaviors, distribution and habitat preferences of fishes. The use of a VEMCO Positioning System (VPS) allows for fine-scale positioning of fish at a three-dimensional level. The objective of this study was to assess the movement of Burbot (*Lota lota*) over a 14-month period. Focusing specifically on seasonal home-range changes and the vulnerability Burbot experience during their spawning period. Additionally, the study will analyze the oxy-thermal habitat niche, as well as the diel movement patterns in Burbot. A total of sixty-six Burbot between the lengths of 366-845mm were tagged during the month of March in 2019. Fish were caught and tagged throughout the lake in order to tag collision within the thirty-eight acoustic receiver array. Preliminary results show Burbot do prefer depth above the thermocline but seem to be capable to survive periods of time below ideal oxygen levels.

Concurrent Sessions 1 (Gallery 1&2)

Muskellunge Stocking Strategies

Kristan Maccaroni, Jim Levitt, Taylor Polomis

Presenter: Kristan Maccaroni, Kristan.Maccaroni@state.mn.us
Affiliation: Minnesota Department of Natural Resources

As part of Minnesota DNR Muskellunge management, stockings consist primarily of fish of the "fingerling" life stage (age-0, with approximately 6 months of post-hatch growth), when they are approximately 10–11 inches long. However, at times older fish are available for stocking. The second most-available life stage stocked are "yearling" fish (age-1, typically 11-18 months post-hatch and 16-17 inches long). Because body size impacts a fish's chance of survival and recruitment to a population, fish of different life stages are stocked at different rates. Currently, when yearling Muskellunge are available, one yearling is stocked for every three fingerlings of a quota. For example, a 90-fish fall fingerling quota would equate to a 30-fish fall yearling quota. This presentation reports on the progress of a study designed to evaluate the validity of the stocking ratio traditionally used for stocking Muskellunge. Between 2008 and 2012, yearling and fingerling Muskellunge were externally tagged with numbered T-bar anchor tags and stocked into three Minneapolis-St. Paul area lakes -- Minnetonka, White Bear, and Bald Eagle. When anglers catch a tagged fish, they can report their catch to MN DNR. The ratio of tag reports of fingerling-stocked to yearling-stocked fish should reflect the ratio of these fish present in the adult population. A tag report ratio of 1:1 fingerling to yearling-stocked fish would suggest that the initial stocking ratio of yearlings to fingerlings was effective at achieving similar outcomes to the fishery. In two study lakes, tag reports consisted predominately of yearling-stocked fish, and in one lake, tag reports are comprised roughly equally of fingerling- and yearling-stocked fish. In this presentation, we will discuss the relevance of these preliminary results as well as future directions of this project.

The "stock what we can get" mentality and moving toward intentional Muskellunge production!

Craig Soupir and Andrew Scholten

Presenter: Craig Soupir, craig.soupir@state.mn.us
Affiliation: Minnesota Department of Natural Resources

Fish stocking is an important component of fisheries management in Minnesota, and this is especially true for Muskellunge. Over the years Muskellunge production in Minnesota has focused on fall fingerlings and relied on a handful of cool water hatcheries and several drainable or natural non-drainable ponds scattered throughout the state to meet stocking quotas. Overall, the muskellunge stocking program in Minnesota has generally taken the approach of stocking whatever the production system could provide on any given year. This 'stock what we can get' mentality is not uncommon in fisheries management. However, confounding this approach is that most muskellunge production efforts in Minnesota have been guided by trial and error and with limited research to assess various production methods. This leads to the question: can the Muskellunge production system adopt and/or refine methods that could provide a more intentional product? This presentation is a general introspection into this question with highlights of some efforts by Waterville State Fish Hatchery to move toward intentional muskellunge production!

New project: Comparing consumption by Muskellunge, Northern Pike, Largemouth Bass, and Walleye populations

Tyler Ahrenstorff and Brian Herwig

Presenter: Tyler Ahrenstorff, tyler.ahrenstorff@state.mn.us
Affiliation: Minnesota Department of Natural Resources

In recent years, there have been concerns from the public about establishing Muskellunge (*Esox masquinongy*) populations in new waters throughout Minnesota. These concerns often revolve around the potential negative impact Muskellunge may have on other game fish, such as Walleye (*Sander vitreus*), either through direct predation or competition. This new research project will use bioenergetics modeling to quantify how much food is consumed by Muskellunge, Northern Pike (*E. lucius*), and Walleye populations and compare the biomass of prey species consumed in a range of lakes. This study will directly benefit MN DNR managers, policy makers, and the public by clarifying the ecological role of top-level predators and providing integral information that forms the basis for management decisions. This presentation will describe the background, methods, and data needs for this new project which starts in 2020.

Quantifying relations between altered hydrology and biological responses for streams in Minnesota

Jeffrey R. Ziegeweid, Gregory D. Johnson, Aliesha L. Krall, Kara Fitzpatrick, and Sara B. Levin

Presenter: Jeffrey R. Ziegeweid , jrziege@usgs.gov
Affiliation: United States Geological Survey

The Minnesota Pollution Control Agency (MPCA) has identified altered hydrology as a stressor on aquatic life for several watersheds in Minnesota. However, a lack of quantitative relations between hydrologic alterations and biological responses limits the ability of the MPCA to determine actions that will help reduce biological impairments. Therefore, the MPCA partnered with the U.S. Geological Survey (USGS) to develop quantitative relations between hydrologic and biological metrics that can be used to further examine effects of altered hydrology. Potential explanatory variables included 178 hydrologic metrics calculated from USGS streamgage data using the EflowStats package in R. Study streamgages had at least 10 years of continuous streamflow record and were located close to MPCA biological monitoring sites. Response variables were community metrics associated with fish-based indices of biological integrity (FIBIs). Best subset regression analyses were used to identify explanatory variables that were most strongly correlated with each response variable. The response variable percent of sensitive taxa was used to calculate final FIBI scores for all stream classes in this study; therefore, percent of sensitive taxa is particularly useful for examining streamflow-biology relations on a statewide scale. Percent of sensitive taxa was most strongly correlated with "low exceedance flow," a hydrologic metric calculated by dividing the 90-percent exceedance value for the flow record by the median flow value. Streamflow-biology relations developed in this study will provide quantitative relations that can be used to assess effects of altered hydrology and identify actions to reduce biological impairments.

Concurrent Session 2 (Gallery 3&4)

Human Communities Can Benefit From Improving Fish Habitat

Joel Hoffman, Kathleen Williams

Presenter: Joel Hoffman, hoffman.joel@epa.gov
Affiliation: United States Environmental Protection Agency

Undertaking large-scale remediation and restoration projects in prominent waterfront locations such as city parks provides an opportunity both to improve fish habitat and fishing, as well as to enhance community well-being. However, to consider both opportunities simultaneously, a community-based decision support process is required, particularly to incorporate the knowledge and values of the community into decision-making. Remediation to Restoration to Revitalization (R2R2R) is a framework to identify ecological and policy-based relationships between large-scale aquatic sediment remediation projects, subsequent habitat restoration projects, and waterfront revitalization. The R2R2R framework builds on ecosystem-based management (EBM) theory by addressing the role of humans through feedback loops, and by recognizing the ability of communities to learn and make choices that improve the environment through translational science. In this framework, translating ecological changes from remediation and restoration projects to public benefits (e.g., fishing, boating, swimming) using the concept of ecosystem services is critical to support decision-making. We use a MN DNR-led project supported by the Great Lakes Area of Concern program to illustrate how R2R2R exemplifies EBM for large, complex sediment remediation and aquatic habitat restoration projects, and to illustrate the connection between aquatic habitat restoration and improved community health.

Use of drawdown as a shallow lake fisheries management tool

Scott Mackenthun

Presenter: Scott Mackenthun, scott.mackenthun@state.mn.us
Affiliation: Minnesota Department of Natural Resources

Shallow lake drawdowns in Minnesota are an important tool for wildlife managers. However the reduction of benthivore biomass, consolidation of substrates, and the return of rooted macrophytes and a clear water stable state can benefit both wildlife and fish. Legislative changes approved in 2012 allowed for temporary drawdowns of public waters, without formal wildlife designation, provided the lake management plan outlines how a drawdown will be conducted and a formal public hearing for public consent is held. This process gives both wildlife and fisheries managers the ability to use drawdowns as a management tool more readily. As annual winterkill frequency in shallow lakes declines, periodic temporary drawdowns through the M.S. 103G.408 public hearing process is a fisheries management tool that can be used to jump start or restore boom and bust fisheries and rearing opportunities.

Loss of Minnesota lake ice cover since 1950

Kelsey Vitense, Jake R. Walsh, Naomi S. Blinick, Andrew E. Honsey, Holly Kundel, Christopher Rounds, Claire Rude, Shyam Thomas, Gretchen J.A. Hansen

Presenter: Kelsey Vitense, viten003@umn.edu
Affiliation: University of Minnesota

Lake ice is a culturally and ecologically important component of Minnesota winters, affecting access to fisheries and fish survival. Lake ice is also a sensitive indicator of climate change. Using ice-in and ice-out data curated by the Minnesota State Climatology Office, we are investigating whether Minnesota ice duration has changed over time, whether rates of ice loss have increased over time, and whether Minnesota lakes exhibit variable temporal trends in ice duration. We used a hierarchical generalized additive model to investigate broad temporal trends in ice duration after accounting for differences in duration between lakes and large-scale climatic drivers that cause oscillatory dynamics in the ice time series. For 176 lakes with ≥10 years of data, we found a loss of ~17 days of ice cover on average since 1950. Additionally, these lakes have lost ice cover at a faster rate since ~1975. Focusing on a subset of 35 lakes that had data with the greatest temporal breadth since the 1970s, we found a loss of ~12 days of ice cover on average since 1970, and the majority of these 35 lakes had similar rates of ice loss. We are working to further investigate changes in ice-out dates and to identify morphological and regional features distinguishing lakes that are most vulnerable to ice loss.

Quantification and Comparison of Muskellunge and Other Piscivore Diets

Kamden Glade, Andrew Hafs, Brian Herwig, Tyler Ahrenstorff, Jeffrey Reed

Presenter: Kamden Glade, kamden.glade@live.bemidjistate.edu
Affiliation: Bemidji State University

Muskellunge (*Esox masquinongy*) are the largest members of the pike family found in Minnesota and are managed for trophy angling opportunities with large minimum size requirements and low bag limits. New introductions intended to disperse angling pressure throughout the state have been controversial, with anglers, lakeshore residents, and biologists expressing concern regarding how introduced Muskellunge might impact resident fish communities. While Muskellunge impacts at the community level appear minimal based on available literature, relatively little is known about muskellunge diets, particularly in Minnesota. In 2019, we began a 3 year study to quantify Muskellunge diet overlap with Northern Pike (*E. lucius*), Walleye (*Sander vitreus*), and Largemouth Bass (*Micropterus salmoides*) in a set of Minnesota lakes with varying prey fish assemblages and lake morphology. Our experimental design focuses on how the presence or absence of Cisco (*Coregonus artedi*) impacts potential diet overlap. Lakes without Muskellunge will also be sampled to compare diets of other piscivores in the presence and absence of Muskellunge. We will estimate dietary niche overlap among the four species, and use multivariate statistics to explain variation in piscivore diets within different systems. We will be presenting preliminary results from our first field season.

Lessons Learned from Walleye Population Estimates

Tanner Stevens

Presenter: Tanner Stevens, tanner.stevens@state.mn.us
Affiliation: Minnesota Department of Natural Resources

Walleye spring population estimates can be very useful for fisheries managers. A large number of fish can be handled in a short amount of time. This can allow managers to gather precise data on size structure, and recruitment. In addition managers can also often observe to top end of their Walleye population with less biases among spring capture gears. The primary benefit of a spring population estimate is the ability to generate a population density. This removes some uncertainty among estimates that are produced via QABG or indexing with standard gill nets. While population estimates are extremely useful, the logistics behind such projects can be complex. The purpose of the is talk to relay logistical information learned from two larger Walleye population estimates (Lake Washington chain and Woman Lake chain) and generate ideas for future population estimates.

University researchers and Minnesota Master Naturalists study early life history of native mussel species

Chris Rounds, Mark Hove, Taylor Koefod, Katrina Carrow, Sam Taylor, Elizabeth Huber, McKenna Rodine, Joel Donna, Susan Binkley, Susan Deetz, John Loegering, Amy Rager, and Dennis Zerwas, Jr.

Presenter: Chris Rounds, mark_hove@umn.edu
Affiliation: University of Minnesota

Our understanding of the early life history needs of several Minnesota native mussel species needs to be improved. Specifically, key fish hosts need to be identified for a variety of freshwater mussels. This information could strengthen rare mussel conservation efforts and enable the Minnesota Department of Natural Resources to begin propagating these species. Most freshwater mussels have a life cycle that includes a parasitic stage where the larvae (glochidia) attach to certain species of fishes. The glochidia attach themselves to the gills or fins of fish where they develop for a few weeks. The glochidia are then released as juveniles where they drop to the riverbed and begin filter feeding. The feeding activities of native mussels clarify the water, which helps fish find food more easily, and captures nutrients from the water, making those resources available to the local aquatic community. The purpose of this project was to study mussel brooding behavior and conduct laboratory trials to determine the host needs for five mussel species: Threehorn (*Obliquaria reflexa*), Canary Kingshell (*Lampsilis sietmani*), Mucket (*Actinonaias ligamentina*), Wabash Pigtoe (*Fusconaia flava*), and Threeridge (*Amblema plicata*). Although no suitable hosts were found for Threehorn or Canary Kingshell, we narrowed down likely candidate host species. With the help of citizen science volunteers, we determined that cyprinids and fundulids were suitable hosts for Wabash Pigtoe. We also found that Northern Pike served as a host for Mucket, and a variety of fishes were potential hosts for Threeridge. With this life history information, agencies can improve species management as well as efforts to re-introduce these species into waters where they have been extirpated.

Concurrent Session 2 (Gallery 1&2)

Environmental DNA as a predictor of carp density

Peter Sorensen, Jessica Eichmiller, Ratna Ghosal

Presenter: Peter Sorensen, soren003@umn.edu
Affiliation: University of Minnesota

Estimating the density and biomass of fish in large rivers and lakes is a difficult but important task, especially for invasive Carps. While sampling using netting and electrofishing is hampered by gear selectivity and an inability to use gears in many locations, these challenges are not shared by measuring the DNA shed by fish. Nevertheless, this technique has its challenges which include sampling in ways that address the release, dilution, and decay of eDNA so that quantitative relationships can be described. We conducted three studies that address this issue using Common and Silver Carp whose densities and distributions were monitored. Ghosal et al. (2018) measured eDNA release by Common Carp as fish were drawn to a specific location in a lake where they were fed. We found that eDNA levels near aggregating carp are highly localized (dropping to near 0 within just 25m) and strongly influenced by feeding activity. eDNA was highly correlated with carp density (r==0.93) when measured in a targeted fashion that uses food. eDNA might have special value at an invasion front if used with food. In another study (Eichmiller et al., in prep.) we measured eDNA in 9 lakes containing radio-tagged Common Carp whose distribution guided our sampling scheme. Carp biomass and eDNA copy number were linearly correlated (r=0.58), as was detection rate (r=0.79). Interestingly, little correlation was found in the winter when carp do not feed. Systematic sampling can produce strong quantitative relationships. Finally, in a study of Silver Carp in a stretch of the Illinois River known to contain many carp, we (Coulter et al. 2019) found that eDNA detection rate (r=0.34) was related to both fish biomass and number in a nonlinear fashion (r=0.29). eDNA can be a valuable tool for detecting and quantitating carps if appropriate sampling schemes are used.

Common Carp Status and Management in Lake Winona

Neal Mundahl, Avery Schnaser, Chris Kluzak

Presenter: Neal Mundahl, nmundahl@winona.edu
Affiliation: Winona State University

Common carp were eliminated from Lake Winona during a 1973 lake reclamation project. Multiple efforts to prevent their return and eliminate spawning opportunities have failed. Carp have remained in the lake for the past 45 years, but recent observations of spawning activity in the lake suggest that their numbers have increased. We used shoreline electrofishing data from Lake Winona (2005-2019) along with carp abundance and effects models to estimate the abundance of carp in Lake Winona, and to evaluate the need for future carp management within the lake. Carp size (mean TL = 614 mm, mean weight = 3.42 kg) did not differ between eastern and western basins, but densities were 3X higher in the western basin (105 vs. 34 fish/hectare). Carp biomass estimates for the eastern (116 kg/hectare) and western (360 kg/hectare) basins suggest that the lake may soon experience significant declines in macrophyte cover and other ecological damage associated with that loss. With an estimated adult carp population of >6900 fish and a carp biomass 1.5X higher than that of all carp killed during the 1973 reclamation, carp management activities (e.g., fish removal, spawning migration barriers) should be initiated soon to protect the Lake Winona game fish community.

Session 3 (Gallery 1-4)

Minnesota fish population genetics

Loren Miller

Presenter: Loren Miller, loren.miller@state.mn.us
Affiliation: Minnesota Department of Natural Resources

Spatial genetic population structure is the distribution of genetic variation among populations across the landscape. As measured by neutral genetic markers (i.e., non-selected), the rate of divergence among populations is determined by degree of reproductive isolation, population size and time. Watersheds provide natural barriers between fish populations but human activities, especially stocking, can move fish across barriers and potentially break down reproductive isolation. Here, I overview population genetic studies of multiple Minnesota fish species to highlight several lessons: 1) all species show genetic structure (i.e., all have genetically distinct populations) but the scale of the structure depends on the species and region, 2) stocking has had varied impacts on genetic structure that depends on the location and strains involved, and 3) stocked fish often fail to alter genetic structure of local/established populations, which 4) indicates a cost to populations to "purge" introduced fish or genes, and 5) stocked fish may naturalize where no or a diminished population exists. Together these lessons suggest cautiously considering whether or not to stock and carefully choosing sources when stocking occurs.

Evidence of non-nutrient mechanisms for the sea mount phenomenon on a mid-lake reef complex in Lake Superior

Thomas R. Hrabik, John Janssen, J. Ellen Marsden, Nigel Wattrus and Tedy Ozersky

Presenter: Thomas R. Hrabik, thrabik@d.umn.edu
Affiliation: University of Minnesota Duluth

The phenomenon of enhanced productivity on and around reef complexes is commonly observed in the marine environment. This "sea mount" phenomenon is frequently attributed to nutrient convection from deep waters to the photic zone by deep underwater currents. In Lake Superior, where there is no nutrient increase with depth, we observed higher fish biomass on an isolated reef complex, the Lake Superior Shoals, than in adjacent deeper areas. We sampled a portion of the shoal complex during the day and at night in late June 2017 and late July 2019. We estimated fish and zooplankton densities using hydroacoustic techniques as well as traditional netting approaches for both zooplankton and fish. Zoobenthos was sampled with bottom grabs. We not only observed higher fish biomass on the top of the shoal, but also 4-10 fold higher abundance of *Mysis diluviana*, a common macrozooplankton species that is a preferred prey item for many fish species. There were less substantial differences in zooplankton densities on the shoal complex than in deeper water, and variability in benthos data were less systematic. Our results indicated that topographic trapping of diel vertically migrating organisms on the apex of the shoals that are transported over the shoals by wind-driven currents at night is an underlying mechanism for enhanced fish production. Our findings show a mechanism other than nutrient convection for the sea mount phenomenon in Lake Superior showing how reefs are unique environments with multifaceted sources of secondary production.

Mercury source changes and food web shifts alter contamination signatures of predatory fish from Lake Michigan

Ryan F. Lepak, J.C. Hoffman, S.E. Janssen, D.P. Krabbenhoft, J.M. Ogorek, J.F. DeWild, M.T. Tate, C.L. Babiarz, R.Yin, E.W. Murphy, D.R. Engstrom, and J.P. Hurley

Presenter: Ryan F. Lepak, rlepak@wisc.edu
Affiliation: University of Wisconsin - Madison

To understand the impact reduced mercury (Hg) loading and invasive species have had on methylmercury bioaccumulation in Lake Michigan lake trout, we reconstructed trends in Hg bioaccumulation from an EPA fish archive (1978 to 2012). On the fish, we measured Hg stable isotope ratios to relate temporal changes in Hg concentrations to varying Hg sources and C and N stable isotope ratios, to track energetic pathways and identify food web influences. Through combined Hg, C, and N stable isotopic analyses, we were able to differentiate between a shift in Hg sources to fish and periods when energetic transitions (from dreissenid mussels) led to the assimilation of contrasting Hg pools (2000 to present). In the late 1980s, lake trout δ202Hg increased (0.4‰) from regulatory reductions in regional Hg emissions. After 2000, C and N isotopes ratios revealed altered food web pathways, resulting in a benthic energetic shift and changes to Hg bioaccumulation. Also, during this time continued increases in δ202Hg indicate fish are responding to several recent United States mercury emission mitigation strategies that were initiated circa 1990 and continued through the 2011 promulgation of the Mercury and Air Toxics Standards rule. Unlike archives of sediments, this fish archive tracks Hg sources susceptible to bioaccumulation in Great Lakes fisheries and here we found fish responded to 1980's regulatory reductions four times more than sediments. Additionally, analysis reveals that trends in fish Hg concentrations can be substantially affected by shifts in trophic structure and dietary preferences initiated by invasive species in the Great Lakes. This does not diminish the benefits of declining emissions over this period, as fish Hg concentrations would have been higher without these actions. Continued work will focus on how predator fish trends have changed in lakes with different invasive species histories and Hg source inventories (e.g. Lake Superior and Lake Erie).

Drivers of walleye recruitment across Minnesota's large lakes

Andrew E. Honsey, Zachary S. Feiner, Gretchen J. A. Hansen

Presenter: Andrew E. Honsey, honse018@umn.edu
Affiliation: University of Minnesota

Fish recruitment is complex and inherently variable, and predicting recruitment is among the most difficult and important challenges in fisheries science. Data-driven approaches (e.g., machine learning) show promise as tools for both predicting recruitment and understanding its drivers. We used a random forest model to infer relationships between year-class strength and 17 predictor variables describing potential biotic, abiotic, and anthropogenic drivers across 30+ years of walleye *Sander vitreus* data from Minnesota's nine largest inland lakes. Our model described 20% of the variation in year-class strength among systems, with predictive performance varying substantially across lakes (-8-37% explained variance). Annual degree-days above 0°C during the first year of life and first winter severity were the most important variables for predicting recruitment success, with weak year-classes predicted to occur with cold temperatures during the first growing season and severe first winters. Other temperature variables, including spring warming rate, the coefficient of variation in May and June temperatures, and degree-days during the second and third years of life, were secondarily important predictors of year-class strength. Predicted year-class strength was positively related to both stock size and stocking, and negatively related to the presence of invasive species; however, these variables were not as important as thermal variables for explaining variation in year-class strength. Taken together, our results indicate that thermal conditions in the first year of life can have a substantial impact on walleye recruitment success. Our results also highlight the potential for differing recruitment drivers and dynamics among lakes. Using data-driven approaches and leveraging long-term datasets describing multiple systems represents an important step toward improving our understanding of fish recruitment and its drivers.

Are angler-reported lengths of released fish biased?

Thomas S. Jones

Presenter: Thomas S. Jones, tom.jones@state.mn.us
Affiliation: Minnesota Department of Natural Resources

This study investigated the accuracy of angler-reported lengths of released walleye on Lake Mille Lacs. Estimates of numbers and sizes of released fish in recreational fisheries provide important information for managers. While harvested fish are often measured, numbers and lengths of released fish are reported by anglers from memory, and there are virtually no data available on potential bias on the lengths of reported fish. In this study, test anglers fished for walleye with live bait and artificial lures during six sampling periods from mid-May through mid-August, 2019. Test anglers measured all walleye, and length-frequencies (L-Fs) from test anglers were assumed to be the true L-Fs of recreational anglers. Angler reported L-Fs from the creel were then compared to bootstrapped distributions of test angler L-Fs for each period. Modal lengths were similar but some periods showed a negative bias for smaller walleye and a positive bias for 21 to 24 inch walleye. However, angler bias was inconsistent between periods, and may depend on a number of factors including regulations, catch rates, and angler satisfaction. Attempts to correct for bias in angler reported L-Fs will be data intensive and costly, and are probably not justified for a relatively small error.

An Assessment Model for a Standard Gill Net Incorporating Direct and Indirect Selectivity Applied to Walleye

Paul Radomski, Charles S. Anderson, Richard E. Bruesewitz, Andrew J. Carlson, Brian D. Borkholder

Presenter: Paul Radomski, paul.radomski@state.mn.us
Affiliation: Minnesota Department of Natural Resources

Fisheries managers regularly use catch-per-effort (CPE) statistics and length-frequency distributions from standard gill-net surveys to inform future management activities. The data from these surveys is implicitly tied to the net's selectivity, and caution should be used when not accounting for selectivity. We combined indirect and direct methods for estimating the parameters of absolute selectivity by using data from Minnesota's standard gill-net surveys for Walleye *Sander vitreus*, enabling the estimation of density from CPE. The indirect piece used a state-wide gill-net database and generalized linear modeling to identify a set of possible shapes for the selectivity curves. The direct piece added information based on 94 mark–recapture experiments that were paired with standard gill-net surveys. The resulting statistical assessment model used a bi-lognormal-shaped selectivity curve that was geometrically similar for each mesh, and it estimated fishing intensity that differed substantially with mesh size. Applications of the selectivity model allow the estimation of Walleye density as CPE divided by absolute selectivity by length-bin. The estimated absolute selectivity for the Minnesota standard gill net increased with increasing Walleye length to a peak of 0.76 ha/net at 535 mm and then decreased to about 0.26 at about 800 mm (1.0 and 0.34 relative selectivities, respectively). Fishing intensity increased with mesh size, so the selectivity curves for the individual meshes and that for the standard gill net (5 meshes in series) differed substantially from the curves that have resulted from indirect selectivity models that have ignored size-dependent encounter probabilities and assumed equal contact probabilities for all meshes. We caution investigators that adjusting gill-net catch data with indirect selectivity models that assume equal contact probabilities for each mesh may introduce considerable bias to estimates of population abundance and length distribution.

Session 4 (Gallery 1-4)

Targeted monitoring for the early life history of 4 fish species

Casey Schoenebeck, Will French, and Tim Martin

Presenter: Casey Schoenebeck, casey.schoenebeck@state.mn.us
Affiliation: Minnesota Department of Natural Resources

Fish early life history is a critical yet often overlooked life stage. During this time, fish are influenced by many abiotic (e.g., water temperature) and biotic factors (e.g., prey availability and predation). Standard survey methods used for Minnesota fisheries surveys are not meant to effectively sample this stage of life; therefore, younger ages are underrepresented in standardized surveys creating a knowledge gap. In an effort to complement the standard fisheries surveys, since 2016 the Sentinel Lakes Program has conducted spring and fall sampling targeting juvenile yellow perch, bluegill, largemouth bass, and rock bass (<150 mm). The Program has used a novel boat electrofishing sampling technique to collect these fish on 4 Sentinel lakes with the goal of better understanding how the aforementioned factors impact early life history, and subsequent recruitment in Minnesota lakes. Otoliths are used to age fish and gonads are used to assign maturity, allowing the estimation of length frequency distributions, mean length at age, and percent maturity. While, this technique does not allow for unbiased estimates of relative abundance, it has allowed us to quantify annual variability in length and observe bimodal length distributions of largemouth bass and bluegill, length-dependent overwinter survival of several species, and gain insight into the drivers of age-0 growth. Additionally, this has allowed us to investigate the potential impacts of complicating stressors like changing seasonal water temperatures.

Minnesota Sentinel Lakes Data

Tim Martin and Casey Schoenebeck

Presenter: Tim Martin, Tim.Martin@state.mn.us
Affiliation: Minnesota Department of Natural Resources

Minnesota has an abundance of lake ecological data that have been collected through the efforts of many individuals, organizations, and agencies over the years. The Minnesota DNR's Sentinel Lakes Program has been a part of these data collection efforts for over 10 years and is continuously developing new techniques and products for processing, retrieving, and interacting with these data. Many of these tools are not limited to the 25 Sentinel Lakes, but can be used on all Minnesota lakes with DNR fisheries and PCA water quality data. This presentation will cover the methods the Program uses to process, QA/QC, and visualize continuous logger data, demonstrate an R package that has been developed for Minnesota lake data, and discuss how the Sentinel Lakes Program is working towards making the data it collects readily available for biologists and researchers.

Fish community response to invasion by zebra mussels and spiny water fleas

Jake Walsh, Ben Martin, Marco Scarasso, Mike Spear, Willie Fetzer, Jake Vander Zanden, and Gretchen Hansen

Presenter: Jake Walsh, walsh229@umn.edu
Affiliation: University of Minnesota

Aquatic invasive species (AIS) can have profound effects on fisheries through altering food webs, though these impacts vary depending on the capacity for native species to alter their feeding in response to invasion. We quantified food web changes in well-studied Lakes Mendota and Monona (Madison, WI) by measuring stable isotope composition of seven of the lakes' most common fishes before (2003) and after (2017) the invasions of spiny water flea in 2009 and zebra mussels in 2015. Both AIS are expected to deplete pelagic resources, however both lakes have productive littoral habitats, providing alternate resource pools for fishes able to access them. We observed massive declines in the keystone herbivore and pelagic resource, *Daphnia pulicaria*, coincident with spiny water flea invasion. Declining herbivory led to increasing biomass of edible phytoplankton, which has not declined with the 2015 invasion of filter-feeding zebra mussels, suggesting that these changes have been due to spiny water flea. In Mendota, where spiny water flea is more abundant, the carbon signatures of six of the seven study fishes shifted to reflect higher littoral reliance, while changes were smaller and more uncertain in Monona. We observed little change in the long-term condition and abundance of Mendota fishes, including walleye, which have increased in abundance but declined in condition since 2015, more likely due to recent stocking. White bass were the only fish that did not shift with invasion, which may explain the observed decline in abundance and condition. We found that most fish were able to adjust their feeding in response to invasion in two systems with alternative resource pools (though, this likely differs in systems without productive littoral habitat). The exception, white bass, reveals the importance of adaptation to novel food web conditions with invasion, helping us better understand how invasions set up winners and losers within fish communities.

Age and growth of a northern Minnesota inland Lake Whitefish population

Will French, Casey Schoenebeck, Tim Martin

Presenter: Will French, will.french@state.mn.us
Affiliation: Minnesota Department of Natural Resources

Lake Whitefish *Coregonus clupeaformis* is a pelagic cold water species typically found in large deepwater lakes of the upper Midwest and Canada. While Lake Whitefish populations in Lake Superior support an intensively managed commercial fishery, relatively little is known regarding population status and dynamics of whitefish in inland Minnesota lakes. Annual vertical gillnet surveys targeting Cisco have been conducted on Ten Mile Lake since 2010 as part of the Sentinel Lakes Program long term monitoring of the pelagic fish community. A total of 74 Lake Whitefish were sampled since 2016 during standard gillnet and vertical gillnet surveys, and were used for preliminary age and growth analyses of the Ten Mile Lake whitefish population. Whitefish ages were estimated via sectioned saggital otoliths, and individuals up to 62y old were sampled. Preliminary results suggest that Ten Mile Lake supports a relatively unexploited Lake Whitefish population, characterized by a top heavy age structure, late maturation, low recruitment, and low annual mortality.

Poster Session (Gallery 5&6)

Quantifying the impacts of zebra mussels on walleye recruitment in Minnesota lakes

Holly Kundel, Kelsey Vitense, Gretchen Hansen

Presenter: Holly Kundel, kunde058@umn.edu
Affiliation: University of Minnesota

Invasive zebra mussels (*Dreissena polymorpha*) can negatively affect first-year growth of walleye (*Sander vitreus*), potentially lowering walleye winter survival. Therefore, we expect that zebra mussel invasion may reduce walleye recruitment success. Further, zebra mussel effects may vary among lakes, and walleye in certain lake types may be more resilient to the effects of zebra mussels. To test these hypotheses, we will use random forest models to quantify the effects of zebra mussels on two measures of walleye recruitment: 1) survival of walleye until the first fall and 2) recruitment to the fishery at age 3. Survival of walleye until the first fall will be indexed by catch rates in fall electrofishing surveys. Fall electrofishing surveys and stocking histories have been compiled by MN DNR research staff, and over 4,000 suitable surveys in 260 lakes dating from 1987 to 2014 have been compiled to date. We are also assembling more recent electrofishing surveys to increase the length of the time series and the amount of data collected post-zebra mussel invasion in lakes. Recruitment to the fishery will be indexed by gill net catch rates of age-3 walleye. To enable an analysis of age-specific catch rates, we are developing age-length keys to assign ages to unaged fish. For both measures of recruitment, we will collate historical data for both invaded and uninvaded lakes. We will also account for lake characteristics known to influence walleye recruitment, including lake size, depth, water clarity, productivity, and temperature. Additionally, we will include stocking variables (occurrence and life stage) as covariates in our analysis. This analysis will help determine the impact of zebra mussels on walleye recruitment in Minnesota lakes and to identify lake characteristics associated with resilience to zebra mussel invasion.

Effects of Spiny Water Flea on Sportfish Assemblages in the Canadian Shield, Minnesota

Ali Chalberg, Brad Morris, Courtney Baker, Kristina Pechacek, David A. Schumann, Casey W. Schoenebeck, Tim Martin

Presenter: Brad Morris, morris.brad@uwlax.edu
Affiliation: University of Wisconsin LaCrosse

Spiny Water Flea (SWF; *Bythotrephes longimanus*) were first introduced to lakes in the Canadian Shield region of northern Minnesota in 1989. Although the introduction of SWF is thought to alter native zooplankton community structure and influence fish assemblages, the magnitude of these suspected effects on fish is poorly understood. Using a two-factor Before-After Control-Impact design, we evaluated the influence of SWF introductions on the relative abundance of Yellow Perch (*Perca flavescens*), Northern Pike (*Esox lucius*), Lake Trout (*Salvelinus namaycush*), and Cisco (*Coregonus artedi*). We identified seven lakes with established SWF populations and paired each with nearby uninvaded, reference lakes using a novel multivariate similarity tool. Reference sites were selected based on the presence of similar fish assemblages, Yellow Perch catch rates, and 14 additional environmental factors. Selected lakes were characteristically clear (mean water clarity ± standard error [SE], reference: 17.3 ± 1.7 ft; invaded: 16.0 ± 1.3 ft) and deep-water systems (mean maximum depth, reference: 107.9 ± 9.5 ft; invaded: 111.9 ± 16.6 ft) that were relatively unproductive (mean TSI, reference: 36.5 ± 1.3; invaded: 37.5 ± 1.4) and supported popular coldwater fisheries. Repeated, standardized gill net catch rates were compared between reference and invaded lakes from 1977-2018 and inferences were made by assessing the variability in catch data before and after known SWF establishment. Yellow Perch ($F_{1, 117} = 0.007$, $P = 0.93$) and Lake Trout ($F_{1, 117} = 0.08$, $P = 0.78$) catch rates were unaffected by the establishment of SWF; however, catch rates of Northern Pike ($F_{1, 96} = 6.59$, $P = 0.01$) generally declined and Cisco increased ($F_{1, 117} = 5.42$, $P = 0.02$) after SWF were introduced. Further analyses will examine the influence that SWF may have on the size structures of the fishes evaluated and zooplankton assemblage structure to better contextualize these preliminary results.

Habitat use, thermal distribution, and diet of Brook Trout (*Salvelinus fontinalis*) as affected by interspecific competition with non-native Brown Trout (*Salmo trutta*) in the Driftless Region of southwest Wisconsin.

Kristina Pechacek, Eric Strauss, Kirk Olson, and Jordan Weeks

Presenter: Kristina Pechacek, pechacek0059@uwlax.edu
Affiliation: University of Wisconsin LaCrosse

Brook Trout (*Salvelinus fontinalis*) and Brown Trout (*Salmo trutta*) are the two dominant salmonid species within the Driftless region of Wisconsin. Brook Trout and Brown Trout require cold, highly oxygenated water and are often found in stream headwaters. Brown Trout, a species introduced to the region in 1887, compete with Brook Trout due to similar habitat requirements. Brown Trout generally are the dominant competitor, but questions remain about how the two species interact in different habitats in the Driftless region. Therefore, the overall objective of the research project is to determine how interspecific competition affects Brook and Brown Trout thermal distribution, habitat use, and diet in two Wisconsin Driftless region streams. This study will examine a treatment stream (Maple Dale Creek) with Brown Trout removal and a reference stream (Cook Creek) with no fish removal. Data collection will occur in southwestern Wisconsin Driftless region during the summer of 2019 and 2020 using the Before and After Control Impact Design (BACI). We expect the removal of Brown Trout will reduce competitive pressure on Brook Trout, resulting in a shift in habitat use, diet, and thermal distribution. Significant shifts from interspecific competition within the food web will be measured using stable isotope analysis before and after the removal of Brown Trout. This research will provide predictive responses for future Brown Trout removal projects. Bringing light to adverse impacts of interspecific competition from Brown Trout on streams with similar characteristics in the Driftless region of southwest Wisconsin.

Determining Perch Age by using Otolith Weight and Size

Mitchel Johansen and Andrew Hafs

Presenter: Mitchel Johansen, mitchel.johansen@gmail.com
Affiliation: Bemidji State University

Predicting the age of a fish from a population accurately and quickly has proven to be difficult. Using the otolith weight and size has been used in the past to help predict fish age by a number of authors and has been proven to be useful. This study has not been investigated for Yellow Perch *Perca flavescens*. Traditional methods of aging fish can have many issues such as quality control in a lab, and can be time consuming and require more than one person to carry out the procedure accurately. In this investigation the population of yellow perch, were split into study groups by the year of collection, the otoliths were removed and dried for examination. The otoliths were measured and weighed to find any evidence of a correlation between otolith weight/size and fish age. These fish have previously been aged to help decided on the intervals between the otolith weight and age correlation. Using the most recent study group for a test of accuracy, then we tested the theory by using the otolith weight and age correlation to calculate and predict an age. Hopefully, this research will provide another way to quickly and accurately predict yellow perch ages with less errors and more quality control for the researchers.

Morphological Lake Characteristics in Comparison to Age-0 Yellow Perch Hatch Rates

Kristina Rands and Andrew Hafs

Presenter: Kristina Rands, Kristina.Rands@live.bemidjistate.edu
Affiliation: Bemidji State University

Yellow Perch (*Perca Flavescens*) play an essential role in aquatic food webs. Perch are a significant food source for other species and hold an essential position as predators in northern lakes. Because of this it is important to understand perch growth rates and median hatch dates. Seven lakes were selected for this study with different morphological features. Temperature loggers were deployed in 2019 after ice-off in four different areas of each lake. The loggers collected data daily at 1, 3, 5 and 7 meters until ice-on. Through previous hatch date predictions, trawls were conducted on each lake. A minimum of twenty fish were sampled from each lake and the lengths were recorded. A model was used to estimate hatch dates of the Yellow Perch based on their lengths. Estimated hatch dates and temperature data were compared to the morphological characteristics of the lake. Validation of results using otolith daily age rings will be presented in the coming months.

Trout Redd Surveys Across Multiple Streams within the Driftless Region in Southeastern, MN

Olivia Graziano, Will Varela, Neal Mundahl

Presenter: Olivia Graziano, OGraziano16@winona.edu
Affiliation: Winona State University

Redd data are vital components when assessing salmonid abundance within stream systems. Annual surveys of spawning activity are crucial in identifying declining populations, healthy and/or stable populations, or populations that are threatened. The objective of this study was to conduct spawning surveys of Brown Trout in sections of similar drainages in the Driftless Region in southeastern MN. Seven reaches were identified, sampled, analyzed, and compared for spawning redd abundance (redds/100 m) and clustering, redd dimensions and habitat, including redd size, cover (presence/absence and type), water depth (bowl and tailspill), and current velocity (front edge of mound). Trout redd abundance averaged 7.49 redds/100 m across all reaches (2.6 - 11.2), redd densities within redd clusters averaged 1.44 redds/m^2 across all reaches (0.56 – 1.45). There were significant differences across reaches: Redd size ($P < 0.01$), Cover (presence/absence) ($P < 0.01$), Clustering ($P < 0.01$), Velocities ($P < 0.005$), Bowl depth ($P < 0.01$), and Tailspill depth ($P < 0.01$). Redds characteristics varied across all sites and showed differences specific to reach conditions. Although differences were apparent across reaches, conditions and habitat varied with respect to geomorphology and habitat improvement reaches. Future studies should continue annual redd surveys and monitor potential fluctuations in redd densities which can indicate changes in population structure.

Habitat use by Lake Sturgeon (*Acipenser fulvescens*) using acoustics and stable isotopes

Morgann Gordon, Kayden Estep, Dan Wilfond, Justin VanDeHey, Joel Hoffman

Presenter: Morgann Gordon, gordon.morgann@epa.gov
Affiliation: United States Environmental Protection Agency (ORAU)

Lake Sturgeon are a long-lived, migratory fish species native to the Great Lakes region that were extirpated from the St. Louis River during the early 1900s. Beginning in the 1980s, Minnesota and Wisconsin DNRs initiated intensive restocking efforts in the lower river. Despite these intensive efforts, there has only been limited evidence for successful natural reproduction. Understanding habitat use by Lake Sturgeon is an important step to address the potential environmental factors, including legacy contaminants, that are potentially limiting the recovery of Lake Sturgeon in the lower St. Louis River. Therefore, our goal was to use both physical (acoustic tags) and chemical (carbon and nitrogen stable isotopes) tags to characterize habitat use and movements of Lake Sturgeon. Both types of tags revealed strong variations among individuals in habitat use, including some fish exhibiting near exclusive use of Lake Superior, harbor, and riverine habitats, as well as other fish using different combinations of these three habitats. Notably, we did not find a significant correlation between habitat use as characterized by either method, suggesting that the fish readily switch habitats, or that feeding areas and residency areas are independent and distinct, or some combination of both. Further decoupling of these tracking methods will aid resource managers determine how restoration of the St. Louis River will affect the population and contribute to recovery.

Yellow Perch Diets in Zebra Mussel Infested Lakes

Daniel McCann and Andrew Hafs

Presenter: Daniel McCann, dannymcca4498@gmail.com
Affiliation: Bemidji State University

With Zebra Mussels (*Dreissena polymorpha*) being introduced to new bodies of water every year, the impacts of overpopulation and clusters of mussels have changed many benthic habitats. Excessive filter feeding has resulted in reductions in Phytoplankton densities and then leading to increased water clarity in many systems. Native species are required to adapt to the impacts made by Zebra Mussels. In this study, gut contents of Yellow Perch (*Perca flavescens*) were examined from four Zebra Mussel infested lakes to obtain a baseline diet of each lake. Lakes and dates of infestation include Cass Lake (2014), Leech Lake (2016), Lake Bemidji (2018), and Upper Red Lake (2019). Gut contents were sorted into the following categories: fish, crayfish, Zebra Mussels, other mussels, invertebrates, and other. Count and weight of each category were recorded. Index of Relative Importance for each diet category were calculated for each lake. Results showed that Yellow Perch diets in all sampled lakes consisted primarily of fish, while crayfish and invertebrates were present but less important to their diet. Cass Lake was the only lake where Zebra Mussels were found inside the stomachs of Yellow Perch. However, the Zebra Mussels were found to be very low in relative importance. With Cass Lake having Zebra Mussels the longest and having the greatest densities, Yellow Perch have adapted to feed on the mussels. Through observations, one can predict that as Zebra Mussel populations grow in the other sampled lakes, Yellow Perch will start to prey more on Zebra Mussels, but continue to rely heavily on prey fish as their main food source. This research provides potential comparisons for shifts in Yellow Perch diets as Zebra Mussel populations increase.

Integrating a sound/light deterrent and dam gate operations at Lock and Dam 8, Mississippi River to reduce upstream migration of Common Carp (*Cyprinus carpio*)

Jeff Whitty, Andy Riesgraf, Dan Zielinski, Peter Sorensen

Presenter: Andy Riesgraf, riesg029@umn.edu
Affiliation: University of Minnesota

The upstream migration of invasive bigheaded carps (*Hypophthalmichthys* spp.) is an ongoing threat to the upper Mississippi River drainage ecosystem. Restricting upstream movements of invasive carp through locks and dams to protect uninhabited reaches is critical, and may assist in population control efforts. This multi-year study is testing whether upstream movement of carp can be significantly reduced by behavioral deterrents including increased water velocities at dam gates and/or a cyclic sound and high intensity strobing light deterrent (Fish Guidance Ltd, UK) on lock gates. To test this design, groups of 25 adult common carp (*Cyprinus carpio*), a surrogate for bigheaded carps, are being tagged with acoustic transmitters (Advanced Telemetry Systems) and displaced downstream of Lock and Dam 8, Genoa, WI every two weeks under varying flows and while the deterrent system is on or off (control). Carp movement through the lock and dam is being monitored by an array of stationary acoustic receivers. Experiments are presently underway and preliminary results will be presented. (Funded by Legislative-Citizen Commission on Minnesota Resources).

Using Northern Pike *Esox lucius* and Yellow Perch *Perca flavescens* to attempt a trophic cascade.

Bryan Sea, Danelle M. Larson, Andrew W. Hafs

Presenter: Bryan Sea, bryan.sea@live.bemidjistate.edu
Affiliation: Bemidji State University

In the midwestern USA, water clarity has decreased in shallow lakes as a result of large populations of Fathead Minnow *Pimephales promelas* and agriculture that impact the life that depend on shallow habitats, such as waterfowl, fish and aquatic plants. Northern Pike *Esox lucius* and Yellow Perch *Perca flavescens* were stocked in a few lakes in attempt to create a tropic cascade and to improve habitat conditions for waterfowl. Lake managers hypothesized that Yellow Perch would feed young-of-the-year Northern Pike and then Northern Pike diets would switch to predominately Fathead Minnow and produce a trophic cascade. We used bioenergetics modeling to estimate relative consumption rates (scaled to the relative population size) in three study lakes in Southern Minnesota to test if Fathead Minnow was a primary diet item of the stocked fishes. Northern Pike had two cohorts modeled, age-1 and age-2-4 due to low sample sizes. Yellow Perch cohorts were modeled for young-of-the-year, juvenile, and adults. Northern Pike diets consisted mainly of Yellow Perch (60-78%), some Fathead Minnow (8-39%), and some invertebrates (2-25%). Yellow Perch diets highly varied, ranging from nearly 100% fish in adults to 100% invertebrates in YOY and juveniles. Consumption rates of Northern Pike revealed that populations from Geneva Lake consumed mostly invertebrates and ate approximately half as many Fathead Minnows than Northern Pike in Rice Lake. Yellow Perch in Geneva consumed over twice the amount of invertebrates than Yellow Perch in Rice Lake and Pickerel Lake. Yellow Perch and invertebrates became main diet items of adult Northern Pike which was unintended. Although creating a tropic cascade failed and both stocked fishes consumed invertebrates which can be competition for waterfowl, highly desirable Northern Pike and Yellow Perch fisheries were created for the public to enjoy.

Implications of management actions (land-use changes and vegetation removal) on condition shifts due to trophic cascades.

Alicia Skolte, Casey Schoenebeck, and Andrew Hafs

Presenter: Alicia Skolte, alicia.skolte@live.bemidjistate.edu
Affiliation: Bemidji State University

Management actions have been known to lead to condition shifts within lakes, and shallow lakes are especially vulnerable to these shifts. Ecosystem conditions exist as a continuum between turbid, algal-dominated and clear, macrophyte-dominated conditions. Lake Shaokatan, a shallow Southwestern Minnesota lake, has undergone a shift throughout the early 21st century towards a clear condition in correspondence with land-use changes. These land-use changes were accomplished through the rehabilitation of three feedlots, four wetland areas, and shoreline septic systems. A recent fluctuation in the summer of 2019, suggesting a shift towards a turbid condition, may have been initiated by the chemical removal of about 15 percent of vegetation within the lake basin. The primary objective of this study examined the long-term trends of water quality, percent phytoplankton composition, zooplankton and fish relative biomass, as well as percent coverage of the littoral area by plants on Lake Shaokatan. Fish biomass was subdivided into piscivores and non-piscivores by the most prominent diet item in each species' adult stage. This study also documented how two management actions (land-use changes and chemical removal of vegetation) had a role in ecosystem shifts. The final objective investigated whether patterns of dissolved oxygen, water temperature, and phosphorus concentrations correlated with trophic level changes and/or served as indicators, along with taxon of plants or phytoplankton, of an oncoming shift in the ecosystem. Results of this proposed study would aid management agencies to make deliberate decisions and inform them of triggers for a condition shift.

Comparison of Summer and Fall Walleye Gill Netting

Paige Wiehr, Tanner Stevens, Andrew Carlson

Presenter: Paige Wiehr, pmwiehr@yahoo.com
Affiliation: South Dakota State University

Gill nets are the primary gear used by the Minnesota DNR to index Walleye, Northern Pike, and Yellow Perch populations for standard lake surveys. Standard lake surveys are generally conducted between June and August with lake specific fixed start dates. This is in contrast to the MNDNR large lake program, where surveys are performed in mid-late September when catch rates are assumed to be at their highest. Recent research has supported this where Walleye catch rates generally increase through the summer and into the fall. For non-large lakes that have important Walleye populations, fall gill nets surveys may provide better data to answer manager's questions. Our objective was to compare summer and fall walleye gill netting surveys on two lakes in the Hutchinson fisheries area. A total of 24 summer gill nets and 15 fall gill nets were set between the two lakes using standard MNDNR protocols. An additional 5 gill nets were set at random locations on the two lakes. We found that the sites with the highest summer Walleye catch rates did not necessarily correspond with highest fall Walleye catch rates and no trend was apparent among net sets for either lake. Walleye catches were mixed with higher catch rates on one lake and lower on the second lake. Fall gill nets did however produce less by-catch of non-targeted species. Less by-catch may allow for more gill net sets to be fished resulting in higher precision estimates of the targeted species. In conclusion, contrasting summer and fall gill netting can produced mixed results, but depending on the sampling objectives it may be advantageous to sample during the fall when the nets have less by-catch and can have higher walleye catch rates.

Zebra mussel impacts on walleye populations and mercury concentrations

Naomi S. Blinick, Tyler D. Ahrenstorff, Bethany J. Bethke, Jodie Hirsch, David P. Krabbenhoft, Heidi M. Rantala, Gretchen J.A. Hansen

Presenter: Naomi S. Blinick, nblinick@umn.edu
Affiliation: University of Minnesota

Zebra mussels profoundly impact lake ecosystems, but their specific impacts on walleye are not well documented and vary among systems. Zebra mussel-induced changes in growth, recruitment, and mercury concentrations of walleye have important implications for harvest, stocking, and consumption of walleye in Minnesota lakes. Using stable isotope analysis of carbon and nitrogen, we will characterize the food webs of 15 study lakes to quantify the reliance on littoral resources and trophic position, and how these are influenced by invasion status. In addition, understanding sources of mercury in walleye and how they are influenced by zebra mussels is critical for fish consumption advisories in Minnesota lakes. We will quantify mercury concentrations and characterize the mercury stable isotope composition in walleye tissues from our 15 study lakes to identify pathways of mercury bioaccumulation and how it is influenced by zebra mussel-induced shifts in food web configuration. Quantifying these effects will inform proactive management and allow for realistic goal setting and data-driven public communication following species invasions before a crisis hits.

Male Largemouth Bass Reproductive Participation and Nesting Phenology in North-Temperate Lakes

Jeffrey Reed

Presenter: Jeffrey Reed, jeffrey.reed@state.mn.us
Affiliation: Minnesota Department of Natural Resources

I conducted spring population estimates of Largemouth Bass on two small north-temperate lakes from 2007 to 2011. A census of nesting males was made in each lake from 2008 to 2011. Combined, these efforts allowed me to determine what portion of the male population construct nests in a given year. Population estimates ranged from 727 to 512 on Burgen Lake and 432 to 297 on Union Lake. Overall, I found a small percentage of male Largemouth Bass in either lake constructed nests in any given year (3.8% to 23.6%). Timing of nest construction was recorded from 2002 to 2012. In most years closed seasons designed to reduce or eliminate harvest of nesting male bass, did little to protect fish which were usually providing parental care to eggs or larvae when the season opened. Given the vulnerability of male Largemouth Bass and their offspring to angling at northern latitudes, the small percent of males nesting, combined with the timing of nesting and the seasonal opening could make them and the population as a whole, vulnerable to the effects of catch and release angling. Further work examining the relationship between the number of nesting males and recruitment is warranted.

The Effect of Winter Severity on Walleye Egg Viability: How Climate Change is Affecting Walleye Populations in Minnesota

Jonah Bacon, Jamie DeBruyckere, Karen Oscarson, Seth Thompson, Jeff Reed

Presenter: Jonah Bacon, bacon116@umn.edu
Affiliation: University of Minnesota

Walleye (*Sander vitreus*) populations across the upper Midwest are declining. One possible explanation behind their decline is that shortened winters, a result of climate change, may decrease the amount of time for egg development, leading to smaller eggs being produced and lower survivorship. In this study we compiled nearly 90 years of data from MN DNR egg take operations on Lake Winnibigoshish (Cut Foot egg take) and Lake Vermillion (Pike River egg take) that included egg diameter and hatch rate. We also calculated winter severity from nearby weather stations. Based on research from other percids, we hypothesized that egg diameter and hatch rate would decrease as winter severity decreased as well. We found no relationship between winter severity and differences in egg size or hatch rate. Our results, which are contrary to the work on other percids, suggest that walleye at the latitudes these populations occur may not currently be experiencing the effects of changing climate. Furthermore, the lack of relationship could be related to inaccuracies and changes in data collection protocols over time, or an insufficient means of quantifying winter severity. Our results also imply the need for more studies aiming to determine any climate-based mechanisms for *S. vitreus* population decline.

Digitizing lake depth data using ImageJ

Christopher Rounds, Kelsey Vitense, Gretchen Hansen

Presenter: Christopher Rounds, round060@umn.edu
Affiliation: University of Minnesota

Lake depth is a key driver of many important limnological processes, including water temperature, nutrient cycling, and fish community structure. Digital lake depth data are lacking for the majority of lakes in Minnesota and other Midwestern states, limiting landscape scale aquatic ecology. Government agencies have historically created bathymetric maps for a variety of purposes. These bathymetric maps contain valuable area-at-depth information that is important for within and cross-lakes studies. Although considerable progress has been made to digitize these maps and create spatially explicit digital bathymetric maps, such efforts require significant time and expertise. Currently, there is a lack of ability to efficiently and accurately derive area-at-depth (hypsographic) information from bathymetric maps. We demonstrate here a technique for efficiently and accurately deriving hypsographic data contained in bathymetric maps using the open source software for scientific image analysis, ImageJ. To date, we have derived hypsographic information over 500 lakes in Minnesota and Wisconsin. In a comparison for a subset of 50 lakes, we found that the hypsographic curves derived from ImageJ are similar to those derived from Digital Elevation Models (DEMs). Lakes that had poorly matched ImageJ and DEM hypsographic curves were due to two main issues: discrepancies between the bathymetric maps and the DEMs, and low resolution contour lines (e.g., 5 foot intervals) on bathymetric maps. Overall, this new method provides aquatic scientists a straightforward way to obtain hypsographic data on large scales.

Minnesota River Channel Catfish population dynamics upstream and downstream of Granite Falls Dam

Anthony Sindt

Presenter: Anthony Sindt, anthony.sindt@state.mn.us
Affiliation: Minnesota Department of Natural Resources

I evaluated catch rate, size structure, growth, and survival of Channel Catfish *Ictalurus punctatus* upstream and downstream of Granite Falls Dam in the Minnesota River. Granite Falls Dam is a significant fish passage barrier with at least 20 fewer fish species present upstream than downstream. Consequently the fish community and food web structure differ between reaches, likely influencing Channel Catfish population dynamics. Fisheries staff sampled Channel Catfish with single unbaited hoop nets at three locations upstream during 2014 and 2017 and at ten locations downstream during 2014 through 2017. Upstream catch rates (mean ± SE) of 45.1 ± 5.2 Channel Catfish/net-night are greater than downstream catch rates of 3.9 ± 0.4 Channel Catfish/net-night (***t***-test: $t = -7.9$, df = 67.9, $P < 0.0001$). Size structure, growth rate, and survival are lower upstream than downstream with hoop net catches indicating 28.4% of stock length (≥ 280 mm) fish are of preferred length (≥ 610 mm) downstream while only 5.8% are of preferred length upstream. I estimated age at capture of 326 Channel Catfish from upstream and 389 Channel Catfish from downstream by counting annuli on thin sections cut from pectoral spines. Estimated von Bertalanffy growth curves for Channel Catfish from upstream ($L\infty = 777.0$, $K = 0.117$, $t_0 = 0.407$) and downstream ($L\infty = 919.8$, $K = 0.091$, $t_0 = 0.166$) are similar for younger fish which reach quality length (≥ 410 mm) around age 7. For older fish, growth is slower upstream where Channel Catfish typically reach preferred length in about 14 years compared to around 12 years downstream. This study expands knowledge about Channel Catfish population dynamics in lotic systems and demonstrates varying population characteristics upstream and downstream of a significant fish passage barrier.

Modelling egg transport and hatching success to investigate the likelihood of invasive carp populations becoming established in the lower St. Croix River

Jeffrey R. Ziegeweid, J. William Lund, Nick K. Frohnauer, Alan Kasprak, P. Ryan Jackson, Evan M. Lindroth

Presenter: Jeffrey R. Ziegeweid, jrziege@usgs.gov
Affiliation: United States Geological Survey

In 2015, five adult bighead carp were captured in the St. Croix River, and resource managers became concerned that invasive carp may establish reproducing populations. However, resource managers did not have a way to evaluate whether flow conditions in the St. Croix River were suitable for successful reproduction of invasive carp. Therefore, the Minnesota Department of Natural Resources and the U.S. Geological Survey (USGS) partnered to collect hydraulic data needed for inputs into a fluvial egg transport model (FluEgg) developed by the USGS Central Midwest Water Science Center. Bathymetry, velocity, and water chemistry data were collected at transects approximately one river mile apart between St. Croix Falls, Wisconsin and Stillwater, Minnesota. Longitudinal profiles were collected in the thalweg between transects. An existing one-dimensional HEC-RAS model was supplemented with collected field data and used in combination with the FluEgg model to predict the potential for successful spawning and recruitment of juvenile invasive carp. The FluEgg model uses these hydraulic data to predict the likelihood that larvae successfully hatch and develop lateral swimming capabilities. Preliminary results indicate a high likelihood of successful invasive carp egg hatching and larval development. However, in several reaches, the heavily braided channel may not be accurately represented from field data and one-dimensional modeling alone. Therefore, a two-dimensional HEC-RAS model is being developed to more accurately represent river hydraulic conditions. Study results will inform prevention and monitoring strategies for invasive carp species.