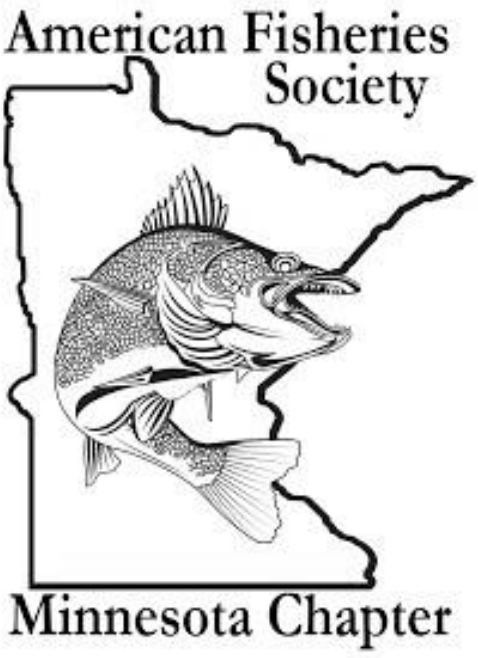
Minnesota Chapter of the

American Fisheries Society

Annual Meeting – Abstract Book



INVESTING IN OUR FUTURE

February 7-8, 2022

Speed Talks (10:40 am – 11:10 am, February 7)

A Golden Opportunity: Strategies to Accelerate Growth of Golden Shiner *Notemigonus crysoleucas* in Minnesota and other Northern Climates

Donald R. Schreiner and Amy J. Schrank

Presenter: Donald R. Schreiner, schr0941@d.umn.edu
Affiliation: University of Minnesota, Sea Grant College Program

The 2018 United States Department of Agriculture Aquaculture Census reported that Golden Shiner were the most valuable baitfish produced in the United States. Over the last twenty years the supply of Golden Shiner in Minnesota has decreased while demand by anglers for use as bait has increased and far exceeds in-state production. Recent projections by Minnesota bait dealers estimate a 10,000 gallon deficient of Golden Shiner annually. Consequently, there is pressure from anglers, bait dealers, and legislators to import Golden Shiner from other states, however, the law currently prohibits this in Minnesota. The primary concerns are that importation can introduce aquatic invasive species, disease, and parasites. Our study aims to increase production of Golden Shiner in Minnesota as a preferred alternative to importation. Growth rates of Golden Shiner in Minnesota are slow, it takes two years for Golden Shiner to reach market size in natural ponds. We propose to overcome this bottleneck by exploring four different strategies to grow Golden Shiner to market size (10-15 cm) in Minnesota within one growing season (May-October). Our strategies include: 1) intensive indoor rearing of Golden Shiner using a recirculating aquaculture system (RAS), 2) growing Golden Shiner in an indoor recirculating aquaponics system, 3) stocking outdoor, constructed ponds with newly hatched Golden Shiner sac-fry (0.5 cm), and 4) producing feed trained Golden Shiner indoors to a size of 3-5 cm, then stocking them into outdoor constructed ponds. Minnesota Sea Grant has partnered with the bait industry and the MNDNR on this project and preliminary results are encouraging.

Effectiveness and costs of aquatic invasive species spread prevention in Minnesota

Nichole Angell, Nicholas Phelps, Tim Campbell, Valerie Brady, Reuben Keller, Amy Kinsley, Adam Doll, Josh Dumke

Presenter: Nichole Angell, angel309@umn.edu
Affiliation: University of Minnesota

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. Effectiveness of AIS prevention strategies will be estimated by evaluating boaters and watercraft inspectors during experimentally controlled boat inspections. During these inspections we will realistically stage a boat with fresh macrophytes and dead or preserved AIS. Participants will be asked to inspect and remove any items as they would after a typical outing on a lake. Both the types of organisms and the amount removed from the boat will be used to estimate effectiveness for any one inspection. We pilot tested these methods in the Fall of 2021. Preliminary results suggest that boating frequency is positively correlated with effective removal by boaters and differences likely exist between types of AIS. In addition, costs of all evaluated prevention strategies will be determined by reviewing existing literature and interviews with AIS managers. This work is ongoing and preliminary results will be presented. Ultimately, these data will be incorporated into the online decision support tool, AIS Explorer (www.aisexplorer.umn.edu) to guide future management decisions.

Vertical Habitat Occupancy and Diel Migration Patterns of Burbot

Tyler Robinson, Andrew Hafs, Shannon Fisher, Jeffery Ueland

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

Aquatic animals frequently exhibit one movement behavior known as diel vertical migration (DVM). Characterized by large-amplitude ascents to shallow depths at dusk followed by a descent back to deeper depths, it has been assumed that DVM behaviors benefit organisms in more than one way. Because Burbot are a benthic species, adult Burbot diel behavior may follow the classifications of diel bank migration (DBM) compared to DVM behavior. Our objective is to quantify the scale of diel migration of Burbot and determine if they choose to move along following the lake contours or swim throughout the water column. Additionally, we hope to determine the temperature and dissolved oxygen preferences of Burbot throughout the year. Preliminary results indicate that Burbot prefer to stay on or near the lake's bottom besides during the summer when they appear to suspend in the water column. Additionally, Burbot choose to suspend off the bottom more during the day than at night. Burbot appear to select for cooler temperatures less than 18 ˚C during the summer and around three ˚C during the winter with no difference between night and day periods. Dissolved oxygen (DO) preferences of Burbot appear to fall between 8 – 11 mg/L. The lowest calculated average dissolved oxygen occupied by Burbot occurred between September and early November. This time frame was when the maximum temperature in Bad Medicine Lake existed, and Burbot were forced to occupy areas of the lake with low DO to avoid the high temperatures. Our findings indicated new patterns never witnessed in Burbot movement. Their ability to suspend in the water column during the summer suggests that Burbot might be more of a visible feeder than previously thought. Fisheries managers can use our data to sample Burbot throughout the year. Knowing the depth Burbot favor and the preferred temperature and dissolved oxygen, managers can select where and when they sample to optimize success in catching Burbot.

Poster Presentations (11:10 am – 12:00 pm, February 7)

Patterns of trophic position, littoral carbon use, and habitat coupling in fish among Minnesota lakes

Sara Kangas, David Gallagher, Payton Johnson, Mary Thelen, Kyle Zimmer, Brian Herwig, David Staples

Presenter: Sara Kangas, kang6529@stthomas.edu
Affiliation: University of St. Thomas

Research has shown food web structure can stabilize ecosystems, with stabilization promoted by species with high trophic position (TP) (through energy integration across trophic levels), high habitat coupling (HC) (through integrating pelagic and littoral energy), and specialization in the use of either pelagic or littoral energy (which increases community niche size). However, it is unknown whether these variables differ among fish species, and if they differ among lakes due to lake features. We sampled 11 species of fish from nine Minnesota lakes and used δ13C to estimate LC and HC and δ15N to estimate TP. We tested whether TP, LC, and HC differed between species across lakes and whether lakes differed in mean TP, LC, and HC using five fish species found in all lakes. Results showed TP, LC, and HC differed among species, with TP highest in Walleye, followed by Northern Pike then Largemouth Bass. Species with the highest habitat coupling were Black Crappie, followed by Northern Pike, Walleye, and Largemouth Bass. Cisco were the only species with notably different LC values reflecting high use of pelagic energy. Overall, species results indicate that high-level predators, Walleye and Northern Pike, are key for stabilizing lakes due to both high TP and HC, while Cisco are important by increasing community niche size. For patterns across lakes, HC, LC, and TP all differed, suggesting some physical lake characteristics cause these variables to systematically change in multiple fish species across lakes. Further, LC of all five fish species was negatively related to chlorophyll a, while no predictors showed significant relationships with HC or TP. Both variables showed weak relationships with lake productivity.

Thus, multiple species of fish differ systematically across lakes in HC, TP, and LC, and additional sampling in 2022 will hopefully clarify lake productivity as a driver of these variables.

Response of Invasive Bigheaded Carp to an Acoustic and CO2 Deterrent

Cassandra A. Kramer, Jackie Culotta, Allen F. Mensinger, Brooke J. Vetter

Presenter: Cassandra A. Kramer, kram8837@stthomas.edu
Affiliation: University of St. Thomas

The continued upstream migration of invasive carp within the North American Mississippi River drainage has created significant economic and ecological distress. Finding effective methods of minimizing the range expansion of invasive carp is imperative for the preservation of North American river ecosystems. A promising method of deterring invasive carp is the use of non-physical barriers at locks and dams throughout the Mississippi River. This project works to develop a method of deterrent using acoustic conditioning as a tactic to increase carp hindrance. By training invasive carp to associate an acoustic stimulus (broadband sound) with the presence of CO2, we aim to prolong the fish's aversion to broadband sound (eventually to be played at the downstream lock gate of Mississippi River dams) while simultaneously decreasing the frequency of CO2 application. Preliminary data has shown promising results, including a reduction in preference to the right side of the shuttle tank (playback chamber) when sound is playing and a reduction in carp shuttling to the playback chamber compared to the acclimation period.

Optimizing eDNA for multiple AIS

Christopher Rounds, Jenna Ruzich, Josh Dumke, Eric Larson, Chan Lan Chun, Adelle Keppers, Anna Totsch, Gretchen Hansen

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

Aquatic Invasive Species (AIS) have drastic impacts on aquatic ecosystems and food webs. In Minnesota, 800 water bodies are listed as infested by one or more AIS. However, this number is likely an underestimate due to the lack of a standard monitoring plan across the landscape of Minnesota lakes. Knowing where AIS exists on the landscape allows for informed management such as strategically placed decontamination stations and potential eradication efforts. However traditional surveys require significant person-power and expertise and are expensive on a large scale. The use of environmental DNA for species detections can mitigate these issues. eDNA is cheaper than traditional surveys, sensitive to diverse taxa at low abundance, and eDNA samples can easily be taken with basic training. In order for eDNA to be used for a diversity of lakes and AIS, the influence of lake characteristics and target species life history on detections must be assessed to inform when and where eDNA samples can maximize AIS detections. We will visit 20 different lakes with known populations of four AIS (spiny waterflea, rusty crayfish, zebra mussels, and common carp). We will visit each lake 5 times throughout the open water season and take covariate water quality samples compromising the physical and chemical lake characteristics. During each lake-visit we will take 10, 250ml surface water samples for a total of 50 eDNA samples per lake. Conventional qPCR will be used to quantify copy numbers of the target AIS using species-specific DNA assays. We will then use occupancy modeling in order to determine the influence of lake characteristics, species life history, and sample location on eDNA detections. These results from this research will inform the best practices of using eDNA to detect AIS in Minnesota.

A Century of Change in Minnesota's Lake Plant Communities

Donna Perleberg and Paul Radomski

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

Aquatic plant communities are good indicators of lake conditions, and persistent changes to those communities are indicative of environmental change. Our study used historical and recent lake plant surveys to detect changes in

Minnesota's lake plant communities over the last century. The primary signal of change was the failure to relocate taxa in lakes where they were historically common. In 55 % of the lakes, surveyors did not relocate at least one taxon that was reported in an historic survey. We found that emergent plant taxa were most likely to have been lost; for lakes where emergents were reported historically, 45% had at least one emergent taxon that was not redetected compared to 30% of lakes where at least one floating-leaf taxon was not redetected and 42% of lakes where at least one submerged taxon was not redetected. Lakes in the southwestern and central ecoregions of the state were most likely to have gross and persistent aquatic plant losses. Eutrophication was the most likely reason for losses, with substantial declines in the probability of presence of many taxa with greater increases in lake phosphorus concentrations.

Student Presentations (8:10 am – 10:10 am, February 8)

Seasonal Variations in Home-Range Size Concerning the Spawning Vulnerability of Burbot

Tyler Robinson, Andrew Hafs, Shannon Fisher, Jeffery Ueland

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

Burbot Lota lota have a broad circumpolar range spanning from rivers of Alaska to lentic systems south to Minnesota. Although much is known about their population dynamics, their movement dynamics have been rarely studied. Our objectives were to assess seasonal home range changes in Burbot in a closed-lentic system and quantify their vulnerability during their peak spawning period. Sixty-six Burbot were implanted with Innovasea acoustic transmitters across Bad Medicine Lake, Minnesota. Thirty-two fish survived the study period between 10 April 2019 to 11 June 2020 and were used for analysis. We predicted that Burbot in Bad Medicine Lake spawned during the second and third weeks of March, where average home range estimates for all sexes were two to three times larger than any other point in the study. Females estimated home range size was significantly larger than males across the whole study. Fish movement throughout the system was synchronized with the ice formation in December and continued in March when they explored new areas. Home range estimates were the smallest in mid-April, which we assumed to be a post-spawn phenomenon. Spawning locations were estimated using ArcGIS optimized hot spot analysis. Results show that although there are specific locations in Bad Medicine Lake that Burbot prefer to use, spawning occurs throughout the entire system. Burbot show a preference for the eastern shore, which indicates an affinity to sharp break lines with a mixture of rock and sand substrate. Our results suggest that extreme vulnerability of Burbot during peak spawning periods is possible but location-dependent. It is not as intense as previously thought by fisheries managers in Minnesota. The results of this study will assist fisheries managers in determining appropriate measures to protect the fish during their most vulnerable stages. While additionally shedding light on new knowledge in movement dynamics and space use of an essential species of fish.

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

Edward Carlson, Casey Schoenebeck, Beth Holbrook, Andrew Hafs

Presenter: Edward Carlson, edward.carlson@live.bemidjistate.edu
Affiliation: Bemidji State University

Cisco Coregonus artedi are a pelagic cold-water fish that are widely distributed throughout many inland lakes across the northern Midwest. Cisco play an important role in lake ecosystems as they are important forage for large piscivores such as Muskellunge, Northern Pike, Walleye and Lake Trout. Cisco populations have been observed to display a range of differences in recruitment, growth, and mortality based on the system in which they are found. With climate change effects becoming more prevalent in Minnesota, biological, chemical, and physical aspects of lake ecosystems are changing and ultimately influencing inland Cisco populations. To investigate how different environmental cues are affecting the population dynamics of inland Cisco, three lakes were selected within Minnesota's northern lakes

and forests and north central hardwoods ecoregions. The three lakes were sampled annually for Cisco using hydroacoustic sonar and vertical gill nets from 2011-2020. Supporting information related to pelagic oxythermal habitat, food availability, and abundance of large predators within each system were collected to understand how different environmental factors were influencing inland Cisco population dynamics. A combination of environmental variables were selected a priori based on knowledge of Cisco biology to develop 15 linear regression mixed-effect models. The upper 95th percentile of total length (mm) was used as the response variable for each of the 15 models to account for the variation in Cisco length across the three lakes. By understanding the effects of changing environments on cold-water fish populations, these results will provide fisheries managers with knowledge to promote and sustain cold-water systems that support large game species.

Spawning-Related Habitat Use of Walleye in the Big Sandy Lake, MN Watershed

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

Presenter: Claire L. Rude, clrude@iastate.edu
Affiliation: Iowa State University

Reservoirs are complex systems with different ecological dynamics from other lake or river systems. Consequently, fish movement in reservoirs can be dynamic due to the interconnections between reservoirs and tributary systems. Walleye are common reservoir sportfish that can be highly mobile and often travel upstream into tributaries for spawning. Yet, what portion of reservoir populations move into tributaries versus remain in the lake during spawning, whether spawning locations vary as a function of fish size, or if fish that move into tributaries behave differently throughout the rest of the year is unknown. The objectives of this study were to 1) assess the proportions of Walleye in Big Sandy Lake located upstream in the Sandy and Prairie Rivers versus the main lake during spawning, 2) determine the relative importance of these spawning areas to Walleye of different sizes, and 3) assess potential differences in behavior throughout the year based on Walleye selection of spawning locations. We deployed an acoustic telemetry array of 31 receivers and implanted acoustic tags into 25 mature Walleye to monitor their movement. Overall, 62% of Walleye remained in the lake during the spring, 33% moved into the Sandy River, and 4% moved into the Prairie River, suggesting the lake and the Sandy River may represent critical spawning locations. Walleye in the Sandy River were larger than those that traveled into the Prairie River or stayed in the lake. Both lake-spawning and tributary-spawning Walleye mostly occupied the main basin of the lake or western and southern bays during the rest of the year, but tributary spawners spent more time in the southern bays near the Sandy River inlet. Results from this study will provide knowledge of preferred environments for Walleye spawning in reservoirs containing both lacustrine and riverine habitats with implications for spawning habitat protection and enhancement.

Examining motivations for illegal baitfish release among Minnesota anglers

Meg McEachran, Abbey Hammell, Ethan Brown, David Fulton, Nicholas Phelps

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

The spread of aquatic invasive species via the movement of recreational anglers across the landscape is well documented, but the determinants of angler behaviors that potentially facilitate their spread are less well understood. In particular, the release of live baitfish offers significant opportunity for the spread of invasive fish pathogens which can pass undetected in otherwise innocuous legal baitfish species. Despite a prohibition on live baitfish release, previous research by our lab found that at least 20% of surveyed Minnesota anglers reported releasing leftover live baitfish into the water, so understanding the motivations behind this behavior is critical for designing education and management strategies to reduce pathogen invasion risk. Employing the Theory of Planned Behavior, we designed and implemented a quantitative social-psychological survey of 8,000 licensed anglers during the spring of 2021. We received 1,467 complete responses from across Minnesota and 31 other states for an adjusted response rate of 18%. Among surveyed respondents, 1028 (70%) reported that they intended to use live baitfish in the upcoming season, and of those, only 148 (14%) reported that they plan to release leftover live baitfish in the future. We found that social norms and negative attitudes towards release were correlated with decreased intention to release live baitfish. However, 248 (25%) of past live baitfish users reported having released their leftover live baitfish in the past year,

indicating that this is a persistent and widespread behavior and that intended disposal method may not translate to actual future behaviors. Understanding the internal and external factors that govern illegal bait release behavior will be a crucial foundation for planning future risk management strategies.

Can Small-Scale Invasive Cattail Removal Positively Impact Fish Communities Across Minnesota?

Brendan Nee, Michael Tuma, Daniel Larkin, Amy Schrank

Presenter: Brendan Nee, neexx029@umn.edu
Affiliation: University of Minnesota

Nearshore littoral vegetation provides crucial habitat for spawning adult fishes, nursery habitat for larvae and juveniles, and habitat for prey. The structural complexity of plant communities that include a mix of floating, emergent, and submergent plant types tends to benefit fishes, including sportfish such as walleye, bass, pike, and sunfishes). Invasive narrow-leaf and hybrid cattail (Typha angustifolia and Typha x glauca, hereafter cattail) are ubiquitous across Minnesota. Expansion of cattails in lake littoral zones has severely altered habitats by forming dense, homogenous stands that change environmental conditions, displace native vegetation, and may have detrimental effects on fishes. Information about how cattail affect fishes and how this impact varies regionally across Minnesota is unknown. Localized mechanical control and suppression (stand fragmentation, channelization) of cattail may benefit plant and fish communities 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. We have selected sites on nine lakes to study the before and after effects of cattail removal on nearshore fish communities. We have established a set of paired sites, cattail retained and cattail removed, at each study lake. Following preliminary sampling, and mechanical harvesting of cattail in one of two paired sites in each lake in 2021, we will resample all sites during summer 2022 to determine if the ecological variables differ in cattail removed sites compared to cattail retained plots. 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.

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

Tyler J. Orgon, Andrew W. Hafs, Carl W. Isaacson, and Shane E. Bowe

Presenter: Tyler J. Orgon, tyler.orgon@redlakenation.org
Affiliation: Bemidji State University/Red Lake DNR

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

Student Presentations (10:30 am – 11:50 am, February 8)

Feeding Patterns and Diet Overlap of Muskellunge and Co-Occurring Piscivores in Minnesota Lakes

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

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

Muskellunge Esox masquinongy are the largest member of the family Esocidae found in Minnesota and are managed for trophy angling opportunities with large minimum size requirements, limited harvest, and stocking to support existing populations or expand angling opportunities. While Muskellunge impacts at the community level appear minimal based on available literature, relatively little is known about Muskellunge diets, particularly in Minnesota. In this study, we used gastric lavage to examine gut contents of Muskellunge, Northern Pike E. lucius, Walleye Sander vitreus, and Largemouth Bass Micropterus salmoides. Diets were quantified using an index of relative importance (IRI) and diet overlap among species was determined using Pianka's index of niche overlap and non-parametric multi-dimensional scaling (NMDS) ordinations. Our experimental design focuses on how the presence or absence of Cisco Coregonus artedi impacts diet and overlap, while lakes without Muskellunge were also sampled to compare diets of other piscivores in their presence or absence. Yellow Perch Perca flavescens and various centrarchids were important prey items across all lakes for Muskellunge, Northern Pike, and Walleye, while crayfish Faxonius spp. and other aquatic invertebrates were critical for Largemouth Bass. Pianka's index of niche overlap indicates that overlap between Northern Pike and Walleye is highest in most lakes, while diet overlap among all species tended to be lower in lakes where Cisco were present despite few observations of direct predation on Cisco. Finally, while NMDS ordinations indicated shared use of prey sources, diet overlap between Muskellunge and other piscivores in this study was low. This is likely due to the broad range of prey consumed by Muskellunge in comparison to the relatively narrow diets of the other predators.

Identifying drivers of isotopic niche overlap and trophic redundancy in fish communities across Minnesota lakes.

David Gallagher, Payton Johnson, Sara Kangas, Mary Thelen, Kyle Zimmer, Brian Herwig, David Staples

Presenter: David Gallagher, david.gallagher@stthomas.edu
Affiliation: University of St Thomas

Recent work has highlighted the importance of trophic redundancy (trophic niche overlap) for maintaining food web stability. Although niche overlap can indicate potential interspecific competition, it can help sustain energy flow in food webs as species compensate for declines in the abundance of other species. To date, most research on niche overlap has been conducted on individual ecosystems, while little is known regarding patterns across ecosystems. We used stable isotope analysis of δ13C (percent littoral carbon use) and δ15N (trophic position) to identify drivers of isotopic niche overlap between 15 fish species from nine Minnesota lakes. We estimated isotopic niche size for each species in each lake, as well as isotopic niche overlap by calculating the probability that an individual of species A occupies the isotopic niche of species B. We tested models predicting niche overlap that fell into three broad categories: niche size, location in niche space, and species identity. Results for niche size showed species A niche size was a better predictor of overlap than species B niche size, indicating species with large niches overlap on others more, but species with smaller niches are not necessarily overlapped more by others. Results for niche space indicated similar trophic positions increased niche overlap more than similar use of littoral carbon, reflecting that species have more distinct trophic positions than littoral carbon use. Lastly, our species analysis indicated niche overlap varied among species, with Yellow Perch having the highest average overlap on other species (49%), followed by Largemouth Bass (42%) and Northern Pike (42%). Cisco showed no overlap on any species. Overall, our study characterizes broad

factors influencing isotopic niche overlap and identifies fish species with the greatest potential trophic redundancy, an important step for understanding food web stability in lakes.

Impacts of Cisco (*Coregonus artedi*) on food web architecture of Minnesota lakes

Payton Johnson, David Gallagher, Mary Thelen, Sara Kangas, Kyle Zimmer, Brian Herwig, David Staples

Presenter: Payton Johnson, john47402@stthomas.edu
Affiliation: University of St. Thomas

Cisco are an offshore planktivore threatened by rising temperatures and decreasing dissolved oxygen in lakes. Cisco conservation is prioritized due to their importance as prey for other fish, but the significance of Cisco to lake ecosystems from a food web architecture perspective is poorly understood. Recent research on food web architecture has shown that lake food webs are stabilized by energy inputs from both pelagic and littoral pathways, suggesting Cisco may be uniquely important in lakes due to their ability to exploit pelagic prey. We used stable isotope analysis of δ15N and δ13C of fish sampled from 9 lakes across Minnesota (5 Cisco, 4 non-Cisco lakes) to test several predictions: 1) Cisco use significantly more pelagic energy than other fish species, 2) Cisco contribute more to isotopic community niche size than any other species, 3) pelagic energy use by other planktivores is higher in non-Cisco lakes, 4) pelagic energy use by piscivores is higher in lakes with Cisco, and 5) contribution of other species to community niche size is significantly larger in non-Cisco lakes. Results showed Cisco used significantly more pelagic energy and contributed significantly more to community niche size than any other species. Bluegill, Pumpkinseed, and Black Crappie used significantly more pelagic energy in lakes without Cisco, but pelagic energy use by Walleye and Northern Pike did not significantly differ between Cisco and non-Cisco lakes. Lastly, contributions to community niche size for all analyzed species did not differ between lakes with and without Cisco, indicating Cisco are unique in their ability to increase community niche size. Our results show Cisco have significant impacts on food web architecture by increasing community niche size and through high reliance on pelagic energy. The ability to utilize pelagic energy makes Cisco an important species for increasing food web stability in lakes.

Life at the top of the food chain: trophic ecology of Walleye and Northern Pike in lakes with and without zebra mussels

Mary Thelen, Payton Johnson, David Gallagher, Sara Kangas, Kyle Zimmer, Brian Herwig, David Staples

Presenter: Mary Thelen, thel5158@stthomas.edu
Affiliation: University of St. Thomas

Differences in Walleye and Northern Pike trophic ecology across lakes are poorly known. Stable isotopes δ13C and δ15N estimate proportion of pelagic versus littoral carbon (LC) in diets and trophic position (TP), respectively. We studied nine Minnesota lakes and estimated TP, LC, and habitat coupling (HC), a metric of littoral/pelagic carbon balance, in prey fish, Walleye, and Northern Pike. We estimated mean TP, LC, and HC, and slopes of TP and LC with fish length, for both species in each lake. Finally, we tested whether: 1) TP, LC, and HC differed between Walleye and Northern Pike across lakes, 2) mean and slope of LC and TP were correlated between species across lakes, and 3) means and slopes of LC and TP were related to LC and TP of prey fish, zebra mussel presence, or Cisco presence. Walleye had higher TP and lower LC and HC compared to Northern Pike. LC and TP means of Walleye and Northern Pike were positively correlated across lakes; thus the two species are responding similarly at the whole-lake scale. Walleye and Northern Pike LC means were related to LC of prey, and mean LC and LC slopes were higher in zebra mussel lakes. Thus, zebra mussels are a critical factor increasing LC use by these top predators. Walleye and Northern Pike TP means and slopes were positively related to TP of prey fish, and TP of Walleye was 0.25 TP higher than Northern Pike. Lastly, prey fish LC use was negatively related to chlorophyll a, but prey fish TP was not related to any predictor variables. Our results indicate Walleye and Northern Pike occupy distinct niches and have differing roles in promoting food web stability. Both predators track prey signatures, indicating broad shifts in LC use and TP in the entire fish community across lakes.

Professional Presentations (12:20 pm – 2:20 pm, February 8)

Neighborhood Fishing Updates from Eagan, Minnesota

Jessie Koehle

Presenter: Jessie Koehle, jkoehle@cityofeagan.com
Affiliation: City of Eagan

Eagan is a southern suburb of the Twin Cities metro area of Minnesota with over 67,000 residents and more than a thousand small surface waterbodies. Fifteen of Eagan's small lakes are actively managed for neighborhood fishing opportunities with partnerships between Minnesota Department of Natural Resources, City of Eagan, and Dakota County. This talk will give an update on City of Eagan efforts to protect and improve lakes and fisheries over the past few years, including results from a 2020 public fishing use survey, a renewed partnership with Minnesota's Get The Lead Out program, efforts to think inclusively about fishing opportunities, and other future directions.

Friday night fish fries: Can we grow Yellow Perch indoors to increase aquaculture supply chain resilience and local food security?

Amy J Schrank, Donald R. Schreiner

Presenter: Amy J Schrank, aschrank@umn.edu
Affiliation: University of Minnesota, Sea Grant College Program

Yellow Perch (Perca flavescens) are a prized food-fish in the Great Lakes region and can be found in venues ranging from 5-star restaurants to Friday night fish fries. The harvest of wild caught Yellow Perch (YEP) has declined, yet demand continues to increase and there is growing interest in the use of aquaculture to fill this unmet demand. Aquaculture supply chains have been disrupted by the COVID-19 pandemic and similar disruptions have decreased food security in underserved, urban communities of color. Our project aims to address both of these challenges by working with YEP producers and the Little Earth Community of United Tribes in Minneapolis, MN. The goal of our project is to develop methods and provide cost estimates for small to medium sized producers to hatch, feed-train, and rear YEP to fingerling and market size in a recirculating aquaculture system (RAS). This will 1) address the negative impacts of COVID-19 on both YEP fingerling supply and local food security, 2) enable production of biosecure fingerlings for grow-out, 3) provide farmers the opportunity to increase vertical integration in their operations, and 4) provide methodological information to the Little Earth Community of United Tribes planned aquaponics facility. To meet these goals, we will compare methods and costs of rearing YEP in both a flow-through system and a RAS by measuring fish growth, mortality rates, and costs for rearing both fingerling and market sized fish. We will develop a guide and outreach materials for producers that describe best practices and cost estimates for growing YEP in RAS. Finally, we will engage with the Little Earth of United Tribes community by providing both workforce development opportunities and outreach materials to support their planned YEP aquaponics facility

Nutrient concentrations in shallow lakes reflect in-lake properties while δ13C and δ15N patterns in food webs are driven by lake morphometry and watershed land use

Kyle D. Zimmer, Thomas A. Langer, Brian R. Herwig, William O. Hobbs, James B. Cotner

Presenter: Kyle D. Zimmer, kdzimmer@stthomas.edu
Affiliation: University of St. Thomas

Biogeochemistry patterns in shallow lakes are influenced by both in-lake factors such as ecosystem state and watershed-level factors such as land use, but the relative importance of in-lake versus watershed factors is poorly known. This knowledge gap makes it difficult for lake mangers to prioritize efforts on watershed versus in-lake strategies for stabilizing the clear-water state. We studied 48 shallow lakes in Minnesota, USA to assess the relative influence of lake size, land use in watersheds, and ecosystem state (turbid versus clear) on water column total nitrogen

(TN) and total phosphorus (TP), as well as δ15N and δ13C in three species of fish. Our land use categories included natural areas, row crop agriculture, and all agriculture (row crops plus alfalfa). A model selection approach revealed different control mechanisms on the behavior of stable isotopes and nutrients. δ13C ratios in fish were most strongly influenced by lake size, while δ15N ratios were influenced by total agriculture in watersheds. In contrast, water column TN and TP concentrations were influenced by the in-lake factor of ecosystem state, with both nutrients lower in the clear state. We detected no effects of land use on TN or TP concentrations, but the strong relationship between agriculture and δ15N in fish implies that there were watershed influences on nutrient processing in shallow lakes. Collectively, these observations indicate that lake managers should minimize agricultural intensity in shallow lake watersheds to facilitate the clear-water state, which will, in turn reduce water-column TN and TP relative to the turbid state.

Distribution and comparative influences of minnows, Black Bullhead, and invasive Common Carp on water quality, submerged plants, and invertebrate communities in shallow Minnesota lakes

Brian R. Herwig, Kyle D. Zimmer, Mark A. Hanson, Shane E. Bowe, Sean R. Vaughn

Presenter: Brian R. Herwig, brian.herwig@state.mn.us
Affiliation: Minnesota Department of Natural Resources

Comparative influences of minnows, Black Bullhead, and Common Carp on shallow lake ecosystems are poorly known, as are factors driving patterns of distribution of these species among lakes. We addressed these questions by studying 125 lakes in 3 northern (Red Lake, Itasca and Chippewa) and 3 southern (Windom, Metro and Alexandria) Minnesota study regions in 2010. We compared the distribution and ecological characteristics of lakes with four contrasting fish communities: fishless lakes (N=18), lakes with MINNOWS present (N=54), lakes with MINNOWS + Black Bullhead (BLB lakes) present (N=42), and lakes with Common Carp (CAP lakes) additionally present (N=11). Fishless lakes were most common in the Itasca study area but were also found in the southern region, while species dominance in the MINNOWS lakes shifted from Fathead Minnow in the southern region to Northern Redbelly Dace at higher latitudes. BLB lakes were found in all study areas, with highest abundance observed in Windom, while CAP and turbid state lakes were only observed in the southern region. The most important factor driving zooplankton and macroinvertebrate abundance was higher abundance in the southern region across fish communities, then by higher abundance in fishless sites versus fish present, and lower abundance in BLB lakes versus other fish communities for large Cladocera. CAP lakes had highest turbidities, but total phosphorus and Chlorophyll a did not differ from BLB lakes. Multivariate analyses confirmed these patterns and indicated region, fish absence, and BLB abundance as key factors influencing invertebrate abundance and water quality. BLB and CAP were associated with connected and/or larger lakes, while MINNOWS were present more often in lakes with larger watersheds. Results indicated these three fish groups generate a gradient of lake features and that BLB and CAP had the strongest influence on lake ecological characteristics.

Recovery of Slimy Sculpin after a Headwater Fish Kill

Neal Mundahl

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

Toxic runoff from heavy rains on 26 September 2019 caused a declared "complete" fish kill on the 2 km-long headwater reach of Garvin Brook, Winona County, MN. This project examined recovery of the Slimy Sculpin (Cottus cognatus) population within the lower 900 m of the kill zone, comparing relative abundance estimates and size structures between the kill zone and a downstream, unimpacted reference section. Electrofishing surveys were conducted at 24 sites (12 within both kill and reference zones) at 6, 11 and 18 months postkill to assess relative abundance (catch-per-effort [CPE], fish/min), and all fish collected were measured (total length, mm) to examine population age structures. Six months postkill, sculpin were present throughout the kill zone, not concentrated at downstream sites that might suggest gradual immigration into the kill zone from downstream. Age structures were similar in kill and reference zones after six months, but CPE was twice as high in the reference (6.3 fish/min) versus

the kill zone (3.0 fish/min). After 11 months, CPE did not differ between zones (14 fish/min), although adult fish were 235% more abundant and immature fish 60% less abundant in the reference versus the kill zone. Young-of-year (YOY) sculpin comprised >80% of the population in the kill zone, but only 39% in the reference zone. After 18 months, YOY sculpin still dominated the kill zone, but both adult and immature CPEs had become more similar between zones. Evidence suggests that the fish kill in Garvin Brook was not "complete" for Slimy Sculpin, as approximately one-half of the population may have survived the event, and those survivors reproduced and repopulated the kill zone within 11 to 18 months. Low predation on YOY sculpin due to reduced abundance of trout and adult sculpin postkill likely allowed more rapid recovery of the sculpin population.

Movement patterns of carp through Mississippi River locks and dams show how these structures can be used to block invasive carp while allowing for native fish to pass, solving the continuity conundrum

Peter Sorensen

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

The construction of 29 locks and dams (LDs) in the Upper Mississippi River (UMR) a century ago changed the ecology of the UMR to a lenthic system dominated poorly-connected pools. Although not well documented, this change undoubtedly caused a shift in its fish community from one characterized by migratory species (ex. sturgeon, herrings), to less mobile, lacustrine species that cannot swim upstream against the high water velocities found at LDs (ex. walleye, bass). Today, this balance is again being threatened; this time by invasive carps which consume vast quantities of plankton, plants and mollusks. Should these carps establish themselves in Minnesota as they have elsewhere, the abundance of many native fishes can be expected to plummet as their growth rates stagnate. Many unionid mussels likely will become extinct. Because invasive carp removal efforts in southern MN have proven challenging, it appears an additional approach might be useful to preserve extant fisheries and river biodiversity. Recent studies show that LDs are the key. Studies of how common carp pass LDs show that some LDs are much more passable than others and that passage can be either increased or decreased at particular LDs on a species-specific basis, especially if combined with other techniques. Changes in LD gate operations and other new techniques/ approaches could thus either stop more carp and/or allow more native fishes to pass at selected locations. For example, LD5, south of Lake Pepin, has the potential to stop over 99% of all carp and allow more natives to pass than it presently does at low cost. Were such a strategy to be enacted, then native fish passage could be enhanced upstream of this location, safely allowing river connectivity to be increased across the majority of the state. My talk will review the data underlying this strategy and describe it.

Professional Presentations (2:40 pm – 4:00 pm, February 8)

Assessment and Management of Unique Muskellunge Populations in Voyageurs National Park

Kristen Patterson, Ryan Maki, Dan Schermerhorn, Jaime LeDuc, Kevin Peterson, Jay Glase, Steve Shroyer, Loren Miller, Alan Kirschbaum

Presenter: Kristen Patterson, kristen.patterson@state.mn.us
Affiliation: Minnesota Department of Natural Resources

The Shoepack Lake and Little Shoepack Lake Muskellunge populations are geographically and genetically isolated populations in Voyageurs National Park. These unique muskellunge populations are found in Shoepack and Little Shoepack Lakes whose remote location and pristine surroundings make these lakes a primary muskellunge angling destination within the Park. Previous work on Shoepack Lake provided a population estimate and modeled future scenarios and threats to this population in the early 2000s. In 2019, a second population estimate was completed on

Shoepack Lake, and in 2021 the first population assessment was initiated on Little Shoepack Lake. The goals of these efforts were to 1) determine current estimates of Shoepack and Little Shoepack Lake muskellunge populations, and 2) determine if the muskellunge populations in these two lakes are genetically distinct and if they would they be viable options for genetic rescue, if necessary. We present initial results from the genetic analysis, Shoepack Lake assessment, mark phase of the Little Shoepack population assessment, and discuss future management implications and needs.

History of Balancing Native and Introduced Trout in Minnesota Streams

Shannon J. Fisher, John Hoxmeier, Doug Dieterman
Presenter: Shannon Fisher, shannon.fisher@state.mn.us
Affiliation: Minnesota Department of Natural Resources

Minnesota has a rich natural history, but by the late 1800s, extensive logging and agriculture altered Minnesota's coldwater stream continuums that once teamed with native Brook Trout (Salvelinus fontinalis). By 1900, Brook Trout were assumed to be extirpated and Brown Trout (Salmo trutta) and Rainbow Trout (Oncorhynchus mykiss) were stocked to replace the fishery. Over time, many coldwater streams stabilized and again became suitable for Brook Trout. By this point, however, highly invasive Brown Trout had naturalized in most southeastern Minnesota streams. Initial observations suggested that Brown Trout displaced Brook Trout through direct predation and competition. As a result, reintroduced Brook Trout populations remained largely isolated to headwater streams – away from abundant Brown Trout in the lower reaches. However, in some instances, base flows increased and streams become colder – allowing Brook Trout to displace Brown Trout invaders. Recently, Brook Trout populations believed to be native remnants to southeastern Minnesota have been identified, and their protection has received interest from both the public and fisheries managers. As efforts are made to expand historic Brook Trout populations, decreased Brown and Rainbow trout stocking and management may need to occur. Minnesota is currently experiencing some of the best trout fishing on record, with anglers purchasing trout stamps in record numbers to fish on coldwater streams. Many of these anglers, though, have become accustomed to catching both abundant and large Brown Trout, and may not be receptive to managing for smaller Brook Trout. Therefore, we will have to draw on lessons learned over a century of stream trout management to balance native species conservation with diverse angling opportunities.

Genomic insights into likely origins of Brook Trout below barriers in North Shore tributaries and Lake Superior

Loren M. Miller, Nadya Mamoozadeh, Nick R. Peterson, Cory Goldsworthy and Mariah Meek

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

Brook trout (Salvelinus fontinalis) in Minnesota tributaries to Lake Superior occur, and are managed separately, as populations above and below natural waterfall barriers. Isolation above barriers and/or natal homing could produce and maintain genetic differentiation among populations in each stream. Prior studies using microsatellite genetic markers identified several genetically distinct populations among the numerous North Shore streams examined. These results were used to select samples from seven streams and Lake Superior for analysis with high-resolution genomic markers (single-nucleotide polymorphisms: SNPs). Our objectives were to determine spatial genetic structure among Brook Trout populations and determine the origins of fish below barriers and in Lake Superior. SNPs delineated eight genetic groups from the seven streams. In streams with samples from above and below barriers, fish below barriers mostly grouped with the population above, indicating downstream movement. Remaining fish grouped closely with samples from other streams, indicating migration between streams. In one stream with two genetic groups, microsatellites suggested that one group was likely composed of migrants from a nearby stream not included SNP analyses. Despite the presence of migrants, there were no individuals with mixed ancestry and thus no evidence for successful reproduction below barriers. Brook Trout in Lake Superior originated mostly from Baptism River with a few from two other Minnesota streams or hatchery strains. Larger sample sizes and more streams will be evaluated. Our working hypothesis is that most Brook Trout in North Shore streams are produced above barriers, some move downstream below barriers, and some of these eventually move into Lake Superior to reside or migrate to other

streams. Our findings will have implications for management that will support both resident and migratory "coaster" life history types of Brook Trout in the Lake Superior watershed.

Influence of terminal tackle and environmental conditions on survival of caught and released salmon and steelhead

Sean Gibbs, Ian Courter, Thomas Buehrens, Ben Briscoe, Forrest Carpenter, Tara Blackman

Presenter: Sean Gibbs, sean.gibbs@mthoodenvironmental.com
Affiliation: Mount Hood Environmental

Gear-type restrictions are intended to improve survival of caught and released fish by reducing handling times and lowering injury rates. To test the merits of these regulations, we conducted a three-year angling mark-recapture study using a control-treatment study design in the Lower Cowlitz River, Washington. Over 7,200 rod-hours were expended angling 2,787 salmon and steelhead with a variety of methods and gear types. 2,101 of these fish were landed and 1,507 hatchery-origin salmon and steelhead were marked with anchor tags. Over 3,700 fish were also trapped, tagged, and released to serve as study controls. Across all species, the average weighted recapture rate of angled fish was 2% lower than control fish, suggesting that mortality due to angling was rare. Recapture rates of fish caught on barbed hooks trended lower compared with fish caught on barbless hooks. Fish hooked in critical locations (eyes, gills, esophagus, tongue), were recaptured at a rate that was 11.4% lower compared with fish hooked in non-critical locations (body, maxillary, jaw, head). Further, fish caught using bait were more likely to be hooked in critical locations compared with other gear types and resulted in those fish being 15% less likely to be recaptured compared with fish caught using other gear types. Water temperature was also found to have a significant effect on recapture, where the probability for recapture declined by 17% for salmon and 9.5% for steelhead with each degree of temperature increase. This large data set can be used to inform regulatory measures that reduce mortality of caught and released fish while maximizing angling opportunity.