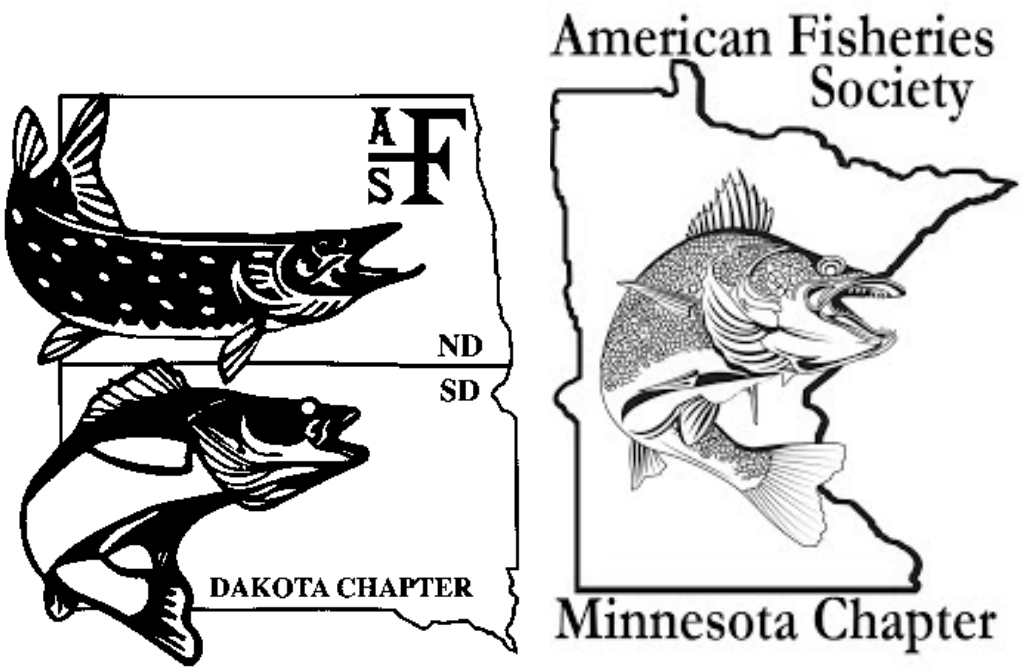
Minnesota and Dakota Chapters of the American Fisheries Society Annual Meeting – Abstract Book



Fisheries in a Connected World

February 25-27, 2019

Fargo, North Dakota

Concurrent Sessions 1 (Room: Dakota)

Citizen Participation in Lake Management Planning – The Lake of the Woods Experience

Phil Talmage

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Managing popular large multi-species fisheries can present a complexity of issues and a variety of perspectives regarding resource management. Lake of the Woods is a popular Walleye lake that straddles the U.S., Ontario, and Manitoba borders. With increasing popularity of the recreational fishery, there was a strong need for citizen engagement in the management planning process. The Minnesota Department of Natural Resources utilized a broad-based citizen engagement process to update the Lake of the Woods Fisheries Management Plan in 2018. This process included creation of a Fisheries Input Group comprised of a diversity of stakeholders, and a broad-based multimedia public information and input program. This presentation will describe the management planning process and how public input was used to update the Fisheries Management Plan and make subsequent regulations changes.

Identifying and Conserving Resilient Freshwater Systems: Can we do it?

Kristen Blann

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The Nature Conservancy, in service of the mission of conserving “the lands and waters upon which all life depends”, has established as a protection goal the identification and conservation of a network of resilient sites and connecting corridors that will sustain North America's natural diversity by allowing species to adapt to climate impacts and thrive. Conservancy staff and scientists, in partnership with dozens of institutions, have already developed and published an approach to mapping terrestrial resilience to climate change on a hypothesized relative continuum across the US, based on geophysical settings associated with ecological and habitat diversity as well as connectivity. However, it is acknowledged that the resilience of freshwater systems in the face of climate change is subject to a different set of controls and dynamics than those that drive terrestrial response. Resilient freshwater systems have been defined as those that can sustain diversity and ecological services as they adapt to climate change. Currently a series of working groups are working to recommend critical metrics to achieve a resilient network of rivers, lakes, wetlands, and estuaries over the next 30 years, while considering the challenges that will occur in that time period. Conservancy scientists have been engaging freshwater staff and working teams across the U.S., building on two previous regional approaches led by the Conservancy in the eastern U.S. and North Carolina. Attributes hypothesized to contribute include longitudinal connectivity linking tributaries of many sizes, gradients and temperature regimes; lateral connectivity linking rivers to their floodplain; and relatively unaltered natural flows within a watershed that retains functioning landscape hydrology.

Protection Framework for Minnesota Lakes That Support Unique Native Fish Communities

Derek Bahr, Jacquelyn Bacigalupi, Peter Jacobson

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Water quality standards in Minnesota are intended to protect water resources for aquatic life and recreational use. However, these standards allow for moderate changes in community structure and may not afford protection for lakes that support unique native fish communities. These communities may contain one or more native coldwater species including Cisco, Burbot, Lake Whitefish, or Lake Trout or may be of exceptional quality, containing a diverse, well-balanced assemblage of both game and non-game species resembling that of an undisturbed system. In some states, measures have been taken to provide protection for similar communities. For example, water quality standards were established to protect habitat in Wisconsin lakes where coldwater species are found. Likewise, an exceptional use designation within a Tiered Aquatic Life Use (TALU) framework was established to protect Minnesota streams that contain exceptional fish communities from future degradation. To date, neither approach has been formally applied to Minnesota lakes; however, research has identified oxythermal habitat conditions where the four primary lake-dwelling coldwater species are found and has developed a TALU framework for lakes using a fish index of biological integrity. The added protection that could be attained by using these frameworks would limit the amount of degradation that could occur in watersheds that contain these lakes before needing remediation. In this study, we evaluated the application of each framework to the appropriate suite of lakes. Use of both frameworks could provide additional protection for hundreds of lakes that contained at least one coldwater species or exceptional fish communities. Of those, only a fraction could be protected using both frameworks. This difference highlights the importance of applying both to adequately protect aquatic life in these unique, high quality lakes that are oftentimes located in watersheds where little human disturbance has occurred.

Freshwater Conservation Zones: a New Approach to Managing our Freshwater Fisheries

Peter Sorensen

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Across the globe, both fresh and marine fisheries are in decline as traditional management approaches struggle to keep up. Especially challenging are the new and rapidly escalating threats associated with climate change, pollution, increasing levels of overfishing coupled with fisheries-induced-evolution, water diversion, and invasive species. The interrelatedness of these phenomena make this an especially wicked problem which neither increased stocking, slot-limits, nor habitat management can easily solve. Seventy-five years ago marine fishery biologists developed the protected area concept to address many of the same issues. This strategy limits exploitative use of key portions of ecosystems so that their fish populations can sustain themselves naturally and hopefully then seed (spill-over) adjoining areas. Nearly 15,000 marine protected areas (MPAs) are now in existence. Recent meta-analyses are starting to illuminate why (and how) some MPAs have either failed or succeeded. In this talk I will address five of these lessons and how they could be applied to our freshwater fisheries (or not). One key lesson is that the size of the area protected is unlikely to be a primary determinant of success in fresh water because of its intimate association with land (watershed), suggesting we need to manage zones that include land (i.e. not just areas of water). Overall, the protected area/ zone concept appears to offer strong, new promise to preserving our fisheries for the next generation in the face of new and growing challenge.

Concurrent Sessions 1 (Room: Conference)

Status and Potential of Mountain Sucker in the Black Hills

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The Mountain Sucker is a widely distributed Catostomid in the intermontane west of North America, typically inhabiting cold, headwater streams. The Black Hills of South Dakota represent a regionally unique ecosystem, functioning as an island of cold-water streams in the short to mid-grass prairie. Though abundant across its range, the disjunct Black Hills populations have greatly declined since the 1960s. Surveys were conducted 2014-2018 to assess the current distribution and abundance of Mountain Sucker. Species distribution modeling using GLMs were built for Black Hill's streams utilizing local habitat covariates. NorWeST stream temperature predictions were used to assess the potential impacts of climate change on Mountain Sucker distributions. Periphyton coverage (∑WAICc = 0.04), canopy coverage (∑WAICc =0.04), stream slope (∑WAICc = 0.99), and Brown Trout abundance (∑WAICc = 0.99) interacted in complex ways to drive model fit. Reflecting foraging and risk avoidance, in conjunction with swimming ability and predatory displacement. Model occurrence probabilities were compared to current observed distribution to identify potential suitable Mountain Sucker habitats. Understanding local habitat requirements and future stream scenarios will allow managers to target restoration efforts towards areas with increased likelihoods of success.

Use of Radio Telemetry to Determine Movements and Mortality Sources of Brown Trout in Rapid Creek, Black Hills, SD

Austin G. Galinat, Steven R. Chipps, Jonathan A. Jenks

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In the early 2000's, annual population surveys indicated that abundance of adult brown trout (*Salmo trutta*; >200 mm) in Rapid Creek, South Dakota had declined by approximately 70% and currently, the factors influencing survival are poorly understood. Recent studies show that growth and condition of brown trout in Rapid Creek are high compared to other Black Hills populations and diet analysis shows that food availability is an unlikely source of mortality. However, a recent study discovered that predation by American mink (Mustela vison) accounted for 32% of brown trout mortality in Rapid Creek. Limited refuge habitat combined with high water clarity in Rapid Creek may enhance capture and foraging success by mink on adult trout. Additionally, the lack of stationary ice cover in tail water reaches, like that of our study area, has been linked to increased predation on trout by predators such as mink. Three experimental sites along Rapid Creek have been selected: (1) in-stream habitat improvement, (2) mink removal, and (3) a control. Eight brown trout from each section were surgically implanted with radio transmitters and tracked for six months. Mortality has been observed at all study sites. 50% of fish in the habitat improvement site (n=4) and 25% of fish in the control site (n=2) were lost to mink predation. 25% of fish in the mink removal site (n=2) were lost to apparent avian predation. An additional six month fish tracking period is currently underway. Survival estimates will be assessed between the three fish populations using mark-recapture survey techniques. Additionally, mink are being captured, implanted with radio transmitters, and tracked to determine movement and home ranges. Data gathered in this study will provide insight into the effectiveness of management techniques such as instream habitat improvements and predator block management on trout populations.

Identifying Rainbow Smelt Spawning Sites in a Missouri River Reservoir

Nicholas B. Kludt, Mark J. Fincel, Brian D.S. Graeb

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Rainbow Smelt *Osmerus mordax* are the primary coldwater forage species in Lake Oahe, South Dakota, yet most aspects of their life history remain mysterious. As Missouri River reservoirs present a novel habitat relative to elsewhere in the range of Rainbow Smelt, we investigated their spawning site use relative to physical and thermal habitat from spring 2016 - 2018. To maximize spatial coverage, we employed a revolving door design whereby 7 reservoir regions were visited for 2 of 3 study years, with 3 survey periods per year and 4-6 transects per region. We used a mobile 420kHz horizontal-beaming hydroacoustic survey paired with fine-mesh gill nets for acoustic target identification and classification. Acoustic signals were tracked in Sonar5 Pro (Lindem Data Acquisition 2015), with target strength/length conversion using the Love (1977) equation with Osmerus and Coregonus mixed stock coefficients (Lindem & Sandlund 1984). Rainbow Smelt observed mean length in nets differed from a subsample of hydroacoustic predicted mean lengths (ANOVA, $\alpha = 0.05$), although average difference of the means was 5.9 mm. Peak Rainbow Smelt spawning aggregations were observed at $6.8 \pm 1.7^{\circ}C$ (Mean ± StDev). We used a PCA to condense our physical habitat metrics, with PC1 representing 77% of cumulative variance. Peak abundance was linked to this physical habitat gradient, representing [steep slope, deep, soft bottom] to [low slope, shallow, hard bottom]. An information-theoretic regression analysis revealed an interactive effect of temperature and habitat, whereby shallower, warmer sites typically had a lower peak abundance. While challenges associated with horizontal hydroacoustic surveys remain, these results represent the first step toward understanding characteristics of spawning Rainbow Smelt in reservoir systems.

An Understudied Invader: Diet and Growth Rates of the Tubenose Goby

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Invasive fish species have caused numerous detrimental effects in the Great Lakes region, but basic life history knowledge of a species is necessary to accurately determine if a species is truly "invasive". One species, the tubenose goby (*Proterorhinus semilunaris*), is thought to have arrived in the Great Lakes via ballast water in trans-oceanic ships. This species has been poorly studied within North America, making it difficult to predict its effects on native ecosystems. This study seeks to inform on the potential of the tubenose goby as an effective invasive species within the context of the Great Lakes. Growth rates and seasonal diet patterns were examined from a population within the St. Louis River Estuary near Duluth, Minnesota, a tributary to Lake Superior. Growth rates and dietary breadth have ramifications for survival, competitiveness, and dispersal ability of fish species, influencing its potential success as an invasive species. Gobies were sampled from shallow vegetated habitat via a seine net during summer and fall periods. I removed otoliths and aged fish on daily and annual increments for growth modelling; furthermore, stomach contents were identified and weighed to provide measures of fitness and dietary breadth between seasons (fall vs. summer) and between several locations within the estuary. Results suggest a relatively low dietary breadth that is heavily dependent on Crustacea, regardless of location or season. Growth analysis indicates that tubenose gobies may be fast-growing and short-lived, indicating an r-selected life history.

Concurrent Session 1 (Room: Executive)

Implications of Fish Movement in an Internationally Managed System

Henry Hansen

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The largescale movements and spatial behavior of channel catfish in the Red River of the North, have direct interactions with geopolitics, anthropogenic structures, and ecosystems. Investigating the spatial dynamics and exploitation of this mobile and internationally managed fish species provides opportunities for resource managers to design evidence-based policy for the diverse interest groups that utilize the fishery. The research comprised of two parts: 1) characterize system-wide movement and survival patterns using mark-recapture methods and acoustic telemetry and 2) project the interaction of hypothetical exploitation scenarios and alternative movement methodologies. Channel catfish were tagged with T-bar tags and acoustic transmitters to track movement patterns and quantify harvest. Approximately 40% of individuals tagged with acoustic transmitters moved into Lake Winnipeg at least once during the study. Conversely, about 30% of T-bar tag recaptures in the U.S.A. had been initially marked in Canada. A large proportion (0.89-0.97) of the individuals remained within the initial study reach where they were tagged. Fishing mortality was estimated to be less than 0.001, and natural mortality was estimated to be 0.16 across the entire system. Projection models demonstrated that trophy stages of channel catfish were highly sensitive to exploitation and were typically depleted at or below a 0.30 exploitation rate. Depletion of populations and changes in stock structure affected subregions within the Red River system differently which resulted in competing strategies among countries and fishers from the perspective of economic valuation of harvests. We found that recruitment from areas with greatest population size appeared to buffer aspects of harvest within regions and to some extent immediately adjacent regions. Movement, regardless of methodology, was critical in supporting exploitation for regions with low recruitment.

Effect of Temperature on Growth, Energy Reserves, Settling Time, and Mortality of Endogenous Pallid Sturgeon Scaphirhynchus albus Larvae

Joseph T. Mrnak, Steven R. Chipps, and Daniel A. James

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Affiliation: South Dakota State University

Pallid Sturgeon *Scaphirhynchus albus* are a federally endangered species endemic to the Missouri River basin and the lower Mississippi River. Successful natural reproduction has been limited for decades and in addition, a recruitment bottleneck is hypothesized to occur during the endogenous-drift phase of development. Understanding factors that affect survival of Pallid Sturgeon larvae is key given their critical status and ongoing recovery efforts. In this study, we evaluated the effects of water temperature on growth, energy reserves, settling time, and mortality of endogenous Pallid Sturgeon larvae (<25 mm TL). We tested three water temperature treatments at a velocity of 9 cm s−1; treatments included low temperature (18.7 °C), medium temperature (20.4 °C), and high temperature (23.3 °C). The high temperature treatment exhibited significantly greater growth rates (1.05 mm d−1) than the low temperature treatment (1.03 mm d−1). Energy reserves of Pallid Sturgeon larvae maintained in the high temperature treatment declined significantly compared to larvae in the medium and low temperature treatments. Moreover, larvae in the high temperature treatment settled on the bottom significantly faster and experienced significantly greater mortality than those in the medium and low temperature treatments. Given the lack of connectivity and flow regime in the Missouri River, the manipulation of dam release temperatures may act as a potential restoration action by shortening the needed riverine drift distance for endogenous Pallid Sturgeon larvae.

Seasonal and Diel Vertical Movement of Paddlefish in the Upper Mississippi River Basin

John Hoxmeier, Joel Stiras

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Diel and seasonal movement of paddlefish has typically been measured in terms of horizontal movements in rivers and reservoirs. Depths at which paddlefish inhabited was often inferred from the location of the paddlefish and the maximum depth available. However, paddlefish are often found at the water surface and may not be following bottom contours of the river. We implanted ten paddlefish in the St. Croix River and Pool 3 of the Mississippi River with acoustic tags measuring depth and temperature. Data was collected from a passive array of acoustic receivers throughout the Mississippi, St. Croix, and Chippewa rivers. We analyzed over 235 thousand detections across the 3 river systems. Diel vertical movement was extensive from spring through fall. Diel vertical movement diminished during the winter, especially in areas of ice cover. Paddlefish occupied deeper water at the onset of winter and slowly moved up in the water column over winter. Reasons for overwinter patterns were unclear, but may be related to the unique physiological and morphological properties of the paddlefish.

Stable Isotope Patterns in Lake Food Webs Reflect Productivity Gradients

Kyle D. Zimmer, Ryan C. Grow, Angela R. Tipp, Brian R. Herwig, David F. Staples, James B. Cotner, Peter C. Jacobson

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Affiliation: University of St. Thomas

Stable isotopes 13C and 15N are used in lake ecosystems to assess energy sources and trophic positions, respectively. However, δ13C and δ15N are also influenced by internal biogeochemical processes in epilimnetic and hypolimnetic habitats in lakes, but it is unknown if differences in biogeochemical processing can affect interpretations of isotope data, or whether lake productivity influences isotope patterns. We sampled δ13C and δ15N in epilimnetic mussels, Chaoborus, Cisco (*Coregonus artedi*), seston, and zooplankton in both the epilimnion and hypolimnion of 22 Minnesota lakes ranging from oligotrophic to eutrophic. Isotope samples were baseline corrected using mussels in each lake (sample - mussel) to control for watershed-level differences in isotope values. Results showed δ13C in Cisco and Chaoborus were both positively related to hypolimnetic zooplankton δ13C, and zooplankton δ13C was positively related to hypolimnetic seston δ13C. Hypolimnetic seston δ13C was negatively related to compensation depth:mixed layer depth, such that seston was most depleted in lakes with deep light penetration. This pattern was likely due to hypolimnetic phytoplankton in clear lakes using respired CO2 depleted in δ13C. Results also showed a positive relationship between Cisco and Chaoborus δ15N and hypolimnetic zooplankton δ15N, which was positively related to hypolimnetic seston δ15N. Hypolimnetic seston δ15N was most enriched in low nutrient lakes with moderate O2 levels deep in the hypolimnion. The δ15N productivity gradient pattern is likely caused by denitrification and microbial degradation enriching hypolimnetic seston relative to epilimnetic seston in low nutrient lakes, while higher epilimnetic primary production enriches epilimnetic seston relative to hypolimnetic seston in high nutrient lakes. Our results indicate isotopic patterns between epilimnetic and hypolimnetic organisms change with lake productivity and should be accounted for in isotope studies of lake food webs.

Concurrent Session 2 (Room: Dakota)

Exploitation and Habitat Use of Lake Sharpe Walleyes

Tanner A. Davis, Mark J. Fincel, Brian D.S. Graeb

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The Lake Sharpe Walleye fishery is one of the most important in South Dakota. Understanding the interactions of regulations, angler harvest, population dynamics, and movement will aid in the management of the system. To that end, we implemented two concurrent tagging projects. In 2017, we started a mark recapture study using jaw tags with a high reward incentive for angler compliance to evaluate harvest and exploitation. We also implemented acoustic tagging in 2018 to evaluate Walleye movement. Preliminary angler returns of jaw tags revealed 14% exploitation in 2017 and 12% in 2018. Our first summer of acoustic tracking showed 58% of Walleye were detected between De Grey to Cedar Creek for a minimum of 1 day. This reservoir region has previously been identified as an ecological transition zone. Age-specific growth data parallels South Dakota's average until ages two and three. Von Bertalanffy growth curves revealed that once Lake Sharpe Walleye reach sexual maturity, growth rates decline and fall below the South Dakota's average. Projected Linf peaked at 546 mm in Lake Sharpe, compared to 582 mm statewide. Further analysis, using otolith aging, shows the population as a whole is generally old with a max sample age of 17. Future analysis will look at walleye movement associated with acceleration and pressure to obtain feeding periods and depths. Combined with the continued jaw tagging and age/growth analyses, we hope to provide a broad picture of Walleye population dynamics in Lake Sharpe.

Role of Angler Harvest on Walleye Population Dynamics in Three Western Reservoirs

Cade A. Lyon, Jacob L. Davis, Brian D.S. Graeb

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Angostura, Shadehill, and Belle Fourche reservoirs in South Dakota are popular sport fisheries, but the interaction of angler harvest and regulations remains unclear in these systems. A pilot Walleye tagging study began in 2018 to understand harvest and population dynamics. Jaw tags were attached at a rate of 500 per reservoir. In each, age-growth analyses were conducted for a subset of Walleyes. After the first season, Shadehill had the highest exploitation rate of 24.4%, followed by Angostura with 22.1%. Belle Fourche had the lowest exploitation rate at 11.7%. Of our aging subsample, 86% would have been within the 381-457 mm protected slot. Interestingly, 73% of aged female Walleye are within the slot. In Shadehill, 66% of aged Walleyes would have been under the minimum 381 mm length limit. Angostura age-3 Walleye accounted for 78% of the sample and had an average length of 411 millimeters. Concordantly, von Bertalanffy growth curves revealed the fastest growth in Angostura, followed by Belle Fourche, and Shadehill. Using data collected over the next two years, these analyses will be extended and impacts of regulations and angler harvest will be modeled using FAMS. Starting in 2019, seasonal hooking mortality will be assessed on Belle Fourche to determine the effects of temperature and depth on delayed mortality. These data will give us a better understanding of how regulations, angler harvest, and delayed mortality direct Walleye population dynamics.

Muskellunge (*Esox masquinongy*) Movement Patterns and Habitat use in the St. Louis River Estuary and Southwestern Lake Superior

Erin Schaeffer, Loren Miller, Jeramy Pinkerton, Paul Venturelli

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The St. Louis River Estuary (SLRE) is a designated Area of Concern by the Environmental Protection Agency due to severe environmental degradation. Uncertain is the spatial ecology of muskellunge (*Esox masquinongy*), an indicator species, in relation to both degraded and restored habitats. We collaborated with the Minnesota and Wisconsin Department of Natural Resources to collect genetic samples and used passive acoustic telemetry to track 60 Muskellunge in the SLRE and southwestern Lake Superior for 15 months. Genetic analysis revealed that the estuary is utilized by two genetic strains (Wisconsin and Minnesota) that were previously stocked to restore a likely extirpated population. Individual movement patterns were highly variable, but Muskellunge tended to move upstream in the spring, downstream and into Lake Superior throughout summer, and to the middle river during fall and winter. Males and females spent significantly more time in the upper and lower rivers, respectively. Movements were influenced by strain in that hybrids and WI strain spent more time in the upper and middle river, and the MN strain spent more time in Lake Superior. A Random Forest model indicated that Lake Superior use was related to strain (the MN strain made up 80% of the 25 individuals using Lake Superior), but not sex or body length. Lastly, a Negative Binomial Hurdle model determined that Muskellunge were detected in restored sites more often than in non-restored, poor quality sites ($P = 0.002$). A better understand of Muskellunge ecology in the SLRE will guide future management and restoration efforts of Muskellunge in the SLRE and other areas of the Great Lakes.

Tracing Habitat Utilization of Muskellunge (*Esox masquinongy*) in the St. Louis River and Lake Superior Using Stable Isotope Ratios

Graham Hanson, Jeramy Pinkerton, Erin Schaeffer, Keith Okeson, Loren Miller, Joel Hoffman

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Muskellunge (*Esox masquinongy*) are a migratory fish species that were stocked in the St. Louis River estuary (SLRE). However, Muskellunge migratory behavior within the SLRE and between the SLRE and Lake Superior is largely unknown, and abundance in the river system at any time influences its carrying capacity. Our goal was to use an intrinsic tag (carbon and nitrogen stable isotope ratios [SIR]) to determine diet contributions from different habitats in the SLRE and Lake Superior, and from this infer migratory behavior. We sampled fin tissue from a combination of angler- and survey-captured Muskellunge from 2015-2017 for carbon and nitrogen SIR. Fish were characterized by genetic strain (Minnesota vs. Wisconsin), size, and sex. Among the 350 fish sampled, we found a wide range of SIR values, corresponding to a diet based in the upper estuary, near Duluth-Superior, or in Lake Superior, as well as to diets based on a varying mixture of locations. Strain and size, but not sex, were significant factors influencing carbon SIR. That is, larger fish and Minnesota strain fish had SIR values corresponding to diets based on Lake Superior and adjacent habitat, while smaller fish and Wisconsin strain fish had SIR corresponding to diets based mostly within the SLRE. Carbon SIR distributions also indicate size-specific habitat utilization by Muskellunge within the SLRE. Angler-captured fish had a reduced SIR range compared to survey captured fish, indicating a sampling bias associated with summer angler behavior. We conclude that St. Louis River Muskellunge are feeding in Lake Superior waters but that the SLRE is their most commonly used feeding ground, and that both stocked strain and size influence habitat utilization.

Concurrent Session 2 (Room: Conference)

Food Habit Assessment of Several Predators After Recent Introductions of Gizzard Shad Into Small Impoundments

Vanderbush, B. L., M. Brown, M. R. Wuellner, G. F. Galinat, B. Miller, G. Simpson, D. Lucchesi and T. St. Sauver

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Gizzard Shad *Dorosoma cepedianum* have been stocked into several smaller impoundments across South Dakota to provide new prey resources; however, there have been no assessments of the impact of shad to predators in these systems. Thus, the objectives of this study were to: 1) document the relative contribution of age-0 Gizzard Shad to Black Crappie *Pomoxis nigromaculatus*, Largemouth Bass *Micropterus salmoides* and Walleye *Sanders vitreus* food habits in Bear Butte Lake, Curlew Lake, Lake Alvin, and Lake Marindahl; and 2) evaluate whether shad have influenced the growth of these predators in these lakes. Nighttime electrofishing was the primary method of fish collection and trap nets and gill nets were used to supplement catches. Food items were collected from each predator species each month from May through September using gastric lavage or necropsy. Food habits were summarized as percent composition by weight. Results from Bear Butte and Curlew lakes show that most predators consumed mainly Cladocera and a variety of other invertebrates in May and June and then switched to Gizzard Shad from July to September. In comparison, few predators in lakes Alvin and Marindahl consumed Gizzard Shad, which seemed to be in low abundance. Bioenergetic modeling scenarios were performed to examine relative contribution of Gizzard Shad to predator growth. Results from this study will provide information on the potential direct benefits that stocked Gizzard Shad may have on predator communities in small impoundments throughout the state.

Percent Occurrence of Historical Sample Size of Select Stream Fishes of North Dakota

Ellen Anderson, Casey Williams

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There are 20 species of fish listed as species of conservation concern in North Dakota. This study examines historical occurrence patterns of 10 stream fish species of conservation concern. Percent occurrence was calculated for each species and stream in which it was previously documented, and for each decade the stream was sampled. Three distinct occurrence patterns were observed. Specifically, species have experienced range extensions, what appears to be population declines, and steady populations. For most species, these general patterns vary within species based on drainage basin. Further monitoring efforts are suggested to track native fish species populations. In addition, a standard sampling protocol should be adopted to simplify future spatial and temporal comparisons.

Centenarian Longevity for Bigmouth Buffalo (*Ictiobus cyprinellus*): a Record for Freshwater Teleost Fishes

Alec R. Lackmann, Allen H. Andrews, Malcolm G. Butler, Ewelina S. Bielak-Lackmann, and Mark E. Clark

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Affiliation: North Dakota State University

The Bigmouth Buffalo (BMB; *Ictiobus cyprinellus*) is a freshwater fish endemic to the Mississippi and Hudson Bay drainages that belongs to the Catostomidae, an especially diverse family to North America (76 of 77 total species endemic). From Native Americans to inland commercial fishing, BMB have been a valued food-fish for centuries. Since 2010, BMB have also become a prized sportfish as night bowfishing has quickly emerged as a multi-million dollar industry in the USA. All forms of harvest are virtually unregulated and not studied, even though BMB were documented as declining in the 1900s. Understanding the age structure, reproductive maturity, and population dynamics of any harvested species is crucial for sustainability. Yet little is known about BMB life history. Using thin-sectioned otoliths, we estimated BMB to reach 112 years of age. This more than quadruples all previous estimates of maximum longevity for this species and makes BMB the oldest documented freshwater teleost (~12,000 species). Using bomb radiocarbon dating of both core and radial samples from individual otoliths, we thoroughly validated these age estimates making BMB the oldest age-validated freshwater fish. We also show that the age structure of numerous extant populations is heavily comprised of old individuals (i.e. 85-90% over 80 years (born prior to 1939), the remaining 10-15% between 35-45 years), suggesting long-term recruitment failure since construction of 1930s dams. Here we show that BMB, and other Catostomidae (55% of species already imperiled), require urgent attention so that a defensible management position for this predominantly unregulated fishery can be achieved. These results also reveal the clear inadequacy of other methods in common use for estimating fish ages, and highlight the broader consequences of ecological neglect that can result from lack of accurate life history data.

Feeding Habits of Smallmouth Bass in the Sheyenne River

Ethan Rasset, Casey Williams

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In the Sheyenne River, little diet information is available for smallmouth bass. This study answers the question, "What do smallmouth bass (*Micropterus dolomieu*) use as food sources in the Sheyenne River?" From May through October 2018, 291 smallmouth bass were collected by hook and line sampling and subjected to a gastric lavage. Stomach contents were preserved and examined. Primary food sources for smallmouth bass were divided into four categories: fish, crayfish, invertebrates, and "other" (consisting of plant material, mammals, etc.). Invertebrates were the most abundant stomach content (in terms of percent occurrence) followed by crayfish. Habitat differences played an impact on food sources; crayfish were consumed in higher densities in rubble or rock substrate. Seasonal changes in feeding habits were evident particularly relating to crayfish and fish. Early season bass had large proportions of fish in their diet while mid-summer bass stomach contents contained a high proportion of crayfish. A steep decline of crayfish abundance in stomachs occurred in October. Invertebrate consumption remained steady throughout the sampling period.

Concurrent Session 2 (Room: Executive)

Benthic Carbon Accumulation and Macroinvertebrate Colonization on Artificial Zebra Mussel Substrate

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Conflicting reports on zebra mussel (*Dreissena polymorpha*) roles of benthic carbon accumulation and macroinvertebrate colonization requires further investigation. Literature predicting how D. polymorpha may fundamentally alter benthic communities and carbon is rare. Lake Bemidji, an open mesotrophic system currently uncolonized by *D. polymorpha*, had 160 artificial *D. polymorpha* communities at zero, low (1.06 / cm²), medium (1.84 / cm²), and high (2.63 / cm²) densities placed onto suitable sites (n=10) for 4- and 8-month intervals. Carbon accumulation was measured using the ash free dry mass method on macroinvertebrate biomass and organic material. Preliminary results show a significantly positive response between overall carbon accumulation and artificial *D. polymorpha* densities (p-values = 0.02). Macroinvertebrate counts also had a significant increase between artificial treatments (p-value = 0.001). Amphipods, the dominant macroinvertebrate taxa, increased by 61% between control and artificial treatments. Zebra mussel engineering capabilities can lead to profound negative impacts on aquatic systems. However, this research suggests that macroinvertebrate communities are enhanced, providing beneficial resources to many other aquatic functions.

Light Could be Coupled with Sound to Create a More Species-Specific Behavioral Deterrent System for Invasive Carps

Clark Dennis; Peter Sorensen

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Affiliation: University of Minnesota

There is an urgent need to develop deterrent systems to impede the spread of silver carp (*Hypophthalmichthys molitrix*), bighead carp (*H. nobilis*) and common carp (*Cyprinus carpio*) throughout waterways in the Midwest. Previous work conducted by the Sorensen lab has shown that a coupled sound and air curtain deterrent system can block >98% of invasive carp passage in the laboratory. While promising, it is important that behavioral deterrent systems be as aversive as possible both because wild fish may be highly motivated (migratory drive, predatory escape) and sound could be masked in natural settings. Sound could be coupled with other deterrent technologies, such as high intensity lights, to improve barrier efficacy by targeting both the hearing and vision of these fishes. This laboratory experiment examined how/whether light could be combined with a sound deterrent to increase barrier efficacy. This was accomplished by exposing bighead carp, common carp and largemouth bass to two types of high intensity lights (5 Hz strobe, constantly on) on their own and then combined with an acoustic deterrent. Our results demonstrate that light alone can block 70% of all fish passages in a darkened laboratory flume, and that a strobe light and constant light were equally effective. When high intensity lights were tested in a well-lit background, we found that a constant light was more effective at blocking bighead carp than a 5 Hz strobe light. Interestingly, native largemouth bass passages were not impacted by high intensity lights when tested in well-lit conditions suggesting some species-specificity during the day. High intensity lights could be added to acoustic deterrents and might increase their efficacy, especially at night. Field tests of a coupled light and sound deterrent system are planned this spring. (Funded by the Minnesota Environmental and Natural Resources Trust Fund)

Spillway Gate Settings in Mississippi River Lock and Dams can be Used to Help Native Fish Upstream Passage

Anvar Gilmanov, Peter Sorensen

Presenter: Anvar Gilmanov, agilmano@umn.edu
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Although 29 locks and dams (LDs) in the Upper Mississippi River play an essential role regulating water depth to permit barge passage, they also disrupt fish passage, in part due to the high-water velocities created underneath the spillway gates. Recently, we discovered that these structures can be used to reduce invasive carp passage by altering spillway gate openings in ways that do not increase scour and damages of the LDs using a numerical Computational Fluid Dynamics Agent-Based (CFD-AB) model (Zielinski, et al., 2018). This scheme has since been implemented at the LDs 8, 5, and 4. The LD8 is located at the Minnesota-Iowa border and since there are seemingly very few Asian carps located to the north of this location, it now appears reasonable to set spillway gate openings at LD2, 4, and 5 to assist the native fish passage. To test this concept, we recently modified the CFD-AB model and verified its correctness using different gate settings at LD2 where fish passage has been monitored. Our simulations show that we can help native fish passage through the LDs as part of the overall integrated scheme to improve river fisheries. This research is funded by the Environment and Natural Resources Trust Fund in association with the Minnesota Aquatic Invasive Species Research Center.

Laboratory Tests of Sound Deterrents Show that While Sound can be Taxon-Specific and Effective for Carp Adding an Air Curtain May Stop Native Fish Too

Jane Feely, Peter Sorensen

Presenter: Jane Feely, feely033@umn.edu
Affiliation: University of Minnesota

Grass Carp and Bighead Carp threaten to spread into Upper Mississippi River watershed and disrupt the ecosystems within. One possible way to stop this invasion is to add sensory deterrents to locks. Sound is of special interest because some fish (carp) have especially sensitive hearing. Our laboratory research has already shown a proprietary sound signal combined with an air curtain can stop up to 98% of all carp without habituation. However, there is concern that these deterrents might block native fishes in the Upper Mississippi River. To test this possibility, this study used a darkened oval flume in which we introduced groups of one of four species of fish (Common Carp, Lake Sturgeon, Bluegill Sunfish, and Grass Carp) and monitored their behavior in response to a complex sound or sound and air combined. We were interested in the effects of the sound alone on native fishes and the effects of adding the air curtain, to see which was most effective in a taxon-specific manner. As expected, most Common Carp were deterred (80% deterred by sound alone, 95% deterred when paired with the air curtain). In contrast, we found that while only 63% of Bluegill Sunfish were deterred by sound, this number increased to 89% when the air curtain was added ($P<0.05$). Similarly, while sound deterred only 38% of Lake Sturgeon, when combined with the air curtain 86% were deterred ($P<0.05$). We conclude that sound has great promise to safely reduce carp passage with little effect on many other fishes, and adding air curtains might be best considered in areas where carp densities are very high and concerns about stopping them are higher. Grass carp preliminary tests are ongoing. (Funded by the Minnesota Environmental and Natural Resources Trust Fund).

Concurrent Session 3 (Room: Dakota)

The State of North Dakota's Stream Fish - Results of a Four Year Study

Casey Williams, Scott Gangl

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North Dakota's stream fish populations have been sampled sporadically since the 1950s. A state-wide survey was begun in 2015 to document the current occurrence of stream fish species. During the last four years, most drainages in North Dakota have been sampled except for the James River and portions of the Red River. So far, 264 sites have been sampled. A total of 104,000 fishes have been collected, including 54 species. Range extensions were documented for several species while some species were absent from areas of historical occurrence. "Significant" findings and general results will be discussed.

Stream Restoration or Habitat Improvement Project? What's the Difference?

Jeff Tillma

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Affiliation: Minnesota Department of Natural Resources

Fisheries biologists often use the two phrases "Stream restoration" and "Stream habitat improvement" interchangeably, yet the goals and objectives for each can be very different. Habitat improvement arose to identify limiting factors for producing desirable gamefish populations and to rectify perceived short-comings. Goals generally focus on increasing desirable habitat for adult fish, generally salmonids. Many methods and structures were tried over the years, constructed from local rock to dimensional lumber. These structures often attract adult fish and concentrate them for anglers to catch, making them popular, but it is unclear whether this has led to an increase in production. Stream restoration is an evolving science that considers both the physical and ecological functions of stream systems. Water and sediment transport, dimensions and stability of the stream channel, floodplain connectivity and the riparian plant community are all factors in a stream restoration project. A successful restoration can support a diversity of fish and invertebrate species and life stages important for a healthy ecosystem. The goals and objectives for restoration projects typically have much broader objectives than do traditional habitat improvement projects. At the same time, anglers are familiar with the habitat improvement approach, and can see the results immediately. Perceptions of stream restoration success is often more difficult to convey to the public due to the complexity of the systems and processes that the restoration is attempting to address. Both methods have their place, however it is important that professionals and stakeholders understand the differences of each approach and frame realistic outcomes for each project type.

Sand Hill River Fish Passage Restoration

Nathan Olson, Jamison Wendel

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Affiliation: Minnesota Department of Natural Resources

Four concrete dams were installed on the Sand Hill River in northwestern Minnesota as part of a flood control project conducted by the Army Corps of Engineers in the 1950s. During normal flows, these dams create a vertical drop of approximately five feet. Surveys conducted by DNR fisheries biologists have conclusively identified these four dams on Sand Hill River as barriers to fish passage. Eleven species of fish were found downstream of these dams, whereas only five species of fish were captured upstream of the dams. Specifically, many large river species such as Channel Catfish, Freshwater Drum, Goldeye, and Sauger that were present below the dams were not captured upstream of the dams. Surveys also showed mussel species are impacted by these barriers. One species of mussel (giant floater) is only found above the dams while five other species are only found below the dams, including the black sandshell, a species of special concern. Discussion will highlight the methodology and partners required to modify these dams and restore fish passage and habitat in the Sand Hill River.

Displacement of Brown Trout by Native Brook Trout in a Driftless Area Stream

John Hoxmeier, Doug Dieterman

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Affiliation: Minnesota Department of Natural Resources

Competition with invasive species, degraded habitat, and a warming climate have threatened brook trout populations throughout their native range in North America. In particular, brown trout have been shown to displace brook trout when the two are sympatric. We annually monitored population dynamics of brook trout and brown trout in a Minnesota stream from 1981 to 2017. Both species increased in abundance during the first 23 years of monitoring. During the most recent 14 years, brown trout abundance steadily decreased while brook trout continued to increase. Adult brook trout production increased from a low of 13.5 kg/ha/yr in 1983 to a high of 357.7 kg/ha/yr in 2013. Adult brown trout production increased from 40.1 kg/ha/yr in 1982 to a high of 256.9 kg/ha/yr in 2000 before decreasing to zero in 2011. Contrary to previous observations and predictions, brook trout displaced brown trout without direct fisheries management intervention. During this time period, both air temperatures and brown trout abundance increased in the region. However, brook trout may be outcompeting brown trout in this particular reach due to decreasing water temperature brought about by increasing base flow discharge. This study provides a rare example of a native species outcompeting an invader without direct management intervention.

Resistance and Resilience of Brown Trout Populations in Southeast Minnesota Streams

Doug Dieterman, John Hoxmeier, Jason Roloff

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Disturbance is an inherent aspect of ecology that is often manifest in stream systems by episodic hydrological extremes of floods and droughts. Several such extremes, mostly floods, have punctuated Driftless Area streams over time. Using a 25+ year long-term monitoring dataset covering 15 streams, we explored how resistant and resilient Brown Trout populations have been to small and large flood events in southeast Minnesota streams. In particular, we examined the recovery time needed for populations to rebound following these hydrologic disturbances and whether management actions, such as stocking or instream habitat improvement, influenced these recoveries.

Concurrent Session 3 (Room: Conference)

Minnesota River Paddlefish, Sturgeon, Backwaters, Plankton, and More: Outcomes of a 3-year ENRTF Funded Project

Anthony Sindt, Michael Vaske

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The Minnesota Department of Natural Resources received funds from the Environment and Natural Resources Trust Fund for a 3-year project to enhance understanding of the Minnesota River aquatic ecosystem. Project objectives include 1) accelerating collection of lower trophic data, 2) quantifying physical habitat characteristics, 3) inventorying backwater fish communities, and 4) evaluating population dynamics, movement, and habitat use of Paddlefish and Shovelnose Sturgeon. Outcomes of this project are strengthening understanding of the Minnesota River ecosystem while providing baseline information that will be used to quantify future changes resulting from land-use alteration, conservation efforts, climate change, and invasive species. For instance, fisheries assessments conducted in backwater habitats collected 51 fish species and helped determine that boat electrofishing and shoreline seining are the most efficient gears for evaluating fish species diversity. Extensive Paddlefish and Shovelnose Sturgeon surveys revealed greater abundances than previously perceived, while acoustic telemetry identified movement patterns varying from minimal movement by most Shovelnose Sturgeon (i.e., ≤ 15 km by 20 of 30 fish) to extensive (i.e., > 230 km) large-scale movements by tagged Paddlefish. Additionally, monthly evaluations of water chemistry, zooplankton, and phytoplankton along the Minnesota River revealed important spatial and temporal trends in potamoplankon communities which serve as the base of the aquatic food web. For example, crustacean zooplankton rather than rotifers dominate the zooplankton assemblage within upstream reaches of the river, likely drifting from upstream impoundments. Yet, when excluding upstream reaches from analyses, zooplankton assemblages vary more temporally than spatially which is likely influenced by temporal variability in river discharge. These and additional outcomes will help inform future management and monitoring efforts.

Impacts of Spiny Water Flea on the Zooplankton Community in Lake Mille Lacs, with Implications for Higher Trophic Levels

Heidi M. Rantala & Jodie K. Hirsch

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Aquatic invasive species have the ability to change freshwater food webs by altering habitat structure and/or consuming resources typically utilized by native species. Spiny water fleas (*Bythotrephes longimanus*) were established in Lake Mille Lacs in east-central Minnesota during the last decade. We examined native zooplankton community structure, abundance, and production in the lake since 2006. We estimated spiny water flea production and consumption of zooplankton since 2010, when they were first documented in the lake. Since spiny water flea establishment, zooplankton densities have decreased and the community has shifted to larger-bodied daphnids and copepods ($p<0.05$). Production of native zooplankton decreased by at least 50% by 2011 ($p<0.05$). Spiny water fleas consumed between 5-545% of small cladoceran secondary production each summer since that time, significantly reducing the availability of zooplankton as food for fish. This study illustrates the ability of spiny water fleas to consume more zooplankton than are produced during a summer, reducing standing stocks. Effects of spiny water fleas may be exacerbated by impacts from an established zebra mussel (*Dreissena polymorpha*) population in Lake Mille Lacs, through competition for food and consumption of immature zooplankton.

Unraveling the Relationships Between Nearshore Habitat and Fish

Donna Dustin

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The impacts of shoreline development on fish have been difficult to detect due to the overwhelming influence of water quality. But parallel advances in nearshore fish and habitat sampling, computer power, and statistical analysis have finally allowed us to detect subtle relationships between littoral conditions and fish. I used Minnesota data for fish index of biotic integrity (IBI), aquatic plant floristic quality index, areal coverage of floating and emergent vegetation, building footprints, and dock density along with water quality and lake morphometry variables to explore possible impacts of nearshore disturbance on fish. Using random forest models, the relationships between littoral habitat, shoreland development and fish begin to come into focus. Variables representing the aquatic plant community are the most strongly related to fish IBI scores in Minnesota lakes, while shoreland development variables have weaker, but still significant relationships to the fish IBI.

Food Web Effects of Zebra Mussels and Spiny Water Flea on Minnesota's Large Walleye Lakes

Gretchen Hansen, Tyler Ahrenstorff, Bethany Bethke, Valerie Brady, Josh Dumke, Will French, Jodie Hirsch, Katya Kovalenko, Ryan Maki, Heidi Rantala

Presenter: Gretchen Hansen, ghansen@umn.edu
Affiliation: University of Minnesota

Zebra mussels (*Dreissena polymorpha*) and spiny water flea (*Bythotrephes longimanus*) are non-native aquatic invasive species (AIS) in North America. In Minnesota, zebra mussels and spiny water flea have been documented in 969 and 59 systems, respectively, with additional detections each year. Both species reduce zooplankton biomass and alter phytoplankton and water clarity; however, how these impacts are transmitted to higher levels of the food web is not well understood. The goal of this study was to quantify the food web effects of these AIS in Minnesota's large walleye lakes. Specifically, we compared comparing trophic position and resource use of young of the year and adult sport fish across lakes at various stages of invasion by zebra mussel and spiny water flea. We measured stable isotope signatures of fish and invertebrates in nine of Minnesota's largest lakes in 2017 and 2018, with a special emphasis on Walleye (*Sander vitreus*) and Yellow Perch (*Perca flavescens*). At the time of sampling, two lakes were uninvaded, two were invaded by zebra mussels, four invaded by spiny waterflea, and one was invaded by both species. We found substantial variation in the percent contribution of littoral resources to Yellow Perch and Walleye across lakes. Young of the year Walleye and Yellow Perch in lakes invaded by spiny water flea relied more heavily on pelagic resources, raising questions about the consequences of reductions in pelagic zooplankton biomass in these lakes. Niche width was also variable among lakes, suggesting differences in the capacity of fish to access a diversity of prey resources which may increase their resilience to food web alterations. Further research will explore whether these results are consistent in an expanded suite of lakes, as well as exploring whether changes in food habits have consequences for sport fish growth and recruitment.

Walleye and Yellow Perch First Year Growth Changes with Zebra Mussel and Spiny Water Flea Invasion in Minnesota's Large Lakes

Gretchen Hansen, Tyler Ahrenstorff, Bethany Bethke, Josh Dumke, Jodie Hirsch, Katya Kovalenko, Ryan Maki, Heidi Rantala, and Tyler Wagner

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Zebra mussels and spiny water fleas have a myriad of impacts on lower trophic levels, such as zooplankton, which are an important food source for age-0 walleye and yellow perch. We used historical summer seining data (1983-2018) from Minnesota's large lakes (N=9 lakes) to evaluate changes in first year growth, corrected for water temperature, of walleye (N=50,012 individual lengths) and yellow perch (N=176,983 individual lengths) in lakes invaded by zebra mussels, spiny water fleas, both, or are uninvaded. By the end of the growing season, compared to age-0 walleye in uninvaded lakes, age-0 walleye were on average 18 mm (14%) smaller in lakes containing zebra mussels, 15 mm (12%) smaller in lakes containing spiny water flea, and 32 mm (25%) smaller in lakes containing both invasive species. On the other hand, by the end of the growing season no significant differences in age-0 yellow perch lengths were detectable for zebra mussel lakes (3 mm or 5% smaller), spiny water flea lakes (1.5 mm or 3% larger), or lakes containing both (4 mm or 6% smaller) compared to uninvaded lakes. Differences between species may be related to life history characteristics, within and between lake variability, or several other factors. Future work will explore how changes in growth of walleye influence recruitment and survival.

Concurrent Session 3 (Room: Executive)

Evaluation of Portable Water Filtration Systems to Reduce the Transport Risk of Zebra Mussels and Asian Clams During Fish Spawning and Trap and Transfer Operations

Benjamin J. Schall

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Invasive species represent a substantial threat to aquatic systems, and aquaculture operations provide a vector for their transportation between waters. Moving large volumes of water during fish spawning or trap and transfer operations increases the risk of transporting invasive bivalve larvae, particularly from sources experiencing non-detection error. This study evaluated the effectiveness of two portable filter systems at reducing or eliminating zebra mussel *Dreissena polymorpha* and Asian clam *Corbicula fluminea* veligers from an infested water source. A small setup was assessed at intervals to 1,420 L using combinations of 20 and 5 µm filters arranged in tandem, while a large setup was tested at intervals to 7,041 L with combinations of 30 and 5 µm tandem filters operating at two pressure ranges. Zero veligers were observed in 36 small setup filtered water samples. Four zebra mussel and zero Asian clam veligers were observed in 60 large setup samples. Total zebra mussel and Asian clam counts from 31 unfiltered, control samples were 27,846 and 1,095, respectively. Overall, both filter systems were highly effective at removing zebra mussel and Asian clam veligers and represent simple, cost-effective safeguards against non-detection error of aquatic invasive species in uninfested waters used for aquaculture practices.

Assessment of Short-Term Mortality of Wild Caught Female Walleye Broodstock

Brian G. Blackwell, Mark J. Ermer, Todd M. Kaufman, Tyrel S. Moos, Steven J. Kennedy, and Ryan J. Braun

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Collection of Walleye *Sander vitreus* eggs to meet stocking needs is an essential part of Walleye management for many state and provincial agencies. The stress of capture, holding and gamete stripping from wild broodstock can potentially lead to Walleye mortality. In waters <1,200 hectares, high levels of mortality could alter population size structure impacting angler success, future egg collections and survival of stocked Walleyes. We quantified short-term (i.e., 5 day) mortality of female Walleyes during artificial spawning operations during 2015 to 2017 in four eastern South Dakota natural lakes (2015 Swan Lake, 2016 Long Lake, 2017 Antelope Lake and Reid Lake). Each year 25 female Walleyes were stripped of their eggs and 25 female Walleyes were included as reference fish. No Walleyes died in 2015, four fish that were stripped of eggs at Long Lake died in 2016 and one stripped of eggs at Reid Lake died in 2017. Overall short-term mortality was minimal during the study at 6.8% (5 of 73 fish). No reference fish expired during the 3 years. Contusions were apparent on ovaries of both egg stripped and reference fish. We believe that if fisheries personnel follow standard Walleye artificial spawning procedures the amount of mortality will be low and should not impact populations of mature female Walleyes.

Environmental Enrichment and an Exercise Routine Improves Rainbow Trout Rearing Performance

Jill M. Voorhees, Nathan Huysman, Eric Krebs, and Michael E. Barnes

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Both environmental enrichment and exercise positively impact hatchery fish. However, continual, long-term, exercise may not be beneficial. This 109-day study examined the use of vertically-suspended structure (an array of four aluminum angles) and an exercise routine (intermittent exercise with one week at a low velocity and the next week at a high velocity) on the rearing performance of juvenile Rainbow Trout (*Oncorhynchus mykiss*) (initial size; 3.6 ± 0.2 g; 69 ± 1 mm; mean ± SE). Unprecedented results were observed in fish reared using both environmental enrichment and exercise routine, as illustrated by their total tank gain (mean ± SE; kg) of 127.2 ± 2.8. In comparison, fish reared without environmental enrichment, but with exercise had a gain of 105.0 ± 4.4, fish reared with environmental enrichment and no exercise had a gain of 100.5 ± 6.0, and fish reared without environmental enrichment and no exercise had a gain of 96.0 ± 6.0. Rearing performance was significantly improved with either environmental enrichment or exercise, but there was no significant interaction between the treatments. Combining vertically-suspended structure, and an intermittent exercise routine, is recommended during juvenile Rainbow Trout rearing.

Harmful Cyanobacteria Blooms at Lake Darling: Influence of Inorganic Nitrogen and Accumulation of Toxins in Fish Tissue

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Lake Darling is a large, hypereutrophic reservoir in northern North Dakota and is the centerpiece of the Upper Souris National Wildlife Refuge (NWR). The refuge covers greater than 32,000 acres, with the lake fed primarily by the Souris River. Frequent cyanobacteria blooms at the lake in conjunction with high public use and its importance as a migratory bird sanctuary spurred interest in a lake monitoring project. Four sites were sampled weekly throughout the growing season on Lake Darling in 2016 and 2017. These samples were analyzed for chlorophyll-a and nutrient concentrations, as well as readings recorded for Secchi disk transparency, temperature, and dissolved oxygen. Abraxis © test strips were used to analyze for presence of microcystin and anatoxin. The lake was highly nitrogen-limited with the ratio of total nitrogen to total phosphorus being less than 5:1 at all sites. These high lake-wide concentrations of total phosphorus with relatively low total nitrogen made Lake Darling highly susceptible to inputs of inorganic nitrogen. The effects of these inputs were most pronounced at the Inlet site where severe blooms were most prevalent based on chlorophyll-a concentration and frequency of high microcystin concentration. Accumulation of microcystin in fish livers did not vary with size. Microcystin was greatest in yellow perch livers with lower concentrations observed in black bullhead, northern pike, walleye, and white sucker. Results of this work will aid the state in its ongoing efforts to assess and mitigate the effects of harmful cyanobacteria blooms on its lakes and reservoirs.

A Multi-Stable Isotope Approach to Determine Mercury Sources to St. Louis River Fishes

Sarah Janssen, Joel Hoffman, Ryan Lepak, Bruce Monson, Greg Peterson, Graham Hanson, David Krabbenhoft

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Mercury (Hg) contamination in the Great Lakes region is a prevalent concern due to elevated Hg concentrations in fish in relation to human health and wildlife guidelines. The lower St. Louis River, the largest tributary to Lake Superior, exhibits fish Hg concentrations twice that of the open lake. Despite these highly elevated concentrations, it is difficult to infer the sources of Hg to these fish due to multiple potential Hg inputs (e.g. precipitation, legacy, or upstream runoff). The aim of this study was to utilize Hg stable isotopes along with carbon and nitrogen stable isotopes to elucidate Hg sources to the St Louis River food web including benthic invertebrates, prey and game fish. Invertebrates and prey fish (yellow perch and shiners) from the St Louis River exhibited Hg isotopic fingerprints similar to Hg-contaminated sediments ($\delta^{202}Hg$ = -0.6 to -0.4), indicating bioaccumulation of legacy Hg. Game fish (walleye and northern pike) displayed greater variability in isotope values, with some individuals exhibiting highly enriched signatures ($\delta^{202}Hg$ = 0.8 to 1.2) compared to prey species, likely due to precipitation. Relationships between $\delta^{202}Hg$ and $\delta^{13}C$ of walleye revealed that substantial variability was related to foraging in Lake Superior. This indicates that legacy Hg is the prevalent source to smaller fish species in the St Louis River, but larger species can be exposed to different Hg sources based on foraging habits.

Concurrent Session 4 (Room: Dakota)

Assessing Double-Crested Cormorant Impacts to Glacial Lake Percid Populations

Doug Schultz, Robin Debruyne, Randy Jackson, Dave Fielder

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Continued restoration of Double-Crested Cormorants to their native range has led to increased competition with anglers for recreational fishery resources. Whether these conflicts are real or perceived, fisheries managers are forced to evaluate the potential of cormorant impacts on fish populations and pursue prescriptive management when deemed appropriate. We will share three case studies where the available data sets include periods of cormorant expansion and active management and the associated responses in percid population metrics such as recruitment, growth rate, and maturity schedule. The commonality in observations from Leech Lake, Minnesota, Lake Oneida, New York and Les Cheneaux Islands on Lake Huron, Michigan can serve as a template for assessing cormorant impacts to fish populations.

Spatial and Temporal Variability in Post-Larval Yellow Perch Density

Steve Hauschildt

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Yellow Perch *Perca flavescens* are important as forage for other species and for sport fishing in many northern lakes. However, estimating post-larval Yellow Perch populations can be difficult because of many environmental factors that cause unexplained variation. The objective of this study was to help reduce unexplained variation by determining a post-larval Yellow Perch population density estimate on Blackduck Lake, MN, provide guidance to help determine the number of trawls required for trawling-based recruitment indices to achieve varying levels of precision, and test for the effects of wind speed and direction on post-larval Yellow Perch spatial variability. This study estimated a density of 0.45 fish/m3 (0.58 SD) during the sampling period (26 Jun – 07 Jul 2017). It was determined that between 10-15 trawls produced a precise density estimate; however, trawls should be taken over multiple days in varying wind speeds to avoid over/under estimation. Trawling should also be performed in-line with wind direction to ensure non-bias estimates are calculated from both upwind and downwind sectors. This study determined wind speed and direction had a significant influence on the distribution of post-larval Yellow Perch, as more fish were caught in the downwind sector until winds reached 15 kmph. Wind did not have a significant influence though on how post-larval Yellow Perch were distributed by total length. During high wind events, more fish were found in the upwind sector of the lake, suggesting that post-larval fish are being moved out of littoral areas. From the results of this study it appears Yellow Perch must continually relocate back into littoral areas after each high wind event moves them out of the littoral areas, until they are strong enough to resist the wind.

Comparison of Inter-annual Yellow Perch Catch Rates in Two Large Mesotrophic Minnesota Lakes.

Marc Bacigalupi, David Staples

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Yellow Perch are ecologically important, and of particular interest to fisheries managers as a critical forage species for Walleye. A new monofilament small mesh gill net was employed to successfully catch Yellow Perch at small sizes, Ages 0-III, in two large northcentral Minnesota lakes in September 2017 and 2018. Males and females reached 50% maturity at 75 mm and 100 mm, respectively, and exhibited sexually dimorphic growth by Age I. Very few males appeared to reach the size at which they would be vulnerable to standard Minnesota Department of Natural Resources lake survey gill nets (140 mm). These population characteristics were similar in both lakes and consistent across the two study years. Overall gill net catch per unit effort (CPUE) increased in both lakes from 2017 to 2018. Statistical power to detect CPUE changes between 2017 and 2018 was higher in Pelican Lake than in Gull due to a strong net site effect and lower net catch variability. Additional data on these lakes and others will inform the effectiveness of this sampling methodology for detecting Yellow Perch abundance changes; the ability to do so would have a number of applications in sport fishery management.

A Collaborative Approach for Evaluating Yellow Perch in Minnesota

Bethany Bethke, Beth Holbrook, and Marc Bacigalupi

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Recent Minnesota Department of Natural Resources (MN DNR) analyses of statewide standard gill-net data has found a declining trend in Yellow Perch catch rates during the past 40 years consistent across lake types and ecoregions in Minnesota. Yellow Perch become susceptible to standard MNDNR sampling gears at approximately 140 mm, yet recent pilot data has shown that some populations reach 50% sexual maturity as small as 75 mm in males and 100 mm in females. Because Yellow Perch may complete their entire life cycle in some lakes without recruiting to standard sampling gears, it is unknown whether declines in standard nets are reflective of an overall abundance decrease, increased mortality on certain size classes, or a shift in size structure causing changes in catchability, and how fisheries management actions might relate to the observed changes. To begin addressing these questions, 24 MN DNR Area Offices will be collaborating on a project to more comprehensively sample Yellow Perch and to evaluate growth and maturity metrics. During September 2019 and 2020, experimental methods including boat electrofishing and small-mesh gill nets will be used to sample fish as small as 50 mm in 30 lakes across the state varying in area (70-52,000 ha), maximum depth (2-49 m), Secchi depth (0.8-5.5 m), and standard net catch (0.1-167 fish/lift). Results from this project will enhance our understanding of Yellow Perch life history strategies, improve and potentially standardize monitoring protocols, and inform future research to evaluate factors such as predation, competition, and resource availability that may alter life history tradeoffs.

Smallmouth Bass Recruitment Dynamics in the Upper Mississippi River

Tanner Stevens, Brady Becker, and Steve Marod

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The upper Mississippi River offers world class Smallmouth Bass *Micropterus dolomieu* fishing. This is the result of fast growth, low mortality, and periodic large year classes. It has been hypothesized that drought years are more conducive to these large year classes. It is unknown however how changes in hydrology via climate change would affect Smallmouth Bass populations. The effects of climate and hydrology on recruitment variability and synchrony in Smallmouth Bass populations were examined in two reaches (Camp Ripley, St. Cloud) of the upper Mississippi River in central Minnesota from 2017-2018. Recruitment (variability, synchrony, and drivers) was quantified using residuals from catch curve analysis, and an information theoretic approach was applied to evaluate the relationship between recruitment, climate and reservoir hydrology. Patterns in recruitment variability [indexed via the recruitment variability index (RVI) and recruitment coefficient of determination (RCD)] and synchrony (as indexed from catch curve regression) were also examined. Recruitment of Smallmouth Bass was consistent in both reaches with few missing year classes (RVI range = 0.58-0.69), but large fluctuations in year-class strength were observed between reaches (RCD range = 0.18-0.65). Year-class strength was not correlated between reaches indicating asynchronous recruitment ($r = -0.31$; $p > 0.05$). In the Camp Ripley reach, stronger year classes were generally associated with lower July discharge. With July discharge correlated with stronger year classes in the Camp Ripley stretch, more common large rainfall events in July has the potential degrade the upper Mississippi River Smallmouth Bass fishery.

Concurrent Session 4 (Room: Conference)

Angling use and Kiosk Compliance at one Rural Reservoir in the Black Hills

Greg Simpson

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Collecting data can be expensive and time consuming aspect of fisheries science. Costs become even more highlighted sampled when the remoteness of waters make it difficult to obtain data. Efforts have been investigated in recent years to determine certain aspects of angler use information in these remote areas. Pressure has been identified through vehicle counters with verification by trail cameras. Angler interviews were investigated for compliance through the use of trail cameras during the summer of 2019. To obtain interviews, we used self-reporting kiosks where angling parties would fill out a simple form and deposit at the same location when finished fishing. Nearly 1,200 anglers were observed fishing at one small lake that were spread over 533 parties. Angler self-reports were fewer noting that only 374 anglers were fishing at the same lake. Compliance was thus set at 32% during this pilot phase. However, many anglers were noted fishing at a secondary entrance and most of these fishermen did not make the effort to visit the kiosk. Data between the camera-verified versus the angler reports added to anglers from this secondary site were not significantly different. Future efforts will be to expand the use of these kiosks in order to make them more available to anglers and hopefully collect more accurate information.

Evaluation of a 20-26" Walleye Protected Slot Limit on Leech Lake, MN

Carl Pedersen, Patrick Schmalz, Doug Schultz

Presenter: Carl Pedersen, carl.pedersen@state.mn.us
Affiliation: Minnesota Department of Natural Resources

Leech Lake is the third largest lake within Minnesota state boundaries and is renowned among anglers as an exceptional multi-species fishery; however, most anglers target Walleye. Declines in Walleye abundance during the early 2000s prompted the implementation of an 18-26" Walleye protected slot limit (PSL), 4 fish possession limit in 2005 to protect and increase spawner stock biomass. Management objectives were exceeded and the regulation was relaxed to a 20-26" PSL in 2014. Despite more liberal harvest regulations spawner stock biomass continued to increase and the regulation was again relaxed for the 2019 fishing season. We will provide data and modeling efforts used to compare varying regulation options and the associated public input process for regulation change.

Status of Lake Sturgeon Restoration Efforts in the Red River Basin

Jamison Wendel

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Affiliation: Minnesota Department of Natural Resources

Overharvest, construction of dams, and poor water quality in the early 1900s decimated Lake Sturgeon populations in the Red River basin. By the mid 1900's, the population was considered extirpated. With improving water quality, protections from harvest, and progress made to remove barriers, efforts to restore Lake Sturgeon populations were initiated in the 1990's. In 1997, the first juvenile Lake Sturgeon were transplanted from Rainy River to Detroit Lake and Otter Tail River. In 2002, a 20 year restoration plan for Lake Sturgeon was developed with a goal of re-establishing self-sustaining populations. With this plan, reintroduction efforts switched to fry and fingerling production for stocking on a wider scale. Multiple federal, state, provincial, and tribal partners have contributed to Lake Sturgeon restoration efforts. After over 20 years of restoration efforts, populations are showing many positive signs of recovery.

Public Input in a Post-Public Meeting World: A Border Water Case Study

Nick Schlesser, Kevin Stauffer

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Affiliation: Minnesota Department of Natural Resources

As part of an effort to review all bag and size limit regulations on the Mississippi River portion of the Minnesota/Wisconsin border waters a number of different methods were used. The pros and cons of several methods will be discussed, as well as thoughts on the future of public meetings when social media and virality trump meeting attendance and newspaper readership. (This talk is a companion to the poster "Results of a Review of Bag and Size Limits for the Mississippi River Portion of the Minnesota/Wisconsin Border Waters" which will show the results and trends associated with the border water regulation review.)

Concurrent Session 4 (Room: Executive)

Multiple Methods to Define the Oxythermal Niche of Adult Cisco

Andrew Carlson and Derek Bahr

Presenter: Andrew Carlson, andrew.carlson@state.mn.us
Affiliation: Minnesota Department of Natural Resources

Cisco are one of the mostly widely distributed lake-dwelling coldwater species in the Midwest. They are found in a variety of systems with differing in-lake habitat conditions that are shaped by lake morphometry, productivity, and climate. Throughout their range, Cisco can exhibit local phenotypic adaptions that largely result from tradeoffs between habitat preference, available habitat, and local selective forces. To assess the variation in lakes and Cisco populations, we compared depth distributions of Cisco captured in vertical gill nets to associated temperature and oxygen profiles from 57 Minnesota lakes. To complement this data and explore the seasonal component to habitat selection, we analyzed data from acoustically tagged Cisco in two lakes. Depths from tagged individuals were associated with the temperatures and oxygen levels (oxythermal habitat) at those locations and compared to the available, seasonally changing habitat using Resource Selection Functions. Results from both methods were contrasted with previously derived species oxythermal thresholds, which have been generally defined as waters with dissolved oxygen >3mg/L and temperatures <20°C with a preferendum around 12°C. Oxythermal habitat commonly utilized by Cisco sampled with vertical gill nets and selected by acoustically tagged individuals confirmed these general thresholds but also suggested that while many populations reside in the previously defined range, the preferendum may be slightly cooler (~7°C) when adequate oxygen concentrations are available. Variation in available oxythermal habitat between lakes further confirmed that Cisco are able to utilize multiple cold and cool-water habitat types, either contributing to or the result of local phenotypic adaptations exhibited by the species.

Stressor Induced Changes to Zooplankton with Discussion of Early Life History Implications

Casey Schoenebeck, Jodie Hirsch, Will French, Tim Martin

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

Stressors such as climate change, eutrophication, and aquatic invasive species can manifest themselves at multiple trophic levels. The Sentinel Lakes Long-Term Monitoring Program samples key indicators and species on 25 Minnesota lakes to detect these changes and better understand the mechanisms driving the change. Since 2008, zooplankton have been intensively monitored and more recently, several juvenile sportfish species like Largemouth Bass, Bluegill, Yellow Perch, and Rock Bass have been monitored; including the zooplanktivorous life stage. In the process of monitoring we have documented several examples of how stressors have impacted zooplankton. For example, we have found that zebra mussels decrease zooplankton abundance while spiny water fleas can change the zooplankton community composition. Changes in zooplankton may have important implications on the food habits of zooplanktivorous fish including the early life history of sportfish. Subsequently, this could be formative for developing cohorts and growth rates. This talk will explore the role selective and opportunistic feeding behaviors of zooplanktivorous sportfish play in exposure to stressor-induced changes in zooplankton.

Sampling Juvenile Fish with Boat Electrofishing as Part of a Long Term Monitoring Program

Will French, Casey Schoenebeck, Tim Martin

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

Overwinter survival of juvenile fishes can be an important driver of fish recruitment, potentially influencing year class strength and fish community composition in northern temperate lakes. Positive relationships between length of juvenile fish and overwinter survival exist for many species, suggesting that growth and mean autumn total length of juvenile fish may be useful in predicting year class strength and tracking long term changes in fish communities. An annual sampling regime targeting juvenile Bluegill, Largemouth Bass, Yellow Perch, and Rock Bass was begun in 2017 as part of Minnesota's Sentinel Lakes Long Term Monitoring Program. Boat electrofishing was conducted in late autumn and early spring to estimate size structure, age structure, and overwinter survival of juvenile fish in four central Minnesota lakes. Catches and size structure were variable between lakes and years, and some evidence for size selective winter mortality was found for all species. This talk will give an overview of sampling to date, discuss challenges identified during the process, and potential course of action moving forward.

Sentinel Lakes Data Tools

Tim Martin

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Affiliation: Minnesota Department of Natural Resources

Minnesota's Sentinel Lakes Long-Term Monitoring Program is responsible for collecting and maintaining high resolution ecological data over long time periods. As such there is a large amount of data that needs to be processed, analyzed, and distributed. In our quest to make these tasks as efficient and accurate as possible we are using web app platforms to provide intuitive user interfaces to data tools, facilitate data exploration through responsive interaction, and apply standardized processing techniques. We have used these technologies for displaying water temperature data and analyzing and displaying various related metrics such as thermal stratification and layers; plotting and modelling various trends occurring on the individual lake, ecoregion, and all Sentinel Lakes levels; processing and QCing water temperature and dissolved oxygen logger data; and providing access to Sentinel Lakes datasets. This presentation will demonstrate these web apps and further discuss how they have been useful to the Sentinel Lakes Program.

Poster Session

Age-0 Walleye Growth Rates Following Spiny Water Flea Bythotrephes longimanus Invasion

Joseph W Amundson

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Affiliation: Bemidji State University

Within Voyageurs National Park, spiny water flea *Bythotrephes longimanus* has reduced Lake Kabetogama and Rainy Lake native zooplankton biomass during summer peak by 40-60%. Subsequently, planktivorous age-0 Yellow Perch *Perca flavescens* growth has decreased. A possible trophic cascade may influence predatory fish growth rates like that of age-0 Walleye *Sander vitreus*. Using seine net and electrofishing data, age-0 Walleye growth rates were modeled as a linear function of growing degree days (GDD) and the slope was compared between pre- and post-spiny water flea establishment. Nearby Lake Vermilion, assumed to have been unaffected by spiny water flea until 2015 and found to have no changes in Yellow Perch growth, was used as a reference for natural variation in age-0 Walleye growth in the region. At 1050 GDD, the two infected lakes showed either no change (Lake Kabetogama) or a decline in mean growth rate (Rainy Lake) of 5% related to GDD, whereas the uninfected lake (Lake Vermilion) showed an increase in mean growth rate of 9% during the same time period. The effects spiny water fleas have on age-0 Walleye growth varied from lake to lake and its broader implications are not completely clear. A lakes limnological characteristics and management plans for Walleye may contribute to changes in growth rates of age-0 Walleye just as much as the presence of spiny water flea. Further monitoring and analysis of now infested Lake Vermilion (this study's reference lake) may help determine the effects spiny water fleas have on age-0 Walleye growth.

Effects of Reduced Daily Limits on Bluegill and Black Crappie Size in Four Central Minnesota Lakes

Owen Baird

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Affiliation: Minnesota Department of Natural Resources

Bluegill and Black Crappie are common fish throughout most of Minnesota and are popular with recreational anglers. However, quality sized Bluegill and Black Crappie are often less abundant and the size of panfish caught by anglers is often less then desired. Angler harvest is believed to often be a major cause of small size structure of Black Crappie and particularly Bluegill populations. In an effort to maintain quality panfish angling opportunities, the Minnesota Department of Natural Resources reduced the sunfish and crappie limits to 5 fish of each species from the statewide regulation of 20 sunfish and 10 crappies on four lakes in the Brainerd area of central Minnesota. The reduced limit regulations started in 2005 and was assessed by spring trap net surveys at least every three years starting in 2005. Three control lakes were also assessed concurrently. The reduced limit lakes generally had larger Bluegill and Black Crappie than the control lakes as the treatment lakes were selected for their existing quality panfish populations. The reduced limit lakes have maintained the quality Bluegill and Black Crappie sizes found at the start of the reduced limit, with some lakes showing increased size structure. The 5-fish sunfish and crappie limits appear to be a useful regulation to at least maintain and possibly improve Bluegill and Black Crappie sizes in central Minnesota lakes.

Larval Rainbow Smelt Emergence and Growth Patterns in a Missouri River Reservoir

Brandt N. Boekhout, Nicholas B. Kludt, Rebecca A. Kludt, Mark J. Fincel, Brian D.S. Graeb

Presenter: Brandt Boekhout, brandt.boekhout@sdstate.edu
Affiliation: South Dakota State University

Rainbow Smelt *Osmerus mordax* are the primary coldwater forage species in Lake Oahe, South Dakota, yet most aspects of their life history remain mysterious. In conjunction with Rainbow Smelt spawning habitat investigations, we examined larval emergence and growth patterns. We conducted night time larval trawls during spring 2017-18 within 2 lake regions, with 3 survey periods per spring. Both regions had 5 sites, with 3 replicate 10-minute trawls per site visit. Captured Rainbow Smelt larva were sorted to 1mm length bins. A subset of 10 larva (where possible) per bin/year/region/period were measured and aged (n = 249). Aging consisted of 2 independent readers, each reader aging the otolith bi-directionally for quality assurance (edge to core & core to edge). Reader agreement was high (Pearson's r = 0.96), and an MSE test showed 69.5% random error, indicating no systemic bias between readers. Rainbow Smelt emergence lasted longer in 2018 (56 days) than 2017 (28 days), although 2017 frequency distributions indicate sampling may have captured only partial trends. An exponential growth equation ($L = ae^{Gt}$) was fit to mean length at age. For the 2018 data, ANCOVA (α=0.05) showed growth differed by lake region and survey period. Notably, the regional instantaneous growth rates were higher in the southern region ($G = 0.017$) than the north region ($G = 0.009$). This corresponds to significantly greater mean between-period warming of the southern zone (t-test, α=0.05). Larger body size following the first growing season typically results in better overwinter survival. Therefore, these spatial differences in growth could impact eventual contribution by zone to Lake Oahe Rainbow Smelt recruitment.

Increased Effort and Funding have Resulted in Increased Knowledge of Minnesota's Nongame Fishes

Lucas J. Borgstrom, Jacquelyn Bacigalupi

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Small-bodied nongame fish species oftentimes serve ecologically important roles in lakes and are generally rather sensitive to human-induced stress. As such, understanding their distributions, both historic and current, can facilitate a more thorough understanding of ecosystem health among other things. Historically, sampling protocols in Minnesota did not effectively capture many of these species; however, in 1997, the Minnesota DNR initiated implementation and utilization of a lake fish index of biological integrity (FIBI) sampling protocol. This protocol provided standardized sampling gear and a sampling scheme designed to capture at least 90% of the species within a given lake. These efforts were bolstered with increased funding after the passage of the Clean Water Land and Legacy Amendment in 2008. The extent of information available to characterize distributions of select small-bodied nongame fishes was investigated pre- and post-1997 utilizing Minnesota DNR Fisheries data. Knowledge of Minnesota's small-bodied nongame fish has greatly increased since the FIBI sampling protocol was implemented in 1997. Range distributions have expanded as a result of the increased sampling effort and a better understanding of the status of these small-bodied nongame fishes has occurred. Most of the range expansions have been coupled with voucher collections that represent confirmable collections of these species, which will be invaluable when discussing the ecological shifts of lake fish communities in the future.

Relationships Between Walleye Feeding Behavior and Relative Weight in Two of Minnesota's Large Lakes

Nicolas Brown, Tyler Ahrenstorff, Bethany Bethke, Gretchen Hansen, and Joshua Raabe

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Walleye *Sander vitreus* is an important gamefish and top-level predator in many aquatic systems in the Midwestern United States. Walleye body condition can indicate individual health and availability of food resources, and stable isotopes (i.e., δ13C, δ15N) provide information on feeding habits. Therefore, our objectives were to determine if relationships existed between Walleye relative weight (i.e., body condition), length, and δ13C and trophic position (based on δ15N) and if potential relationship were similar between Mille Lacs and Upper Red Lake, two of Minnesota's large lakes. Walleye were sampled by experimental gill nets in fall 2017, tissue samples were analyzed for stable isotopes, and relative weight was calculated for each fish. Linear regressions and ANCOVA were used to evaluate potential relationships. Walleye relative weight did not have a significant relationship with δ13C or trophic position in either lake, indicating relative weight was similar regardless of littoral or pelagic diet and trophic position. However, there was a relationship between isotopic signatures and length for both Mille Lacs and Upper Red Lake. In Mille Lacs, larger Walleye had a more pelagic diet whereas in Upper Red Lake, larger Walleye had a more littoral diet. These differing relationships with size between lakes is likely due to physical and biological differences between Mille Lacs and Upper Red such as percent littoral area, depth, and species composition. Collecting data over multiple seasons and years may offer further insight into these relationships and if they vary temporally.

The Effects of Wetland Connectivity and Fish Presence on Amphipod Density in Western Minnesota

Jake Carleen, Danelle Larson, Carl Isaacson, Jeff Ueland

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Affiliation: Bemidji State University

Amphipods (referred to as "scuds" or "freshwater shrimp") are key wetland biota in the Prairie Pothole Region. Amphipod populations are thought to have substantially declined coinciding with increased wetland hydroperiods and increased wetland connectivity from agriculture. Fish have benefited from the stable hydrologic regimes and increased paths for dispersal, and may predate on amphipods and/or alter habitat quality. We assessed over 100 wetlands in western Minnesota in spring 2018 to determine amphipod densities and fish presence. Amphipod densities ranged from 0 to 1477 individuals/m3 with high density wetlands clustered around Detroit Lakes, MN and Fergus Falls, MN. Isolated wetlands with high amphipod densities were found in the forests of Itasca State Park and in areas of high agricultural impact near Windom, MN. Using GIS, we analyzed distance to permanent streams or ditches (National Hydrography Dataset) and the nearest Type 4 or Type 5 wetland (National Wetlands Inventory) as a wetland connectivity measure. We found that wetlands within 100m of a stream or ditch had 81% lower median amphipod densities (Mann-Whitney U Test; n=82, U=426.5, p=0.0061). Distance to nearest Type 4 or Type 5 wetland or visual presence of fish had no significant effect on amphipod densities. In spring 2019 and 2020 we will visit over 100 wetlands using more robust methods to sample amphipods, fish, and habitat. Increased sample size and a stronger gradient of fish abundances and amphipod densities will allow us to further elucidate the effects of fish on amphipods.

Examining Black Bullhead (*Ameiurus melas)* Age and Growth in Shallow Minnesota Lakes

Michael S. Collins, Anna M. Mendes, Brian R. Herwig, Danelle M. Larson, Andrew W. Hafs

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The Black Bullhead (Ameiurus melas) is a widely distributed ictalurid fish species found throughout much of Minnesota, and are often highly abundant in southern MN lakes. This species is an opportunistic feeder that orients towards lake bottoms, feeding on a wide range of invertebrates and plant material. Highly abundant populations of Black Bullhead and other benthivorous fish contribute to increased turbidity and declining macrophyte production, thus reducing habitat quality for wetland-dependent wildlife. Literature is very limited on methodologies for ageing this species, as is information about population age structures and growth. The purpose of this study is to evaluate ageing methods for Black Bullhead by comparing lapilli otolith and pectoral spine structures. Additionally, this study seeks to determine if spine lengths measured on live fish are correlated to estimated age. If correlated, this might allow for simplified, non-lethal ageing estimates. Calcified ageing structures were collected from 320 individuals across six Minnesota lakes within two distinctly different regions: a northern region in the Chippewa National Forest and a southern agricultural region near the Iowa border. Using sectioned otolith and pectoral spines, ages were determined by two readers in a typical blind reading procedure. Preliminary results for otolith ageing indicated a reader agreement of 87%. To date, age-0 through age-6 fish have been observed in this study. Early data analysis shows variability in growth between regions. Age-3 fish from northern populations mean length-at-age was 211 mm as compared to 251 mm in southern lakes. Analysis of spine age is currently underway to present final reports of lowest coefficient of variation among ageing methods, and to compare growth trajectories and age structures among lakes.

Proposed VHS Free Zones

Sean Sisler, Ling Shen, Paula Phelps, and Shannon Fisher

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Viral hemorrhagic septicemia (VHS) virus is highly infectious and has caused large-scale fish kills in the Great Lakes Basin. The Minnesota Department of Natural Resources (MNDNR) has intensively screened fish for VHS from waterbodies with high boat traffic lakes, important fisheries, production ponds, and bait harvests since 2008. Fortunately, VHS has not been detected in fish from Minnesota waters outside of Lake Superior. With more than 10 years of VHS testing yielding no detection of VHS, and never having a documented case of VHS in a Minnesota waters, the MNDNR has been working with the United States Department of Agriculture to explore declaring portions of Minnesota as VHS Free Zones (VHSFZ). The MNDNR is still reviewing potential risks, but if VHSFZ are approved, intensive surveillance could be replaced with reduced monitoring and more focus on fish kill investigations.

Longnose Sucker Status in the Black Hills

Dalton Flahaven, Seth J. Fopma, Brian D.S. Graeb

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Affiliation: South Dakota State University

The Longnose Sucker is the most widely distributed Catostomid in North America, typically inhabiting cold, clearwater streams and lakes. The Black Hills of South Dakota represent a regionally unique ecosystem, functioning as an island of cold-water streams in the short to mid-grass prairie. Fish populations associated with this island habitat are often disjunct from conspecifics and are at a greater risk for extirpation. Longnose Sucker were once widely distributed across the Black Hills, with the majority of the population occurring in the Redwater and Crow Creek drainages. Surveys were conducted (2014-2018) to assess current distribution of Longnose Sucker. Of 430 surveys in that period, Longnose Sucker were observed at only 3 locations. Sampled Longnose Sucker were measured (TL), weighed (g), and PIT tagged prior to release. Age-at-capture was estimated using published age-length keys (Walton 1979) for unique individuals (n=30). Estimates ranged from 4-9 years old, with the majority of the current population composed of sexually mature individuals (≥ 5 years old). While our capture/encounter rates were low, the lack of juvenile suckers is consistent with other studies. A more robust understanding of juvenile ecology is needed to accurately assess this species. Understanding distribution and population trends will inform management and conservation efforts targeted towards this state-threatened species.

Evaluation of Age and Growth Rates of Smallmouth Bass, Pre and Post Construction of East End Devils Lake Outlet

Cooper Folmer, Casey Williams, Michael Johnson

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The east end outlet of Devils Lake began releasing water into the Sheyenne River in 2012. With the outflow of water from Devils Lake, comes an increase of nutrients into the Sheyenne River. An exceptional, yet underutilized, sport fishery for smallmouth bass (Micropterus dolomieu) exists in the Sheyenne River below Baldhill Dam, northwest of Valley City, ND. Over the last several years, size structure of smallmouth bass appears to have shifted towards quality/preferred size, as opposed to the memorable, and more so trophy fish that were previously abundant in the river. The purpose of this study is to determine if the inputs from the Devils Lake outlet influences the growth rate of smallmouth bass in their early years. A small sample size of eight fish was taken from the river and aged using sectioned otoliths. Age of smallmouth bass ranged from age 3 to age 11+. Back calculation of length at age was used to estimate and compare annual growth rate (age 0-3) for fish spawned before and after the Devils Lake releases into the Sheyenne River.

Rough Fish No More: Research and Management of Rare Hiodon and an Endangered Freshwater Mussel

Alex Franzen, Mark Hove, Bernard Sietman, Mike Davis, Dan Hornbach, and Alia Benedict

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Conservation of the federally endangered Spectaclecase mussel (*Margaritifera monodonta*) requires protection of its likely sole larval host fishes, Mooneye and Goldeye (Hiodon species). Unfortunately, anecdotal evidence suggests many Hiodon populations are declining and the common view of Hiodon through labeling them as rough fish does not reflect their importance in aquatic ecosystems. To improve Spectaclecase and Hiodon conservation we established the following research objectives: determine if fishes other than Hiodon are Spectaclecase hosts, study how and when Spectaclecase brood larvae and infest hosts, and develop host fish management recommendations. Approximately 62 fish species, 20% of co-occurring fishes, have ranges that overlap with the five remaining stable Spectaclecase populations in North America as determined by the USFWS. Of these, only two cyprinid species, Gravel Chub and Redfin Shiner, have not been tested for host suitability. However, trials on 15 other cyprinid genera strongly suggest minnows are not hosts leaving only Hiodon as the probable hosts for Spectaclecase. High water during 2018 limited our ability to video and work in the St. Croix River. We were able to show that Spectaclecase brood larvae during the expected period in June. Limited underwater video observations failed to show Hiodon-Spectaclecase interactions but revealed a possible commensal relationship with crayfish that warrants further research. A review of the literature on Hiodon biology suggests Hiodon have declined throughout their ranges, Mooneye are less tolerant of turbid water, and dams can prevent Hiodon migratory movements. Using natural history information we composed a draft Hiodon management plan and are soliciting suggestions for improvement. Results from this project will be shared with natural resource agencies and published to support conservation of these three species.

Dietary Niche Overlap Among Fish Species in Shallow Minnesota Lakes

Natalie G. Ganzel, Rachel M. Klaras, Kyle D. Zimmer, Brian R. Herwig, Danelle M. Larson, David F. Staples

Presenter: Natalie Ganzel, ganz3047@stthomas.edu
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We analyzed diets of nine dominant fish species in four shallow southern Minnesota lakes to understand diet patterns and niche overlap using bootstrapped estimates of MacArthur and Levins' measure of niche overlap. We examined 517 diet samples, focusing on Northern Pike, Yellow Perch, Black Bullhead, Fathead Minnow, Common Carp, Green Sunfish, and Golden Shiner, though not all species were found in all lakes. Fathead Minnow and Northern Pike had the least amount of niche overlap with other species due to uniquely high use of detritus in the former and high rates of piscivory in the latter. However, Golden Shiner and Common Carp overlapped considerably with Fathead Minnow in the lake where all three were found, indicating the potential for enhanced intraspecific competition when these three species coexist. Despite similar niche size across lakes, the relationship between Yellow Perch and Black Bullhead was the most variable across the four lakes. It ranged from nearly complete niche overlap when densities of both species were high, to virtually zero overlap when densities were low. Moreover, Black Bullhead exhibited the most "jack of all trades" characteristics by showing the most amount of overlap with the greatest number of other fish species. Overall, our results indicate niche overlap among fish species in shallow lakes is highly variable across species, with some species showing very little overlap due to more unique use of resources such as detritus and piscivory. Other species have highly variable relationships with each other, ranging from nearly no to complete niche overlap. The extreme variability in these species likely reflects the large variation in population sizes that influence intra and interspecific competition, as well as habitat characteristics such as abundance of plants that vary greatly in these systems and influence resource availability.

Comparing Ship-based Down-looking to Sled-based Up-looking Acoustic Estimates of Pelagic Fishes in Lake Superior's Upper Water Column

Ryan Grow, Tom Hrabik, Dan Yule, Bryan Matthias, Jared Myers, Chad Abel

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Down-looking acoustic surveys are commonly used to determine fishery status for resource managers, particularly in the Great Lakes and marine systems. However, there are some limitations and biases built in to traditional down-looking acoustic surveys. In this study we examined the use of a multi-directional acoustic sled to overcome these limitations while examining the Lake Superior pelagic fish community including cisco (*Coregonus artedi*). We concurrently deployed the acoustic sled during traditional down-looking surveys to directly compare the fish densities obtained from each gear, which we then followed with a mid-water trawl to inform our acoustic data with species composition. Our findings from western Lake Superior showed a significant difference between fish densities detected by the sled survey and the ship based down-looking survey indicating a portion of pelagic fish biomass was missed by the traditional down-looking survey. This study also seeks to provide a baseline for future research looking to discover which species in a given system are most effected by traditional survey biases, as well as future work into using alternate forms of acoustic sampling to inform fisheries management and research.

Effects of Alternative States and Fish Stocking on Energy Flow and Food Web Characteristics of Shallow Lakes

Catherine E. Hegedus, Claire E. Herzog, Kyle D. Zimmer, and Brian R. Herwig

Presenter: Catherine Hegedus, ege0014@stthomas.edu
Affiliation: University of St. Thomas

Northern Pike and Yellow Perch (hereafter pike and perch, respectively) are often stocked in shallow lakes, but to date impacts of stocking are largely unknown. It is also unknown whether food webs in clear-state lakes derive most of their carbon (C) from littoral sources, while food webs in turbid-state lakes obtain most their C from phytoplankton. We assessed impacts of stocking pike and perch on lake ecosystems and food web sources of C by sampling δ13C and δ15N in four large shallow lakes in southern Minnesota in summer of 2017. We used δ15N to test whether trophic position of fish species differed in each lake, and whether patterns of trophic position for each species across the four lakes were linked to fish community characteristics. We also tested whether reliance on littoral C differed across the four lakes for each fish species using baseline-corrected δ13C. Results showed trophic position differed among fish species in just three of four lakes, and only two lakes had trophic positions of perch and pike generally higher than other non-piscivorous fish. Trophic positon of all fish species was also positively related to abundance of perch, such that trophic position of other fish species was highest in lakes with highest perch abundance. Perch effects on trophic position are likely driven by perch serving as a forage base for larger piscivores and by perch reducing competition for macroinvertebrates by preying on smaller planktivorous fish. Our δ13C results showed fish were more reliant on littoral energy in the two lakes with higher abundance of submerged plants relative to the other two lakes. Overall our results indicate perch facilitate upward shifts in trophic positions of fish species, and basal sources of energy flow differ between lakes in turbid and clear states. Thus, management activities inducing state shifts or favoring high densities of perch will result in major changes in predator-prey interactions and energy flow in shallow lakes.

How Big is the Buffet: What Determines Niche Space of Fish in Lakes?

Sarah E. Howe, Claire E. Herzog, Kyle D. Zimmer, Brian R. Herwig, David F. Staples

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Similar to Hutchinson's description of the ecological niche as "n-dimensional hyperspace," trophic niche space for communities represents the range of resources available to consumers. Though past research has emphasized importance of lake size for fish niche space, we hypothesized lake depth would be important for trophic niche space for fish because variance in energy sources and variance in trophic position of invertebrates increases with lake depth. We tested our hypothesis by sampling stable isotopes 13C and 15N in fish and aquatic invertebrate communities in 7 Minnesota lakes that varied in size and maximum depth. We used 13C and 15N as the former indicates variability in energy (carbon) sources at the base of food webs, and the later variability in trophic position within food webs. Larger variance in 13C and 15N in fish and invertebrate communities indicates greater trophic niche space. We used Bayesian analysis to estimate niche space as the standardized ellipse area of 13C and 15N of invertebrate and fish communities in each lake, and we then tested whether lake size and maximum lake depth were related to niche space size. Results showed lake size was not related to invertebrate or fish community niche space, while lake maximum depth showed a positive relationship with niche space of both invertebrate and fish communities. Moreover, fish niche space expands with increasing invertebrate niche space. Our results indicate lake depth influences trophic niche space of fish communities and should be considered along with lake size in attempts to understand overall niche utilization by fish in lakes.

Loss of Coldwater Fish Habitat in Glaciated Lakes of the Midwestern United States After a Century of Land Use and Climate Change

Peter Jacobson, Gretchen Hansen, Leif Olmanson, Kevin Wherly, Catherine Hein, Lucinda Johnson

Presenter: Peter Jacobson, peter.jacobson@state.mn.us
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The relative contributions of eutrophication and climate change to the loss of coldwater fish habitat was estimated for 5,220 stratified lakes in Michigan, Minnesota, and Wisconsin. A hypolimnetic oxygen model was coupled with a landscape disturbance model to estimate change in oxythermal habitat since European settlement. The General Additive Model predicted late-summer oxythermal habitat conditions as a function of remotely-sensed Secchi depth (mean of 1995-2014 values), geometry ratio (area0.25/max depth), and mean July air temperature (1995-2014). The use of the remotely-sensed water clarity variable allowed modeling of lakes that do not have in situ water quality data. The landscape disturbance model predicted remotely-sensed water clarity as a function of levels of catchment land-use disturbance, geometry ratio, and proportion of glacial outwash soils in each catchment. Historic coldwater habitat was estimated for undisturbed landscape conditions and an earlier period of climate and then compared to contemporary conditions. Eutrophication and climate change substantially reduced coldwater fish habitat over the past century in many stratified lakes in Minnesota, Wisconsin, and Michigan. The greatest loss of coldwater habitat occurred in lakes with substantial land use changes in their catchments, primarily in the Great Plains and Eastern Temperate Forests ecoregions. Oxythermal habitat in many other lakes in the Northern Forests ecoregion remained intact, with only modest changes primarily due to a warming climate. To maintain coldwater habitat, deep, clear lakes in the forested ecoregions of Minnesota, Wisconsin, and Michigan should receive high priority for catchment protection efforts. Protective catchment land-use measures will be needed for coldwater fish to survive further climate warming.

Low-Cost Bathymetric Mapping of the Missouri River - A Focus on Pallid Sturgeon

Jennifer Johnson

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Affiliation: U.S. Fish and Wildlife Service

We used a simple, affordable, commercial depth finder to record bathymetric data while simultaneously sampling for pallid sturgeon. Our goal was to collect current and accurate bathymetric data at a microhabitat scale. We created 1x1 m triangular irregular networks and used the Benthic Terrain Modeler to classify bathymetry data into four terrain classes; crests, depressions, slopes and flats. We summarized the amount of each terrain class within a 25m radius around each trotline set.

The Future of Conservation: Are Hunters and Anglers Enough?

Craig J. Kelling, Kyle O. Daly

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Wildlife and fisheries conservation in the United States largely relies on performance-based funding within a user-pay and user-benefit system. This system relies on successful management by state fish and wildlife agencies to sustain, and ideally increase, hunting and fishing participation, which, in turn, results in sustained or increased funding through license sales and equipment purchases by hunter and anglers. In Minnesota, approximately 85% of the Minnesota Department of Natural Resources' Game and Fish Fund comes from hunting- and fishing-related activities directly through the sale of licenses, tags, and stamps or indirectly through federal excise taxes on hunting, recreational shooting, and angling equipment. The game and fish fund makes up approximately 20% of the DNR's overall biannual budget. Nationally, an estimated 58.8% of the collective annual budget of state fish and wildlife agencies comes from these sources. This user-pay, user-benefit funding system for conservation, commonly referred to as the North American Model of Wildlife Conservation, has been emulated around the world. However, the percentage of Minnesotans buying hunting and fishing licenses has declined approximately 5% and 2%, respectively, since 1995. This trend is occurring across the nation, resulting in declines of license sales and equipment purchases. With many State agencies so heavily reliant on the contributions of hunters and anglers is our conservation funding model sustainable?

Dietary Niche Breadth and Composition of Dominant Fishes in Shallow Southern Minnesota Lakes

Rachel M. Klaras, Natalie G. Ganzel, Brian R. Herwig, Kyle D. Zimmer, David F. Staples, Danelle M. Larson

Presenter: Rachel Klaras, klar0003@stthomas.edu
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We collected 517 fish diets from nine species of dominant fish across four southern Minnesota lakes, and estimated trophic niche size using Levins' measure with bootstrapped 95% confidence intervals. We also used canonical correspondence analysis (CCA) to test whether diet composition differed within fish species across the four lakes. Results showed Northern Pike had the smallest niche size across lakes, reflecting a highly specialized and piscivorous diet consisting of Fathead Minnow, Yellow Perch, and Golden Shiner. Niche size of Fathead Minnow varied the most among the four lakes, and CCA indicated that niche size was driven largely by the amount of detritus in diets, with detritus more important when Fathead Minnow densities were high. Yellow Perch and Black Bullhead had large niche sizes, and the size was relatively consistent across lakes for both species. Despite similar niche size across lakes, CCA indicated significant differences in diet composition across lakes for both Black Bullhead and Yellow Perch, with diets varying along a spectrum of greater importance of macroinvertebrates to greater importance of zooplankton. The consistency of niche size in these generalist species across lakes suggests these species are exploiting all resources available to them, while differences in actual diet composition across lakes indicates types of available resources varies among lakes. Thus, there may be an upper bound on the size of trophic niche space for these two species based on limitations on the diversity of resources available in shallow lakes. Differences in a species' feeding niche may be related to habitat complexity (abundance of submerged aquatic plants), fish densities, or prey availability (invertebrate densities) that influences resource availability and feeding behavior.

Presence of the Endangered Pallid Sturgeon in the Confluence of the James River and the Missouri River

Jason Kral

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We looked at the presence of the endangered Pallid Sturgeon (Scaphirhynchus albus) in the confluence of the James River (river mile [rm] 799.0) and the Missouri River from 2006-2018. Pallid sturgeon were sampled as part of the Pallid Sturgeon Population Assessment Project on the 59-mile National Recreational River known as Segment 7. Pallid sturgeon were sampled using gill nets, trammel nets, otter trawls, trotlines and hook and line throughout the year. A total of 1,210 pallid sturgeon were sampled in Segment 7. Of those 805 (67%) were sampled in the James River confluence. Pallid sturgeon were sampled in the confluence that were stocked above Gavins Point Dam and others moved over 600 miles upstream from their stocking location. We hypothesis to congregate in the turbid break-line pools of the James River confluence.

Comparison of Consumption and Excretion Rates of Yellow Perch and Black Bullhead in Managed Shallow Lakes Using Bioenergetics Modeling

Danelle M. Larson, Brian R. Herwig, Kyle D. Zimmer, Michael Collins, Jake Carleen

Presenter: Danelle Larson, danelle.larson@state.mn.us
Affiliation: Minnesota Department of Natural Resources

Yellow Perch (YEP; *Perca flavescens*) and Black Bullhead (BLB; *Ameiurus melas*) can be key species in shallow lakes fish communities, but their ecological impacts are not well quantified in these systems. We hypothesized that both species will have relatively high consumption rates of macroinvertebrates and correspondingly high rates of growth, excretion and egestion, which can be in direct competition with other wildlife and influence lake nutrient loading. We examined stocked YEP populations and naturally colonized BLB populations in three shallow lakes in southern Minnesota throughout the summers of 2017. We measured relative abundance, size and age structure, and diets of YEP and BLB in each lake. We conducted bioenergetics modeling to quantify and compare each cohort's rates of consumption, specific growth, egestion, and excretion. The YEP ranged in length from 50-300mm and spanned ages 0-4. The BLB ranged in length from 60-280mm and spanned ages 0-2. Young-of-year YEP consumed invertebrates of many taxa, while the adults (ages 1-3) consumed mostly Fathead Minnow (*Pimephales promelas*) and smaller YEP. Individual YEP had high rates of consumption (4-10 g d-1), proportional maximum consumption (p=0.8-0.9), and rapid growth (0.02 g-1 d-1), particularly at age-0. The YEP and BLB consumed similar daily biomass of food (~5 g d-1), but the YEP selected high-energy foods whereas the BLB consumed 3x lower energy-density diet items. Consequently, the BLB had slower growth (0.002 g-1 d-1) and 2-5x lower rates of egestion and excretion. When rates were scaled by relative fish population size, the ecosystem-level impacts varied by lake; at two lakes, BLB populations had higher levels of consumption and excretion, while at Rice Lake YEP biomass and feeding impacts were substantially greater.

Sentinel Lakes Data Tools

Tim Martin

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Minnesota's Sentinel Lakes Long-Term Monitoring Program is responsible for collecting and maintaining high resolution ecological data over long time periods. As such there is a large amount of data that needs to be processed, analyzed, and distributed. In our quest to make these tasks as efficient and accurate as possible we are using web app platforms to provide intuitive user interfaces to data tools, facilitate data exploration through responsive interaction, and apply standardized processing techniques. We have used these technologies for displaying water temperature data and analyzing and displaying various related metrics such as thermal stratification and layers; plotting and modelling various trends occurring on the individual lake, ecoregion, and all Sentinel Lakes levels; processing and QCing water temperature and dissolved oxygen logger data; and providing access to Sentinel Lakes datasets. This presentation will demonstrate these web apps and further discuss how they have been useful to the Sentinel Lakes Program.

Potential Biotic and Abiotic Effects of Isolation in Coves within the Harlan County Reservoir, Nebraska

Brian Mason, Keith Koupal, Melissa Wuellner

Presenter: Brian Mason, masonbe@lopers.unk.edu
Affiliation: University of Nebraska Kearney

As reservoirs age, sedimentation and erosion may create disconnections between reservoirs and their coves. However, little is known about the ecological changes that may occur to habitat and fish communities due to disconnection. The objective of this study is to evaluate differences in water quality and fish communities in connected, intermittently disconnected, and completely disconnected coves in Harlan County Reservoir. Water quality and fish communities were sampled at four locations within three connected, two intermittently disconnected, and three completely disconnected coves in spring, summer, and fall of 2017 and 2018. Water quality measures were compared by cove type and to the same measures in the reservoir at the nearest long-term monitoring station using analysis of variance (ANOVA). Similarities in fish communities by cove types were evaluated using a Jaccard's similarity index. Preliminary results suggest that most water quality metrics do not differ significantly by cove type, but different cove types may support different fish communities. Results from this study may be used to evaluate the influence of connection to reservoirs on coves. This study could also provide baselines for evaluating ecological changes to water quality and fish communities if connection is restored to disconnected coves in the future.

Evaluation of Mussel Growth Rate in the Sheyenne River Post-Devils Lake Outlet

Jayme M. Menard, Louis.M. Wieland, A.W. DeLorme

Presenter: Jayme Menard, jayme.menard@vcsu.edu
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Mussels are considered crucial organisms in aquatic ecosystems. The intention of this work is to evaluate the effects of the Devils Lake outlets releasing large amounts of water into the Sheyenne River since 2012. These inputs not only drastically changed the flow regime of the Sheyenne River but they are also laden with high levels of dissolved ions. Mussels are influential in water quality as they are suspension feeders, which also makes them susceptible to changes in flow regime and changes in water quality. This study uses the Three Ridge mussel, Amblema plicata, to evaluate the growth rate of mussels using a thin-sectioning technique previously used by Haag and Commens-Carson (2008). Yearly growth lines in the shell section can be identified and measured to determine annual growth rates. Thin sections taken from two cohorts of mussels harvested from the Sheyenne River were examined. The first cohort (n=12) was collected from 2007-2009 which is before the East End Devils Lake outlet was opened in 2012. The second cohort of mussels (n=16) were harvested summer 2017. We are comparing the difference in the deposition of mussel growth rings between the two cohorts to see if there is a change in growth rates in the second cohort corresponding to the opening of the East end Outlet in 2012.

Methodology and Inspection History for BKD in Minnesota State Coldwater Hatcheries

Tim Monahan, Ling Shen, Ranjit Bhagyam, Shannon J. Fisher

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Minnesota Department of Natural Resources (MNDNR) has four coldwater hatcheries (Crystal Springs, Lanesboro, Peterson and Spire Valley) in operation and closed the French River Hatchery in June of 2018. Bacterial Kidney Disease (BKD) is caused by *Renibacterium salmoninarum* and has been identified in all five hatcheries. R. salmoninarum is a gram-positive, slow-growing and fastidious bacteria. Traditional bacterial detection methods are not applicable to R. salmoninarum and thus alternate methods of detection are utilized and under continual development. The MNDNR Fish Health Pathology Laboratory has annually inspected the MNDNR coldwater hatcheries for BKD and other reportable salmonid diseases since the early 1980s. The detection of R. salmoninarum has been a problematics factor in fisheries management's efforts to establish a heritage brook trout strain for southeastern Minnesota. To better address BKD concerns, we provide a review of current R. salmoninarum detection methodologies used by MNDNR and gathered historical inspection data and testing results for lethal and ovarian fluid samples from each hatchery. Data clearly demonstrate that R. salmoninarum has historically been and is currently prevalent in Minnesota's hatchery system. By addressing pathogen prevalence and advances in current detection methodologies, perhaps fisheries managers can better strategize how to manage with, instead of around R. salmoninarum being present in Minnesota's coldwater hatchery system.

Effects of Mermithid (Nematoda: Mermithidae) Parasitism on Predation of Black Fly Larva (Diptera: Simulidae) by Trout Species in Rapid Creek

Chuck Mordhorst, Gene Galinat

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We examined the relative frequency of parasitism of larval simulidae by mermithid Nematodes in Rapid Creek, South Dakota in order to determine how mermithid parasitism effects drift behavior of larval simulidae and frequency of consumption by the trout species present. Significant differences were observed between the proportions of infected simulidae present in the stream substrate, drifting, and in the stomach contents of multiple trout species (brown trout (Salmo trutta), rainbow trout (Oncorhynchus mykiss), brook trout (Salvelinus fontinalis), lake trout (Salvelinus namaycush)).

Brown Trout, Pool Habitats, and Stream Habitat Improvement

Dylan Lewis, Neal Mundahl

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Size and abundance of adult Brown Trout can be influenced by the quality of stream pool habitats, which may be altered during stream improvement projects. In fall 2017, we examined size and abundance of Brown Trout in 18 pools in Garvin Brook, including pools in improved and unimproved stream reaches, to examine possible relationships between trout and pool habitat variables. Improved pools included various combinations of skyhooks, LUNKER structures, mid-channel boulders, and placed woody structures, whereas unimproved pools included natural woody structure and undercut banks. Two-pass removal sampling was used to determine trout abundance and size, and pool habitats (depth, volume, substrate, current velocity, cover [bank, logs, boulders, vegetation, water > 60 cm]) were assessed. Pool lengths ranged from 12.1 to 28.9 m, volumes from 18 to 121 m3, and maximum depths from 0.63 to 1.63 m. Bank cover and log cover were the only habitat variables appearing in the majority of top models (AICc) predicting trout abundance and size. Improved pools had greater volume, more bank cover, more boulder cover, and more deep water, but unimproved pools had more log cover. Trout densities (0.22 fish/m2) did not differ between improved and unimproved pools, but improved pools averaged 3X more trout >30 cm compared to unimproved pools (3.58 vs. 1.17 fish). Boulder cover was not associated with either more or larger trout. Future stream improvement projects in small (3 to 8 m stream width) streams like Garvin Brook can maximize large trout abundance by including deep pools with both bank cover and log structures.

Fish Passage Assessment of the Sheyenne River Watershed, North Dakota

Tait Ronningen, Steven Krentz, Bill Rice, Adam Weishair, Josh Wert, Holly North, Katy Banning, Kate Huber, Kelsey Loverink, and Sam Hultberg

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Globally, dams and road stream crossings have altered stream morphology, flow regimes, and connectivity. These alterations have led to decreased recruitment and survival of aquatic organisms resulting in aquatic biodiversity loss. The Northern Great Plains is not exempt from these issues. The U.S. Fish and Wildlife Service conducted a pilot study during the 2018 summer to assess fish passage in the Sheyenne River Watershed of eastern North Dakota. During the pilot study, we inspected 524 dam and road stream crossings to determine where fish passage is limited due to structures blocking or restricting fish passage upstream. This work identified 29 dams and 30 culvert locations that were potentially blocking fish passage upstream. Additionally, this work developed a flow constriction index to identify culverts with flow velocities that could limit fish passage. An abundance of aging infrastructure that is in dire need of replacement has brought forward a unique opportunity for aquatic connectivity partnerships between federal, state, county, and local stakeholders. Through the means of successful partnerships, the end goal is to restore native fish and other aquatic species to self-sustaining levels by reconnecting habitats fragmented by barriers. The U.S. Fish and Wildlife Service will be applying this methodology to other watersheds throughout the Northern Great Plains to assist with prioritizing limited resource dollars where they can have the greatest benefit for the aquatic species.

Spatial Distinction of Water Chemistry in the North Platte River and Lake McConaughy, Nebraska

Garrett Rowles, Melissa Wuellner, Keith Koupal

Presenter: Garrett Rowles, rowlesgw@lopers.unk.edu
Affiliation: University of Nebraska Kearney

Trace elements of water may be absorbed into the calcified structures of a fish and can reflect the water environments of the location that a fish lived at a particular time. Elemental signatures of water can be compared to core otolith elemental signatures to elucidate natal origins of fish. For these elements to be used as a tracer of the environmental history of a fish, elements present in the environment must be deposited on the otolith in a ratio comparable to the ratio that is present in the ambient water. Additionally, elemental signatures of the water should be spatially distinct across different habitats and, ideally, temporally stable both within and between years. Therefore, the objective of this study was to assess trace elements of water at nine potential spawning locations seasonally to determine spatial distinction and temporal stability within a year and between two years of these signatures. Water samples were collected from four sites within Lake McConaughy, four sites within the North Platte River, and one site in a tributary of the North Platte River. Samples were sent to the Water Science Lab at the University of Nebraska Lincoln for microelemental analysis using inductively couple plasma-mass spectrometry. Sites that were distinct from each other along with which elements provide the greatest degree of spatial distinction will be shared as well as implications for elucidating natal origins of fish in this system.

Results of a Review of Bag and Size Limits for the Mississippi River Portion of the Minnesota/Wisconsin Border Waters

Nicholas Schlesser

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Bag and size limits on the Mississippi River portion of the Minnesota/Wisconsin border waters have been largely unchanged for the last 50+ years. We conducted a series of public meetings and a follow up electronic survey collecting public input about a broad collection of gamefish species. Results and trends from this input and the subsequent meetings and survey to rate potential regulation options will be presented. (This poster is a companion to the talk "Public Input in a Post-Public Meeting World: A Border Water Case Study" which will discuss the opportunities and difficulties agencies face collecting public input in the digital age.

Lake Whitefish and Cisco Recreational Gill Netting Participation Survey

Calub Shavlik and Mandy Erickson

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Affiliation: Minnesota Department of Natural Resources

A postcard survey was sent to 1410 people that purchased Whitefish and Cisco netting licenses during 2015, 2016, or 2017. The survey consisted of questions targeting demographics, netting history and success, and netter preferences. This poster highlights key findings from the survey.

Age and Growth of Recently Reintroduced Lake Sturgeon Populations Compared to an Established Population

Allison Shorter, Jamison Wendel, Nathan Olson, and Michael Brown

Presenter: Allison Shorter, allison.shorter@sdstate.edu
Affiliation: South Dakota State University

This project is focused on a comparative assessment of Lake Sturgeon Acipenser fulvescens growth, size and age structures from Minnesota (a reintroduced sturgeon population) and Wisconsin (and established sturgeon population). Lake Sturgeon (n=115) were sampled during the summer of 2018 on the Otter Tail river, Pelican River, and in Detroit Lake, MN. The total length ranged from 54 to 165 cm, with a mean length of 122 cm. Yellow Lake, WI Sturgeon were sampled (n=380) between 2005 to 2008. The Yellow Lake fish ranged from 38 to 190 cm total length. Males and sturgeon of unknown sex had a mean length of 129 cm, while females had a mean length of 162. Pectoral spines were collected and sectioned into 1.5 mm transverse sections with an Isomet saw. Sections were place on slides with immersion oil and images were captured with an Olympus SZX12 microscope and DP71 digital camera. Aging was done by two independent readers. Ages for the MN population ranged from 4 to 26 years. The ages of Lake Sturgeon in Yellow Lake ranged from 3 to 74 years. Additional comparisons will be conducted between samples including, von Bertalanffy parameters derived for the two populations.

Size and Abundance of Brown Trout Associated with Under-Bank Cover and Mid-Channel Boulders in Garvin Brook's 2014 and 2017 Habitat Improvement Projects

Alicia Skolte

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Affiliation: Winona State University

Stream habitat improvement (HI) projects are an integral part of management for Brown Trout in southeastern Minnesota, and this study examined the size and abundance of trout associated with various artificial cover structures in two improved sections of Garvin Brook. Both improved reaches (construction in 2014 and 2017) incorporated large, mid-channel cover boulders, but reaches differed in the type of under-bank cover structure used (LUNKERs [2014] versus skyhooks [2017]). Electrofishing was used to capture Brown Trout associated with individual or clustered cover structures (5 boulders and 5 bank covers per reach), with all trout then weighed (g) and measured (mm total length). Brown Trout catch per unit effort (CPUE) did not differ between boulders and bank cover in either section, but CPUE was twice as high in the 2014 HI section (6.7 fish/minute) versus the 2017 HI section (3.2 fish/minute). Greater numbers of fish were found associated with wooden structures, and in the 2014 HI reach. Artificial cover structures were used by trout in both the 2014 and 2017 HI sections, with differences in trout size and abundance between sections possibly influenced by other habitat differences (e.g., pool size, log cover, riparian use) between HI reaches.

Understanding Stakeholder Desires for Small South Dakota Lakes

Aaron P. Sundmark, and Larry M. Gigliotti

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Affiliation: South Dakota State University

Water and land resources that are owned by government agencies make up a large component of what is considered the "Public Trust", which establishes a trustee relationship of government to hold and manage wildlife, fish, and waterways for the benefit of the resources and the public. In South Dakota, there are more than 400 small lakes (<150 acres) with adjacent public lands in that are managed by the state agency. Many of the state's rural communities rely on these local lakes for outdoor recreation opportunities. Understanding the desires of stakeholders and local residents is critical in providing opportunities for recreation that they seek from their local lakes. In January of 2017, four separate, but very similar, mail surveys were sent to residents of 9 communities (zip-codes) across South Dakota that were in close proximity to 7 small lakes. In total, 3,753 surveys were sent and 1,318 surveys received responses (response rate=40%). Questionnaires offered space for residents to provide additional comments. The objectives of this poster were to categorize and enumerate comment topics from the four surveys, consider the proportion of comments that are "positive" or "negative" towards specific topics, and provide the state agency with management opinions that would likely satisfy residents' desires for local recreation. This analysis of comments provided evidence of the importance of small, local lakes not only for fishing, but several other forms of non-fishing recreation across South Dakota. It also continues to highlight the great value of these lakes for family and community recreational uses.

Effects of Rainbow Trout on Brook Trout Populations in Lake Superior Tributaries

Craig G. Tangren, Andrew W. Hafs, Kathryn Renik

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Affiliation: Bemidji State University

Historically Lake Superior and its tributaries hosted spawning migrations of Brook Trout known as "Coasters." In the late 1800s and early 1900s habitat loss and overfishing significantly depleted Coaster populations, which remain low. Today there are large numbers of introduced species, including three species of Pacific Salmon, Brown Trout, and migratory Rainbow Trout, known as "Steelhead." Steelhead population declines in the 1970s caused fisheries managers to stock juvenile Steelhead above natural migratory barriers to increase populations of returning Steelhead. Anecdotal evidence suggested the presence of Steelhead above natural barriers harmed Brook Trout populations. Stocking was largely discontinued beginning in the early 1990s. This study will attempt to determine 1) if Steelhead had an effect on the size of Brook Trout populations above migratory barriers, 2) if there is a continuing effect on below barrier populations of coaster Brook Trout, and 3) if downstream migration contributes to Brook Trout populations below migratory barriers. Results will be presented on populations effects above barriers and on other objectives completed by the time of the conference.

Movement of Hatchery-Reared, Age-0 Paddlefish in Lake Sharpe, South Dakota

Dylan Turner, Landon Pierce, Daniel James, Cameron Goble

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Affiliation: U.S. Fish and Wildlife Service

Paddlefish Polyodon spathula are a large river species native to several major rivers and tributaries throughout the USA. Abundance of Paddlefish has declined due to habitat modifications (i.e., channelization, dams, and water quality) and unsustainable commercial harvest. Some meta-populations within the Missouri River have been sustained with hatchery stocking, but in Lake Sharpe, SD, Paddlefish are nearly extirpated. Since 2015, the South Dakota Department of Game, Fish and Parks (SDGFP) and U.S. Fish and Wildlife Service (USFWS) have stocked, >180,000 Paddlefish in Lake Sharpe to restore the fishery. However, little is known about initial age-0 movement after being stocked. Thus, our objective was to examine movement patterns of age-0 Paddlefish within Lake Sharpe. We surgically implanted acoustic telemetry tags (Vemco V8-4x) into 50 individuals to track movement using a Vemco receiver array (n = 23 passive receivers) within Lake Sharpe. Paddlefish moved an average of 60 ± 9.2 rkm (total movement, regardless of direction) and an average of -25 ±4.8 rkm (downstream movement) during the first 3 months after stocking. The majority of Paddlefish generally moved away from their stocking location and used a large portion of the reservoir within a short time frame post-stocking. This information will better inform SDGFP and USFWS if stocking locations influence movement of juvenile paddlefish within Lake Sharpe, SD.

A Survey of Brown Trout Spawning in the Whitewater River and Garvin Brook in Southeastern Minnesota

Will Varela, Neal Mundahl, Cole Weaver

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Suitable habitat for spawning is crucial to the success of self-sustaining populations of salmonids. To date, only limited trout spawning surveys have been conducted in southeastern Minnesota. The objective of this study was to conduct spawning surveys of brown trout in sections of four streams, three within the Whitewater River drainage plus one in an adjacent drainage, Garvin Brook. We collected and compared data on spawning redd abundance (redds/100 m stream reach) and clustering, plus redd dimensions and habitat, including redd size, cover (presence/absence and type), water depth (bowl and tailspill), and current velocity (front edge of mound). Redd abundance averaged 7.4 and 6.0 redds/100 m and redd densities within redd clusters averaged 0.863 and 0.888 redds/m2 in the Whitewater River and Garvin Brook, respectively. Overall, redds averaged 0.42 m2 in area in water 31 cm deep with a current velocity of 35 cm/sec. Redds in the Whitewater River were located in significantly deeper, faster water, and were less likely to be placed under overhead cover compared to those in Garvin Brook. Brown trout spawning redds in these streams exhibited dimensions and habitat use typical for this species. Future studies should focus on spawning habitat availability and possible redd superimposition to determine if suitable spawning habitat may be limiting in any of these streams.

Assessing thermal-optical walleye habitat in Minnesota lakes to help guide management

Kelsey Vitense, Jordan S. Read, Gretchen J.A. Hansen

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Walleye (Sander vitreus) are a popular game fish in Minnesota and are managed in over 1,400 lakes. Light and temperature conditions in lakes have strong impacts on walleye feeding and growth, wherein peak walleye foraging activity occurs under low light conditions (8-68 lx) and maximal growth rates are attained in cool waters (11-25 °C). The amount of walleye habitat in a lake can be summarized as the benthic area where optimal light and temperature conditions overlap, known as the thermal-optical habitat area (TOHA). Previous work on Mille Lacs modeled safe walleye harvest as a function of TOHA and showed that declines in walleye abundance were associated with declines in TOHA and excessive harvest beyond predicted safe levels. We are working to extend this framework to inform state-wide management of all walleye lakes. We present our approach for estimating current and historical light and temperature conditions for Minnesota lakes managed for walleye. The resulting TOHA estimates will be used to quantify the relationship between walleye abundance and habitat in Minnesota and subsequently identify under- and over-performing walleye stocks relative to available habitat to guide management.

35 years of Land Management; is the Whitewater River in SE MN still Impaired by Total Suspended Sediment?

Cole Weaver, Neal Mundahl, Will Varela

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Since 1987, the Whitewater Watershed Project in southeastern Minnesota has significantly reduced soil erosion and flooding through contour farming, reduced tillage practices, buffer strip implementation, and cover crop use, improving conditions for trout in the Whitewater River, one of the most important stream trout fisheries in the state. Despite this improvement, trout populations may still be exposed to storm-related runoff events that can cause moderate to severe physiological stress. Potentially harmful runoff events were monitored using automated water quality stations using observed turbidity/TSS concentrations along with a concentration-duration response model for salmonids. TSS levels capable of producing moderate physiological stress in trout were estimated as 200 mg/L for > 15-28 hours, 500 mg/L for > 5-9 hours, or 1000 mg/L for > 1-4 hours. During isolated runoff events TSS concentrations exceeded 1000 mg/L. However, five water monitoring stations operating from June-October recorded no potentially lethal events, but found that elevated TSS could have stressed trout during 40-69% (model 12-29 or 20-29) of the storm event pulses observed. These results indicate that trout populations in the Whitewater River watershed may still be harmed by sediment transport and could benefit from improved erosional practices. If the frequency and intensity of rain events increase due to climate change as predicted for this region, trout populations in these agriculturally dominated landscapes must be protected with continued improvements in land practices.

Statewide Decline of White Crappie in Minnesota Lakes

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White Crappie populations have declined in Minnesota lakes since 1970. Our objective was to determine contributing factors to the statewide decline in White Crappie populations in Minnesota. Populations were first categorized based on historical abundance trends White Crappie. Trends of selected species were then compared within the corresponding White Crappie population categories. Finally, linear and nonlinear regression was used to determine trends in water quality among lakes with viable White Crappie populations. Out of 294 White Crappie populations, 58 were historically viable populations. Of these, sixteen are persisting, eight have shown large declines, and 34 have collapsed. In lakes with collapsed populations turbid water species (Black Bullhead, Yellow Perch) have shown large declines in relative abundance. Water clarity in the 58 lakes with White Crappie populations has significantly ($p<0.0001$) increased from 1970 to present. We found that White Crappie have declined among all types of White Crappie populations. In collapsed populations other turbid water species have shown a similar decline while clear water species have increased or remained similar. Lakes with White Crappie populations had a significant increase in secchi depth. Based on similar declines of other turbid water species and increasing water clarity; declines in White Crappie populations are likely the result of improved water quality in Minnesota lakes.

Assessing the Role of Nutrients in Harmful Cyanobacteria Blooms on the Des Lacs Lakes, North Dakota

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Des Lacs National Wildlife Refuge (NWR) is in northwest North Dakota, in the Prairie Pothole Region. It lies within a major migration corridor for waterfowl and shorebirds and serves as a nesting location and stopover site. The lakes on Des Lacs NWR are subject to frequent harmful cyanobacteria blooms (HCBs), which effect wildlife and domestic animals. A collaborative project between the United States Fish and Wildlife Service and the North Dakota Department of Health was initiated in 2016 to better understand the relationship between algal biomass, nutrient concentrations, and cyanotoxin production. Weekly samples were collected at five sites on Des Lacs between June and October from 2016 to 2018. Samples were collected for nutrients, chlorophyll-α, transparency, and the presence of microcystin (using Abraxis© test strips). Des Lacs experienced lake-wide blooms each year with spikes in microcystin concentrations that occurred between August and September. This study found that HCBs, in Des Lacs, appear to be driven by inorganic nitrogen, and had an inverse relationship with chlorophyll-α concentration. Sampling will continue in 2019 with the addition of sediment analysis and the measurement of nutrient inflows from runoff and stormwater events. Sediments will be analyzed to determine phosphorus saturation levels which will indicate its maximum potential in the system. A conceptual model will be developed to determine the causes and timing of HCBs with hopes of improving management in this system and other areas that suffer from HCBs in the upper Midwest.