2021 Wisconsin AFS Annual Meeting
Abstract Submission - Presentations

Great Lakes

Title: **Multi-Stock Tagging of Lake Whitefish in Northwestern Lake Michigan**
Author: Scott Hansen, *Wisconsin Department of Natural Resources*

Abstract:
The relative abundance of lake whitefish (Coregonus clupeaformis) in Green Bay and Lake Michigan proper has changed dramatically over the past two decades. Recent recolonization of Wisconsin's Green Bay west shore tributaries during the spawning season has contributed to strong recruitment events, reviving a long-extirpated fishery. Meanwhile, lake whitefish recruitment throughout Lake Michigan, outside southern Green Bay, has generally declined. Although smaller scale tagging and spatially comprehensive genetic studies have provided some insight into the distribution and exploitation of Lake Michigan stocks, a comprehensive mark-recapture study of all stocks/populations in northwestern Lake Michigan was lacking. During the 2017 and 2018 November spawning periods, nearly 8,500 lake whitefish were tagged using individually numbered loop tags in the Fox and Menominee Rivers, Big Bay de Noc, and North/Moonlight Bays in a cooperative effort between commercial fishers and the Wisconsin DNR. Primary objectives were to: 1) Determine stock specific migration and seasonal distribution in Green Bay and Lake Michigan and, 2) Define stock specific annual use of fall spawning grounds. Tag recovery information to date suggest that fish from the river spawning stock make up most of the harvest in the approximate southern half of Wisconsin waters of Green Bay. While the northern half is more of a mix of stocks, mainly consisting of river and Big Bay de Noc stock fish. In Lake Michigan, harvest in the northern waters off the Door County Peninsula consist primarily of North/Moonlight Bay stock, and a smaller percentage of Big Bay de Noc stock. While the southern Lake Michigan waters consist of about equal proportions of North/Moonlight Bay and Big Bay de Noc stocks. Very few river-tagged fish were reported outside of Green Bay. To date, all tagged fish recovered during the November spawning period were originally tagged in the same location.

Title: **Generalized Movements, Spawning Site Fidelity, and Thermal Ecology of Lake Whitefish in Northwestern Lake Michigan**
Author: Daniel Isermann, *USGS-Wisconsin Cooperative Fishery Research Unit, University of Wisconsin-Steven's Point*
Co-author(s): Tom Binder, Todd Hayden, Scott Hansen, David Caroffino, Daniel Dembkowski, Wesley Larson, Charles Krueger, and Christopher Vandergoot

Abstract:
Understanding stock structure and fishery contributions of lake whitefish has become increasingly important because of observed recruitment declines in certain portions of the Great Lakes, including portions of Lake Michigan. We used a combination of acoustic telemetry, conventional tagging, genetics, and temperature loggers to evaluate the movements, spawning site fidelity, and thermal ecology of lake whitefish spawning at four different locations in northwestern Lake Michigan: the Fox and Menominee Rivers, Big Bay de Noc, and along the lakeside of the Door Peninsula near North and Moonlight Bays. Preliminary analyses indicate: 1) few lake whitefish tagged on the lakeside of the Door Peninsula enter Green Bay; 2) lake whitefish tagged in the Fox River typically do not venture north of Chambers Island;

3) lake whitefish tagged in Big Bay de Noc rarely go south of Chambers Island but do leave the Bay; 4) approximately two thirds of the lake whitefish tagged in the Menominee River remained south of Chambers Island; 5) spawning site fidelity of lake whitefish is low and varies among locations, and 6) lake whitefish spawning in tributaries to southern Green Bay are part of a genetically distinct stock, which is a new finding in terms of genetic stock structure. Recovery of non-reward loop tags that were applied to fish at the same time we implanted transmitters support movement patterns we have observed using telemetry. These findings have important implications for harvest management and we will also discuss the next phases of our research.

Title: **Two-model approach to lake whitefish stock assessment in Green Bay and Lake Michigan, Wisconsin**

Author: Iyob Tsehaye, *Wisconsin Department of Natural Resources*
Co-author(s): Scott Hansen

Abstract:
Successful management of exploited fish populations typically requires delineating spatially distinct unit stocks and assessing population and fishery dynamics within each unit to set management regulations. Lake whitefish (Coregonus clupeaformis) stocks in Wisconsin waters of Lake Michigan, which are exploited by commercial and recreational fisheries, are managed using a stock-based approach, incorporating several management units across Green Bay and Lake Michigan. An existing lake whitefish assessment model for Green Bay and neighboring waters of Lake Michigan assumed that all fish originated from a North–Moonlight Bays (NMB) spawning stock with little or no contribution from Green Bay (GB) tributaries. However, incidences of spawning lake whitefish activity have been recorded for southern Green Bay in recent decades, initially in the Menominee River (since around 1995), followed by colonization of other tributaries to the bay. Meanwhile, movement studies (recently led by UW-Stevens Point and WI-DNR) showed the GB and NMB spawning lake whitefish population barely intermixed, justifying the application of a two-stock assessment approach. Estimates of total lake whitefish abundance did not vary considerably between the single-stock and two-stock assessment approaches. However, the two-stock/model approach revealed shifts in relative abundances and productivities between the two populations, with (increasingly) higher abundances of lake whitefish within Green Bay than on the lake side of Door Peninsula, pointing to the need to adapt spatial allocation of fishing effort accordingly.

Title: **Relative survival and dispersal of different lake trout genetic strains stocked into Lake Michigan**

Author: Matthew Kornis, *U.S. Fish and Wildlife Service*
Co-authors: Charles Bronte, Ted Treska, Jory Jonas, Sergiusz Czesny, Erik Olsen, Ben Dickinson, Laura Schmidt, Cheryl Masterson, Phil Kacmar, Wes Larson, Chuck Madenjian

Abstract:
Lake trout have been the focus of a rehabilitation effort in Lake Michigan since the 1960s through stocking and controls on mortality. Five genetic strains (Lewis Lake, Seneca Lake, Superior Apostle Islands, Huron Parry Sound, and Superior Klondike) were stocked during the 2010 – 2015 year classes. Use of multiple strains represented a rehabilitation strategy to foster genetic diversity, promote use of varied habitats, and provide resilient responses to change. We evaluated the performance of these five genetic strains amidst stocking changes and resurgent natural reproduction in Lake Michigan. Based on coded-wire tag returns in surveys and fisheries (adjusted for stocking rates), Seneca Lake strain (native to finger lakes region of New York) and Lewis Lake strain (comprised on Lake Michigan remnant genetics) lake trout had greater relative survival than Superior Apostle Islands and Huron Parry Sound strains. Seneca Lake strain fish generally performed better than other strains in areas with high sea lamprey predation, while Lewis Lake strain performed better in areas with low sea lamprey predation. The

Superior Klondike strain, a humper morphotype from Lake Superior, also survived well but had greatly reduced dispersal compared to other genetic strains representing lean morphotypes. Of the lean morphotypes, the Lewis Lake strain exhibited modestly greater movement distance than the Seneca Lake strain from locations where both strains were stocked. An evaluation of genetic composition of natural recruits indicated that the Seneca Lake strain had disproportionately higher contributions to natural recruitment, the Lewis Lake strain contributed as expected, and the Lake Superior lean strains and the Green Lake strain (Lake Michigan remnant genetics) under-performed relative to expectations. These findings were included in a recent report to the Lake Michigan Committee and will help managers evaluate and make adjustments to the lake trout rehabilitation program.

Title: **Catch and bycatch in a Lake Michigan commercial lake whitefish trawl fishery**
Author: Titus Seilheimer, *University of Wisconsin Sea Grant*

Abstract:
Understanding seasonal and spatial patterns of fish harvest and bycatch are important for guiding science-based fisheries management decisions for commercial fisheries. This study quantified catch rates of lake whitefish and non-target species (i.e., bycatch) in an experimental trawl fishery. From February 2015 to May 2018, a total of 1,441 experimental trawls were completed in the Two Rivers, Wisconsin area. Trawl drags were completed in depths from 61.8 to 327 feet during all seasons of the year. More than 245,000 lake whitefish were harvested during the study along with ten species that were captured as bycatch and represented 2.4% of the total catch. The most common bycatch species were returned (i.e., small or non-marketable due to condition) lake whitefish (1.3%) and lake trout (1.0%) to the lake. Depth was an important factor in lake whitefish distribution, with the highest harvested lake whitefish catch rate (fish per mile) was in the 100-149 foot depth contour, followed by the <100 foot group. Although seasonal patterns were observed for bycatch, slightly more in winter and spring, the patterns were not consistent across all species. Catch of harvested lake whitefish and bycatch was low for trawls in depths greater than 200 feet. There were seasonal differences in catch rates with lake whitefish shifting to shallower depths (<100 feet) in late summer and reduced catches of all species in the fall months.

Trout

Title: **Interspecific competition of non-native Brown Trout and Brook Trout within Wisconsin Driftless region**
Author: Kristina Pechacek
Co-author(s): Eric Strauss, Kirk Olson, Jordan Weeks

Abstract:
Brook Trout (Salvelinus fontinalis) and Brown Trout (Salmo trutta) are the two dominant salmonid species within the Driftless Region of Wisconsin. Brook and Brown Trout require cold, highly oxygenated waters. Brook Trout are native to Wisconsin and can usually be found in stream headwaters. Brown Trout, a species introduced to the region in 1887, compete with Brook Trout due to similar resource requirements. Brown Trout generally are the dominant competitor, but questions remain about how the two species interact in different habitats within the Driftless Region. The objective is to determine how interspecific competition affects Brook and Brown Trout thermal distribution, habitat use, and diets in two Wisconsin Driftless streams. This study examined Maple Dale Creek (treatment stream) where Brown Trout were removed and Cook Creek (control stream) where no fish were removed. Data was collected during the summer of 2019 and 2020 using the Before and After Control Impact Design (BACI). Brown Trout removal reduced competitive pressure on Brook Trout, creating possible shifts in

habitat use, diets and thermal distribution. Changes within the food web were determined using stable isotope analysis before and after the removal of more than 15,000 Brown Trout from the treatment stream. After the removal of Brown Trout there has been significant changes with the Brook Trout population. This research will provide possible management plans for future Brown Trout removal and Brook Trout preservation projects. Bringing light to adverse impacts of interspecific competition from Brown Trout on streams with similar characteristics in the Driftless Region of southwest Wisconsin.

Title: **A long-term look at Wisconsin Brook and Brown Trout populations and the role of hydrologic change**

Author: Bryan Maitland, *Wisconsin Department of Natural Resources*
Co-author(s): Alex Latzka, Matt Mitro, Paul Frater

Abstract:
Wisconsin boasts over 13,000 miles of coldwater streams that support many world-class fisheries for native Brook Trout and introduced Brown Trout. A core strategy of the WI Trout Management Plan involves regular monitoring of trout populations to assess temporal and spatial population trends. Here, we inventory data on catchable trout densities (i.e., Brook Trout > 4 in., and Brown Trout > 8 in.) in wadeable streams across Wisconsin using single-pass electrofishing survey data from 1994-2020. Brook Trout population densities have generally fluctuated between 200 and 400 fish per mile, and Brown Trout densities between 100 to 300 fish per mile. Brook Trout densities show a series of peaks and declines from 1995 to 2004, then on average increased steadily through 2012. There was a large decline and subsequent increase from 2012 to 2016, and thereafter densities of adult Brook Trout declined into 2020. In contrast, densities of adult Brown Trout, while also displaying a series of population declines and recovery, have generally increased over the 26-yr period. A second core strategy is to evaluate how management actions and environmental drivers influence trout population dynamics. While trout are doing well statewide, local threats persist. Hydrologic changes may make some streams less suitable for trout survival at times. On the one hand, altered precipitation patterns associated with climate change have led to more frequent and extreme floods, which can, depending on their timing, threaten the successful emergence of fry or the survival of juveniles. Simultaneously, high capacity wells can deplete groundwater levels which decreases groundwater input and can result in higher temperatures, lower flows, and sometimes dry channels. We will introduce a collaboration with the DNR Water Use Section aiming to develop models that relate changes in precipitation, groundwater withdrawal, streamflow, and water temperature to the measured density of trout in Wisconsin streams.

Title: **Plum Creek Trout Habitat Project**

Author: Zach Mohr, *Wisconsin Department of Natural Resources*

Abstract:
A trout habitat project was started on Plum Creek in the Summer of 2019 and completed during the summer of 2020. The goal of this habitat project was to increase Brook Trout abundance and make fishing more accessible along this section of stream. Plum Creek was a great candidate for a habitat project because it is a Brook Trout reserve stream, has naturally reproducing Brook and Brown Trout, and is popular among resident and nonresident trout anglers. Like many of our habitat projects, funding and grants were obtained from outside government agencies and stakeholder groups. The section of Plum Creek where work occurred was had eroding banks and provided minimal trout habitat. Heavy equipment was used to grade both banks and place rock at the toe. Various habitat structures targeted towards brook trout were installed. Evaluation of the habitat work on Plum Creek is ongoing and will continue into the future.

Title: **Evaluation of trout population trends and fisheries management in the West Fork Kickapoo River Watershed**

Author: Kirk Olson, *Wisconsin Department of Natural Resources*
Co-author(s): Kevin Mauel, Kristina Pechacek

Abstract:
The West Fork Kickapoo River Watershed includes some of the most well-known trout water in the state. The watershed has experienced major improvements in land use over the past century, which have resulted in increased groundwater infiltration and discharge in stream channels. During this same time frame the fish community has shifted from one composed of stocked trout and abundant warm-water non-game species, to one dominated by naturally reproducing brown trout. The change in fish community has been attributed to both improved land-use and in-stream fish management activities (i.e. habitat restoration and stocking). Between 2018 and 2020, WDNR Fisheries management sampled 35 sites throughout the watershed to evaluate the current status of fish populations in the watershed. Brown trout were captured in all but two sites (upstream of impassible fish barriers) sampled in the watershed. Brown trout populations were robust on most streams throughout the watershed, with 78% exceeding the median and 39% exceeding the top 25th percentile for relative density of brown trout in streams surveyed across the state of Wisconsin. Brook trout were found in 28 of sites sampled at lower densities, with 29% and 17% exceeding the statewide median and 25th percentile, respectively. Overall trout densities were generally greatest in 2nd and 3rd order streams in the western portion of the watershed, likely the result of differences in bedrock geology influencing groundwater contributions to streamflow and adult habitat availability. Larger (i.e. preferred and/or memorable size) brown trout were typically found in the lower portions of the watershed, while larger brook trout were most abundant in reaches where brown trout were not present. Brook trout populations were greatest in headwater streams and in reaches where brown trout were absent. Stocking contributed little to densities of brook trout at stocking sites, all of which supported naturally reproducing brook and brown.

Title: **Effects of stream discharge and temperature on the proportion of Brook and Brown Trout in Wisconsin's Prairie River**

Author: Logan Cutler, *University of Wisconsin – Stevens Point*
Co-author(s): Dave Seibel and Dr. Justin VanDeHey

Abstract:
Brook and Brown Trout often coexist in streams, but each species has different habitat preferences. Temperature and stream discharge are well documented as important factors for Brook and Brown Trout growth, reproduction, and survival. However, the impacts of temperature and discharge on Brook and Brown Trout competition in streams aren't as well understood. Therefore, our objective was to determine the relationship between discharge, temperature, and changes in the Brook Trout and Brown Trout populations of Wisconsin's Prairie River between 1991 and 2019. Mark-recapture electrofishing surveys were conducted from 1991 to 2019 on Wisconsin's Prairie River. Population estimates were then calculated for each species and percent Brown Trout was determined for each year. Stream discharge data were taken from a USGS monitoring gage downstream in Merrill, Wisconsin. Air temperature data were obtained from a weather station in Merrill. Percent Brown Trout from each survey year was plotted against seasonal extremes in air temperature and stream discharge to determine if certain conditions favored either Trout species. Regressions were performed on these plots to determine fit and significance. Annual survey methods accounted only for adult trout, so data were also compared with temperature and flow data from two years prior to account for young of year trout. Of the thirty-two selected regressions, six were statistically significant ($P < 0.05$). Percent Brown Trout was higher with higher minimum discharges in the previous fall and winter, and with higher temperatures in the previous fall. Percent

Brown Trout was also higher with higher minimum and maximum discharges for two winters prior, and with higher minimum discharge for two springs prior. These trends help understand and predict variation in the proportions of Brook and Brown Trout over time in streams where the two species compete.

Title: **WI Brook Trout Seasonal Migration**

Author: Emma Lundberg, *Wisconsin Department of Natural Resources*
Co-author(s): Matthew Mitro

Abstract:
Movement of stream salmonids has been widely studied for a variety of purposes, including to understand the timing and use of essential habitats and spawning-related movements. Knowledge about trout movement may be used to refine policies and management goals to protect trout fisheries. Research into movement often suggests that patterns are highly variable, with some individuals showing high site fidelity and others demonstrating long-range movements. Brook Trout Salvelinus fontinalis may exhibit high rates of movement and adaptive plasticity for habitat use. Changes in movement and habitat preferences often occur at the onset of winter as adults seek suitable winter habitat following the fall spawning season. In northern Wisconsin, long harsh winter conditions with extensive ice cover are well-documented, but it is often uncertain where trout species overwinter and how these populations transition between summer, spawning and winter habitat. Additionally, northern Wisconsin is a historic hub for research into interactions between beaver Castor canadensis and Brook Trout, which set the stage for contemporary approaches to statewide beaver management that include maintaining free-flowing conditions in trout streams by removing beaver and beaver dams. In recent decades, there has been renewed interest in beaver and salmonid interactions across the United States, in both scientific and public spheres, as the ecological benefits of beaver are increasingly documented. In this research we ask, what are the seasonal movement behaviors of Brook Trout in Marinette County, Wisconsin? We use single-pass electrofishing and install stationary PIT monitoring systems to record timing, duration, and patterns of seasonal migration within the study system, Upper Middle Inlet. With these data we create a watershed-scale picture of seasonal Brook Trout movement and habitat use that could potentially be disrupted by beaver activity.

Title: **Phenology and Habitat Utilization of Spawning Brook Trout in the Little Plover River, WI**

Author: Natalie Coash, *University of Wisconsin – Stevens Point*
Co-author(s): Zach Mohr, Ben Schleppenbach, Joshua Raabe

Abstract:
Brook Trout Salvenius fontanalis are a native salmonid species within Wisconsin that require cold, high quality, flowing water. Brook Trout naturally reproduce in the Little Plover River, a groundwater dominated stream in central Wisconsin, but experienced mortalities during low flows and dry reaches from 2005-2009 caused by drought and groundwater pumping. Efforts to improve watershed health and river flows include groundwater pumping changes, wetland restoration, and riparian and channel modifications. Understanding Brook Trout spawning locations (i.e., redds), timing, and behavior would aid in identifying important locations and time periods for restoration and protection. Therefore, we conducted weekly redd surveys in Autumn 2017-2020 by walking the main passage of the river and recording redd locations consisting of at least two actively staging or spawning Brook Trout over a designated redd. Redd locations were over-laid on a simulated groundwater upwelling arcGIS map of the Little Plover River. Brook Trout spawned throughout most of the stream but redd locations varied by week and annually. In 2017, redds were denser in areas with higher groundwater inflows. In 2018-2020 redds were located upstream and at differing groundwater inflows. Varying redd locations could be due to differences in river discharge, with much higher flows in 2018-2020 potentially influencing groundwater

inflow and/or Brook Trout movement. Peak redd activity occurred during the second and third weeks of November during all four years. As water levels continue to rise over the period of study, we look into how habitat availability and quality may play a role in spawning location and possible effects on recruitment. This research provides valuable information on Brook Trout spawning behaviors and can be used to help ensure maximum benefits of restoration efforts and is part of an ongoing evaluation of the Brook Trout population and watershed restoration efforts of the Little Plover River.

Title: **Hard times ahead for Wisconsin trout streams?**
Author: John Lyons, *University of Wisconsin - Madison*

Abstract:
At the moment, Wisconsin trout streams as a whole are doing better than anytime in the last 100 years. But, unfortunately, this moment is not likely to last because of ongoing global warming. A joint federal, state, and university study of the Great Lakes Region, with substantial involvement from Wisconsin DNR and the University of Wisconsin-Madison, has projected that over the next 30-40 years, if nothing changes in terms of land-use and stream management, suitable stream habitat will decline 66% for brook trout and 32% for brown trout in Wisconsin because of a warming climate. Some of these declines may be prevented through protection and enhancement of groundwater inputs to streams and promotion of increased stream shading, but even with substantial management efforts, major trout stream losses seem almost inevitable. And if concentrations of greenhouse gasses in the atmosphere are not ultimately controlled, the climate will continue to warm beyond mid-century projections, and stream trout persistence anywhere in the state will eventually become precarious. Trout stream losses will likely not be gradual but rather will be abrupt and triggered by droughts and heat waves, expected to become more extreme under a changing climate. The last decade has been the wettest since record-keeping began, and high precipitation has increased groundwater and offset warming temperature trends and kept trout streams in good shape (and perhaps lulled us into a false sense of security). However, the inevitable future drought will put many streams at risk, and trout stream management should focus on building resilience to warmer and drier conditions.

Human Dimensions

Title: **Changes in demographics and distribution of Wisconsin anglers during the COVID-19 pandemic**
Author: Ashley Trudeau, *University of Wisconsin – Madison*
Co-author(s): Ben Beardmore, Gretchen Gerrish, Greg Sass, Olaf Jensen

Abstract:
The COVID-19 pandemic has resulted in social and economic hardship nationwide. Outdoor recreational activities, however, have remained popular among Americans. Recreational fishing is one obvious choice of activity for anyone who wishes to spend quality time outdoors and away from crowds. The pandemic may therefore be influencing rates of participation, the demographics of recreational anglers, and the intensity and distribution of recreational fishing effort across fisheries landscapes. For example, recruitment, retention, and reactivation (RRR) efforts of natural resource agencies may receive a boost from pandemic-driven increases in fishing participation, especially if younger anglers are successfully recruited and retained. In addition to these potential changes in demographics, angler decision making when choosing fishing sites may be influenced by differences in potential crowding. We tested for changes in sales of short-term and annual Wisconsin fishing licenses as well as for differences in the distribution of vehicles and boat trailers among lake access points in Vilas County, WI. License sales among first-time buyers and young people increased in the summer of 2020. However, sales of fishing

licenses to non-Wisconsin residents declined, likely as a result of reduced out-of-state tourism. No overall change in vehicle traffic to lakes in Vilas County was found between 2020 and previous years, but lakes bordering public lands showed increased vehicle traffic during the first summer of the pandemic. This change in vehicle counts may be related to angler attraction to natural appearing lakes, or based on lake proximity to camping sites. The potential ecological and fisheries effects of these changes in distribution and demographics of fishing effort are unclear, but our results point towards the social importance of maintaining opportunities for outdoor recreation during times of crisis.

Title: **Sizing up angler preference for walleye size limits**

Author: Robert Holsman, *Wisconsin Department of Natural Resources*
Co-author(s): Max Wolter, Lawrence Eslinger, Joseph Hennessy

Abstract:
Regulations that specify allowable size of harvest are an important fisheries management tool especially for highly sought species like walleyes (Sander vitreus). In recent years the most common size regulation for walleyes in Wisconsin has been a 15-inch minimum size limit. Throughout the state, numerous variations to this standard have been implemented to maintain sustainable harvest opportunities in fisheries with unique circumstances including lakes in the Ceded territory, the Wisconsin River and its associated flowages, and the Lake Winnebago system. As the Department of Natural Resources revises its walleye management plan in 2021, we surveyed resident and nonresident anglers by mail and online to ascertain their preferences for walleye size limits in conjunction with their self-reported behavioral intentions to harvest walleyes of different sizes. Survey respondents indicated that catching keeper sized walleyes was the most important determinant of a successful trip, far outpacing those who wanted lots of action or those interested in trophy fish. Despite the interest in keeper sized fish, a plurality of anglers reported releasing more walleyes than they harvested among legal sized fish they caught. The results of this study generally show support for heterogeneity in approaches to managing walleye geographically, including increased application of harvest slots and protected slots. Results show anglers were most likely to harvest walleyes between 15 and 18 inches while the likelihood of keeping legal fish over 18 inches declined steadily until 30 inches where likelihood of harvest increased again.

Title: **Is that minnow in your bait bucket an invasive species? An inquiry-based activity for teaching taxonomy in college-level courses**

Author: Rob Mooney, *University of Wisconsin - Madison*
Co-author(s): Ben Martin, Jake Vander Zanden

Abstract:
Despite the importance that taxonomy and species identification have in our current understanding of ecology, evolution, and conservation of organisms, it is a challenging topic to teach in college biology courses. One of the primary reasons for this challenge is the lack of student motivation to learn organism classification and identification, which is often reinforced by curricula that do not show the practical value of taxonomic knowledge. Here we provide an inquiry-based learning activity designed to show students the real-world value of organism identification. In this activity, students relate the misidentification of baitfish to the spread of invasive species via the baitfish industry. Students role play as fish ecologists and help a bait shop owner identify the specimens in their baitfish supply and subsequently develop a strategy to ensure that the business is not contributing to the spread of invasive species. By relating the field of taxonomy to species invasions, instructors can show students that they are learning information and gaining skills that have utility outside of the classroom. We found our fisheries-based activity to be an appealing alternative to other species identification activities, especially in a course that focused on the ecology and taxonomy of Wisconsin fishes.

Title: **Angler Awareness of Ecological Relationships in Lake Michigan**
Author: Lauren Bradshaw, *Wisconsin Department of Natural Resources*
Co-author(s): Nick Legler

Abstract:
The Wisconsin Department of Natural Resources (WDNR), in cooperation with other states and agencies, regularly adjusts stocking for salmon and trout species in Lake Michigan. These management decisions are complex and made largely in accordance with available data (e.g., on prey biomass, natural reproduction), fish community objectives, management goals, and stakeholder feedback. Anglers play an important role in fisheries management, and we conducted an online angler survey to inform the WDNR Fisheries Management program regarding angler behavior and preferences surrounding Lake Michigan's salmonid fishery. The questionnaire was sent to a random sample of Great Lakes salmon/trout stamp holders and 2-day Great Lakes license holders in November 2020 and assessed angler behavior, satisfaction with salmon and trout fishing on Lake Michigan, preferences regarding various management options, and awareness of ecological relationships in Lake Michigan. Results indicate that anglers are largely satisfied with their recent salmon and trout fishing experiences on Lake Michigan. However, some management tradeoffs related to the predator-prey dynamics in Lake Michigan may not be well understood by anglers and angler perceptions sometimes differ from ecological data. These results have direct implications for how and where the Wisconsin DNR could better communicate with anglers and stakeholders to more effectively integrate science-based decision factors with angler perceptions.

Title: **Using Anglersheds to Explain Catch Rate Differences Among Local, Non-local, and Non-resident Anglers of Wisconsin's Northern Highland Fishery Research Area Lakes**
Author: Michael Lant, *Northland College*
Co-author(s): Greg Sass, Zachary Feiner, Derek Ogle

Abstract:
An understanding of angler catch rate characteristics related to proximity of residence to lakes (local, non-local, non-resident) is important for informing fisheries management. The Northern Highland Fishery Research Area compulsory creel census records zip code data from all anglers fishing Escanaba, Nebish, and Pallette lakes near Boulder Junction, Vilas County, Wisconsin. We used this zip code data to develop species-specific anglersheds (the area of influence or spatiotemporal draw of anglers to a waterbody) and compared Walleye, Muskellunge, Smallmouth Bass, and Yellow Perch catch rates among local (Vilas, Oneida counties), non-local (Dane, Milwaukee counties), and non-state resident anglers. Anglersheds varied in size and spatial density among species and lakes, with gamefish having larger anglersheds with larger numbers of anglers coming from urban areas. Species-specific angler success (fishing effort required to catch one fish) was highest for local anglers; however, non-local and non-state resident anglers were also relatively successful. Therefore, our results suggest a need to manage not only for local anglers, but also for non-local (tourist) anglers. The common assumption that local anglers have greater fishing success may not hold for northern Wisconsin sport fisheries.

Coolwater & Warmwater Species

Title: **Temporal stability of adult muskellunge abundance in northern Wisconsin lakes**
Author: Dan Dembkowski, *University of Wisconsin – Stevens Point*
Co-author(s): Daniel Isermann, Lawrence Eslinger, Thomas Cichosz, Joseph Hennessy, John Kubisiak

Abstract:

Safe harvest levels for mixed muskellunge fisheries in the Ceded Territory of northern Wisconsin are based on estimates of adult abundance obtained from mark-recapture surveys conducted over a two-year period of time. Abundance estimates are considered valid for up to two years after the initial marking period. However, muskellunge typically have low rates of population turnover, suggesting more stability in population abundance and that estimates ≥ 2 years old may have utility in setting harvest quotas. We estimated annual adult muskellunge abundance in six northern Wisconsin lakes during 2014-2020 and used extant estimates from an additional 23 lakes to evaluate interannual variation in abundance over periods of 1-10 years. Using the current approach of estimating abundance, lake-specific estimates varied substantially but due to high amounts of uncertainty around individual estimates, often did not differ significantly among years. Although the lack of statistical differences in abundance estimates among years suggests a single estimate could be used to set harvest levels for several consecutive years, observed interannual variation in abundance could be meaningful from biological and management perspectives given that mean between-year differences in abundance estimates ranged from 31% (for estimates made 1 year apart) to 143% (for estimates made 10 years apart) and potential exploitation that could result from harvest quotas set directly from past abundance estimates generally exceeded the maximum allowable rate of 27%. We posit that observed interannual variation in abundance may not necessarily reflect actual interannual variation in adult abundance and may instead be related to the sampling approach. We discuss an alternative approach to estimating muskellunge abundance using encounter histories of PIT-tagged individuals that may minimize variation around estimates and produce estimates more reflective of actual adult abundance.

Title: **A Management Plan for Lake Sturgeon in Yellow Lake, WI**

Author: Craig Roberts, *Wisconsin Department of Natural Resources*
Co-author(s): Gene Hatzenbeler, *Wisconsin Department of Natural Resources*
Mark Luehring, S. Ben Michaels, and Adam Ray, *Great Lakes Indian Fish and Wildlife Commission*

Abstract:
Yellow Lake, in Burnett County, WI is home to one of a few lake sturgeon fisheries in the Midwestern US that supports both a recreational angling and tribal fishery. However, this unique resource was being managed using an outdated population estimate from 1986. To address this concern, we utilized a Breeding return-time Jolly-Seber model to more accurately reflect the status of the current lake sturgeon population and to update the harvest quotas in the Yellow Lake system. This model utilized data collected during the spawning seasons of 2011 to 2019 from spawning lake sturgeon captured in the Yellow Lake system. In addition, we calculated total annual mortality, length frequency, and growth parameters. Average length of female and male lake sturgeon was 63.4” and 51.2”, respectively. Total annual mortality of adult sturgeon was calculated at 6.3%. The von Bertalanffy growth function (K) was 0.11 for female sturgeon and 0.17 from male sturgeon. The current population estimate was 861 adult lake sturgeon or approximately 0.4 fish/acre. This estimate resulted in an updated harvest quota of 32 fish and was split evenly between the recreational angling and tribal fishery. Further data collection will allow this model to become more precise and be adjusted on a yearly basis.

Title: **Effects of Bullhead Removal on Fish Community Dynamics in a Northern Wisconsin Lake: Project Update**

Author: Logan Sikora, *University of Wisconsin – Stevens Point*
Co-author(s): Justin VanDeHey, Greg Sass, and Greg Matzke

Abstract:

Bullheads (Ameiurus spp.) are found throughout much of the United States yet remain a relatively understudied species. However, Black (A. melas) and Yellow Bullheads (A. natalis), can dominate the biomass and reach nuisance levels in north temperate lakes, which may influence native fish community and aquatic ecosystem structure. Empirical evidence has suggested that Ameiurus spp. may be negatively influencing recruitment and abundance of some popular northern Wisconsin sportfishes (e.g., Walleye Sander vitreus and Yellow Perch Perca flavescens). To better understand the ecological role of Bullheads and potential effects on native fish communities, we are conducting a whole-lake Bullhead removal. Our study will test for biotic (e.g., fish community) and abiotic (e.g., limnological) responses associated with the manipulation. We initiated our experiment on Howell Lake (Forest Co., WI) in summer 2019 by collecting pre-Bullhead removal fish community and aquatic ecosystem data (e.g., limnology, macroinvertebrates). Beginning in spring 2020, we initiated the Bullhead removal and then removed 20,125 adult Bullheads (>4 in; 117.6 adults/acre), which corresponded to 5,327 lbs of biomass (31 lb/acre). Additionally, 145,642 juvenile Bullheads (<4 in; 851.7/acre) were removed. A total of 820 Black Bullheads collected in June, July, August, and October 2020 were used to examine seasonal diet habits. Bullhead removal and collection of fish community and limnological data will continue in 2021. Results of our study will help to further our knowledge of the underlying mechanisms related to Bullheads in structuring fish communities and aquatic ecosystems.

Title: **Effects of Climate-Induced Shifts in Hatch Timing on Early Life History of Largemouth Bass in Wisconsin**

Author: Giancarlo Coppola, *University of Wisconsin – Stevens Point*
Co-author(s): Craig Kelling, Daniel Dembkowski, Daniel Isermann

Abstract:
Largemouth bass abundance has increased in many lakes in the upper Midwest and this likely reflects trends in bass recruitment related to climate trends. Earlier hatching should translate to age-0 largemouth bass reaching larger sizes earlier, a greater occurrence of piscivory, and a higher probability of overwinter survival. Information on the early life history of largemouth bass in northern lakes is lacking and a better understanding of the mechanisms regulating bass recruitment is needed to determine how future climate trends may influence bass populations. We used total length (TL), hatch date, and diet information collected from age-0 largemouth bass cohorts in multiple Wisconsin lakes to predict how climate-induced shifts in hatch timing might influence pre-winter TL distributions of age-0 bass, prevalence of piscivory, and overwinter survival. Our results suggest that the ontogenetic dietary shift from invertebrates to fish for juvenile largemouth bass occurs at sizes that are also conducive for age-0 overwinter survival. Additionally, shifts in hatch timing of one week or more can influence the pre-winter length distribution of age-0 bass and that earlier hatching could result in more fish that are of TLs conducive to overwinter survival and piscivory. However, the effects of temporal shifts in hatch timing varied among lakes within different regions of the state (south vs. north), with fewer bass in southern lakes attaining TLs conducive to overwinter survival.

Title: **Food web response to whole-lake bass and sunfish removal in a north temperate lake**

Author: Holly Embke, *University of Wisconsin - Madison*

Abstract:
Basses and sunfishes are warm-adapted fishes that have increased in recent decades in Wisconsin. Concurrently, declines in cool-adapted species, including Walleye (Sander vitreus), have occurred but the cause is not understood. Multiple factors have been associated with these declines, including rising lake temperatures, habitat degradation, harvest, and species interactions. To quantify the role that competition and/or predation plays between increasing bass and sunfishes and the rest of the fish community, we are

conducting a whole-lake experiment to remove bass and sunfishes from an experimental lake in northern Wisconsin while measuring the response of other fishes and invertebrates. From 2018-2020, ~220,000 fishes were removed, while species-specific fish catch-per-unit-effort (CPUE) and invertebrate relative abundances were measured. Adult Walleye, Golden Shiner, and Yellow Perch CPUE increased. Overall, zooplankton declined, while some groups of zoobenthos have significantly increased, indicating fish removals have altered lake energy flows. We will continue removing centrarchids in 2021 and monitoring these populations. This information will be used to understand the conditions necessary to support self-sustaining fish populations given global environmental change.

Title: **Assessing abundance of centrarchids in northern Wisconsin lakes with different Walleye** recruitment histories

Author: Ethan Brandt, *University of Wisconsin – Stevens Point*
Co-author(s): Daniel Dembkowski, Alex Latzka, Joseph Hennessy, Daniel Isermann

Abstract:
Declining Walleye recruitment in some northern Wisconsin lakes has coincided with increased abundance of adult Largemouth Bass, but focused research has suggested that adult bass are not directly responsible for Walleye recruitment bottlenecks. Increased abundance of adult Largemouth Bass may indicate that abundance of all centrarchids has increased in northern Wisconsin lakes due to environmental change. However, standard sampling gears used by the Wisconsin Department of Natural Resources do not effectively sample small fish (< 100 mm total length), which are more likely to interact with larval Walleye than adult fish. Consequently, our goals were to identify gears that can be used to effectively sample small centrarchids and to determine if current and historical relative abundance estimates of centrarchids are related to Walleye recruitment history. Two sampling seasons were completed during 2019 and 2020 using multiple gears to target small fish. Boat electrofishing and mini-fyke nets sampled a similar range of centrarchid species; however, the effectiveness of these gears was dependent upon shoreline characteristics, which varied by lake. Thus, both gears may need to be used in conjunction to obtain a more accurate representation of the centrarchid fish community. Current and historical centrarchid abundance was not related to Walleye recruitment history and this suggests that sustained Walleye recruitment can occur in lakes with relatively high abundance of centrarchids.

Title: **Evidence for synchrony between Yellow Perch and Walleye recruitment dynamics and temporal trends in northern Wisconsin lakes**

Author: Ethan Brandt, *University of Wisconsin – Stevens Point*
Co-author(s): Zachary Feiner, Alex Latzka, Daniel Isermann

Abstract:
Walleye recruitment in the Ceded Territory of Wisconsin (CTWI) has declined, potentially because of a bottleneck occurring in the first year of life and climate-induced changes in lake environments. Yellow Perch are an ecologically and culturally important fish species in this region, but mechanisms driving Yellow Perch recruitment are unclear because of a paucity of targeted sampling. Because of their similar thermal requirements, Walleye and Yellow Perch may share similar temporal patterns in recruitment, meaning observed declines in Walleye recruitment may be cause for concern about Yellow Perch populations as well. Consequently, our goals were to determine the environmental drivers of Yellow Perch recruitment and whether it was correlated with Walleye recruitment. We predicted the probability of Yellow Perch recruitment success using age-3 Yellow Perch caught in fyke net surveys as a recruitment index across the CTWI, and used historical data to test for differences in Yellow Perch abundance among lakes with sustained or declining Walleye recruitment. Additionally, two sampling seasons were completed during 2019 and 2020 using multiple gears to target small Yellow Perch (< 150 mm total length) in 11 northern Wisconsin lakes with sustained or declining natural Walleye recruitment.

Yellow Perch recruitment was negatively related to growing degree days, similar to previous findings in Walleye. Yellow Perch abundance was also lower in lakes with declining as compared to sustained Walleye recruitment histories, suggesting that changing environmental conditions may be causing broad shifts in fish assemblages in northern Wisconsin lakes.

Title: **Otter Lake – From Winterkill to Walleyes: A Lake Profile**
Author: Joseph Gerbyshak, *Wisconsin Department of Natural Resources*

Abstract:
The fish community in Otter Lake, a 661-acre impoundment located in east-central Chippewa County, has come a long way since the lake was created in 1969. Historically a winterkill lake, Otter Lake had a thriving bullhead fishery; however, anglers desired more. With the help of government agencies, local stakeholder groups and sportsman's clubs, the lake was transformed to support a quality centrarchid fishery. Current fisheries management is focused on developing the walleye population and Otter Lake was selected to be a Wisconsin Walleye Initiative lake. Large fingerling walleye stocking began in 2013 at a rate of 10/acre and continues on an alternate year basis. Early indications show signs of a thriving walleye population supported solely by stocking. Otter Lake is no secret to anglers either. According to a recent creel survey, it receives almost five times the fishing pressure of an average lake in the Ceded Territory and continues produce quality fishing opportunities.

Potpourri

Title: **Strengthening Inferences by Complementing Traditional Fisheries Research Techniques with Genomic Approaches**
Author: Jared Homola, *Michigan Department of Natural Resources*

Abstract:
Gnomic data provide unique insights for making fishery management decisions, but inferences are often strengthened when those data are combined with information gained from traditional direct observation fisheries techniques. Amplicon sequencing and eDNA metabarcoding are two genomic approaches that are readily complemented by other data types. For instance, amplicon sequencing facilitates cost-effective simultaneous genotyping of thousands of samples, providing high resolution data for performing stock delineations and mixed stock analyses. However, when combined with telemetry or physical tagging data, researchers are better able to disentangle the unique effects of dispersal and gene flow, improving our understanding of when and why fish occupy certain habitats. eDNA metabarcoding provides a means of simultaneously detecting broad suites of taxa present in waterbodies. The relative biomass of species can also be estimated based on eDNA concentrations, which can be translated into abundance estimates if length frequency data obtained via capture-based surveys are available. Additionally, because water samples used for eDNA analyses can be collected very quickly, the communities in a large number of waterbodies can be profiled and help direct subsequent more labor-intensive netting and electrofishing surveys to the locations of greatest interest, such as those with new detections of an emerging invader. As the incoming Assistant Unit Leader at the Wisconsin Cooperative Fishery Research Unit and leader of the UW Stevens Point Molecular Conservation Genetics Lab, I will expand on these themes and others to describe my vision for how genomic tools can complement ongoing research and monitoring efforts to help inform fisheries management in the waters of Wisconsin.

Title: **Effects of Commercial Fluridone Herbicide on Non-Target Fathead Minnow (*Pimephales promelas*)**

Author: Angelo Cozzola, *University of Wisconsin – Madison*
Co-author(s): Dr. William Karasov and Dr. Gavin Dehnert

Abstract:
Fluridone is a commercial herbicide that is commonly applied at low concentrations for extended periods of time to selectively control invasive species, e.g. Eurasian watermilfoil (Myriophyllum spicatum). Although this herbicide is used directly in lakes, the impacts of environmentally relevant concentrations of fluridone exposure on non-target species is poorly understood. In order to assess non-target impacts of fluridone, we conducted a series of experiments where we exposed fathead minnows (Pimephales promelas) at different life stages to environmentally relevant concentrations of the commercial formulation Spritflo®, (0.0, 3.0, 12, 25, and 100 ppb fluridone). Fluridone exposure significantly increased hepatosomatic index at 100 ppb ($P < 0.05$) and significantly increased nuptial tubercle counts, a secondary sex characteristic, at 25 ppb ($P < 0.05$) in adult fathead minnows. Additionally, fluridone exposure significantly decreased larval survival at 3.0 ppb ($P < 0.05$) and significantly impacted larval behaviors such as gross movement and position preference at 3.0 ppb and 12 ppb, as well as prey capture ability at 100 ppb in fathead minnows ($P < 0.05$). Extended exposure periods to concentrations as low as 3 ppb showed significant effects on fathead minnows suggesting conflict with common fluridone applications. Future research will focus on species susceptibility and additional chronic exposure assays.

Title: **Predation by a native planktivore exceeds an invasive invertebrate's production**

Author: Ben Martin, *University of Wisconsin - Madison*
Co-author(s): Joseph Mrnak, Jake Vander Zanden

Abstract:
The long-term persistence of an invasive species depends on the biotic and abiotic conditions of the recipient ecosystem. Predation by native species represents a major barrier invasive species must withstand in order maintain an established population. In our study, we focus on the apparent disappearance of an invasive zooplankton, spiny water flea, in Trout Lake (Vilas Co, WI). Although spiny water flea only established in 2014, we observed their population peak in abundance in 2017 and decline thereafter. As of 2020, spiny water flea's density has dropped below our detection limits, even though the lake is sampled at a high frequency and effort. Alongside the rise and fall of spiny water flea, we have observed an increase in cisco densities, especially larger individuals that are likely more capable of preying on the highly defensive spiny water flea. Given these observations, we asked whether predation on spiny water flea by cisco could exceed spiny water flea's production? Here, we estimated cisco consumption of spiny water flea with a bioenergetic approach and spiny water flea production with a production to biomass approach. Both models were calculated at the daily time scale so we could compare the ratio of cisco consumption to spiny water flea production. For both cisco consumption and spiny water flea production, we modeled several scenarios with our most conservative model including a low proportion of spiny water flea in cisco diets (0.05), a low proportion of maximum consumption for cisco (p-value = 0.1), and a high estimated spiny water flea biomass. In all of our models, cisco consumption greatly exceeded spiny water flea production. Even the most conservative model showed cisco consumption was greater than spiny water flea consumption for 92.5% of the spiny water flea season (99/107 days). Although our model results do not directly answer what happened to spiny water flea in Trout Lake, it is highly suggestive of what may have happened.

Title: **Leveraging panarchy theory to restore native food webs**
Author: Joseph Mrnak, *University of Wisconsin-Madison*
Co-author(s): Jake Vander Zanden, Greg Sass

Abstract:
Invasive species are a global concern, particularly for aquatic ecosystems. Though prevention is the single best management practice for invasive species control, detection often occurs after the species has established within a system. Post-establishment, new ecosystem dynamics and species interactions become rampant, making management efforts difficult. Here, panarchy theory can be applied to gain better insight into system dynamics by creating a framework to characterize complex natural systems as dynamically organized and structured. We reason that this theoretical framework allows for management actions (e.g., whole-lake biomanipulations) to be leveraged against natural ecosystem processes, providing a greater probability for desired outcomes. Using this framework, we discuss past invasive Rainbow Smelt control/removal efforts. We then introduce our project testing for the role of food web configuration (i.e., presence or absence of a top predator) in the restoration of native food webs and invasive Rainbow Smelt control. To accomplish this, we stocked Cisco (competitor) into Crystal and Sparkling lakes and will stock Walleye (top predator) into Sparkling Lake. Adult Rainbow Smelt will be manually removed from both systems during spring spawning. We hypothesize that greater Rainbow Smelt control and Cisco reintroduction success will occur in the system with top predators (Sparkling) than without (Crystal). Our study will have implications for future native species reintroductions and invasive species control efforts. Further, if the applicability of panarchy theory is evident, this concept may aid in the critical challenge of invasive species management. Our biomanipulations started in fall 2020. Our study will run through summer 2025.

Title: **Diets of Double-crested Cormorants in the Lake Winnebago System, Wisconsin**
Author: Ryan Koenigs, *Wisconsin Department of Natural Resources*

Co-author(s): Daniel Dembkowski, Charles Lovell, Daniel Isermann, Adam Nickel

Abstract:
Double-crested cormorant Phalacrocorox auritus Lesson (cormorant) populations have increased throughout the Great Lakes region causing concern related to the impact of cormorant predation on fish communities. A recent decline in yellow perch Perca flavescens (Mitchill) abundance within the Lake Winnebago System, Wisconsin prompted an assessment of cormorant diets to evaluate potential effects of cormorant predation on the sportfish community. Diets were collected from 883 cormorants (417 from Lake Winnebago and 466 from Lake Butte des Morts) between 2015 and 2017. Cormorant diets on both waterbodies consisted mostly of freshwater drum Aplodinotus grunniens Rafinesque and gizzard shad Dorosoma cepedianum (Lesueur). Yellow perch and walleye Sander vitreus (Mitchill) observations were infrequent, and represented <5% of cormorant diets by weight each year. Under current conditions, cormorant predation likely has minimal impact on the Lake Winnebago sportfish community, but more research is needed to assess potential impacts on Lake Butte des Morts.

Title: **Estimating Mortality of Lake Sturgeon in the Lake Winnebago System Using Traditional Age-Based Approaches and Capture-Recapture Models**
Author: Jeremiah Shrovnal, University of Wisconsin Stevens Point

Co-author(s): Daniel Dembkowski, Ryan Koenigs, Joshua Raabe, Daniel Isermann

Abstract:
The lake sturgeon population in the Lake Winnebago System (LWS) supports a culturally and economically important spear fishery. Harvest from the spear fishery is closely monitored and managed by the Wisconsin Department of Natural Resources (WDNR) through use of a safe harvest cap system that limits exploitation to 5% or lower. Harvest caps for males and adult females are based on mark-recapture estimates of population abundance that are adjusted for natural mortality rate. The current estimate of instantaneous natural mortality rate (M = 0.055) was estimated using a statistical catch at age (SCAA) model formulated using corrected ages estimated from fin rays. Correction is required because fin ray age estimates are not accurate for older fish. Mark-recapture methods can also be used to estimate mortality rates and the WDNR marks Lake Winnebago lake sturgeon captured in annual assessments with passive integrated transponders (PITs). Recapture of fish tagged with PITs provides information that can be used to estimate apparent survival and mortality rates using capture-recapture models. The primary objectives of our research are to determine if: 1) total and natural mortality rates are similar among estimation methods that rely on corrected fin ray ages or mark-recapture methods and 2) potential differences in mortality rate estimates would affect safe harvest caps for the spear fishery. Preliminary results indicate variation in mortality estimates among fin ray age correction methods as well as among mortality estimation methods. This research will provide WDNR biologists with suggestions on estimating mortality rates of lake sturgeon to improve management of this important fishery.