# AFS 150th Virtual Annual Meeting
# September 14 - 25, 2020
# Symposium: Biology, Management, and Culture of Walleye, Sauger, and Yellow Perch: Status and Needs

**Organizer: John Clay Bruner, University of Alberta**

Walleye, one of the most sought-after species of freshwater sport fishes in North America, and its "sister" species, the Sauger, have demonstrated appreciable declines in their numbers from their original populations since the beginning of the 20th century. Similarly, Yellow Perch, once the most commonly caught sport fish and an important commercial species in North America, have also shown declines. Yet, some western states and provinces are trying to extirpate Walleye and Yellow Perch where they have been introduced outside of their native range. The purpose of this two-day symposium is to present up-to-date information on the biology and management of Walleye, Sauger, and Yellow Perch, since the 2011 publication of the AFS book, *Biology, Management, and Culture of Walleye and Sauger*, the book *Biology and Culture of Percid Fishes Principles and Practices* (Springer Press, 2015), and pertinent review papers in *Biology of Perch* (CRC Press, 2016). Presentations will include topics on systematics, genetics, physiology, ecology, population dynamics, culture, recent case histories, and management practices, which will be of interest to managers, researchers, and students who deal with these important species, particularly in light of habitat alterations, population shifts, and other biotic and abiotic factors related to a changing climate.

**Three student presenters won AFS Fish Habitat Section Student Travel Awards**

**John Cannaday, Cathleen Marie Doyle, Collin J. Farrell**

**One student presenter received the J. FRANCES ALLEN SCHOLARSHIP AWARD**

**L. Zoe Almeida**

**One Postdoc received the AFS Emerging Leader Mentorship Award**

**Dr. Corbin Hilling**

**One student (not part of this symposium but giving a talk on a percid) won the AFS Best Student Paper Award**

**Aaron Coons**

**There is a recording on the AFS 2020 Virtual Annual Meeting website for AFS registrants of the LIVE DISCUSSION SEPTEMBER 23, 2020 WEDNESDAY 3:15 pm to 5 pm (Eastern Standard Time) based on the symposium.**

**The following video talks (over 8 hours of Percid Pleasurable Programming) are available on the AFS 2020 Virtual Annual Meeting website.**

**Yellow Perch #1-8.**

**1 Do Warmer Winters Threaten Southern Populations of Yellow Perch?**

Climate change is altering thermal regimes in aquatic systems worldwide, often impacting species on the southern edges of their ranges. Yellow Perch, *Perca flavescens*, a cool water species, have a patchy distribution at the southern edge of their North American range, occurring primarily in systems that provide coolwater refugia during summer months (e.g., tailwaters below hypolimnetic release dams). However, minimum winter temperatures are much warmer in these systems than in northern locations. In northern populations, egg quality is linked to overwinter thermal conditions, with long, cold winters resulting in higher quality eggs compared to short, warm winters. We explored if Yellow Perch from the Savannah River, SC required similar exposure to long, cold winters for proper reproductive development. We conducted controlled laboratory experiments and quantified spawning phenology, fecundity, egg quality, and larval quality metrics, and compared these results to other Yellow Perch populations across North America. Our results provide improved understanding of the thermal requirements for successful Yellow Perch reproduction at southern latitudes and allow for insights into how reproductive strategies and trade-offs differ across the species range.

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**2 Percids Kicking Acid: Biology of Recovered Walleye and Yellow Perch Populations in a Historically Acidified Hydropower Reservoir**

Cheat Lake was historically degraded by acidification from acid mine drainage and acid precipitation throughout the Cheat River watershed. Consequently, the fish community of Cheat Lake was largely limited to acid-tolerant species. Acid remediation efforts throughout the watershed improved water quality and Cheat Lake's fish community rebounded. Notably, an extirpated Walleye population has returned with the aid of stockings and Yellow Perch now provide a popular fishery. We evaluated the population characteristics and diets of both species to better understand their biology and support management decisions. We found both species grew faster than most other populations in developed growth standards. Yellow Perch were never stocked, but seemingly support a

healthy population. Further, we validated the existence of natural reproduction from the lake's recovering Walleye population based on young-of-year from skipped stocking years. Relative abundances for both species have increased over time and support that both species are doing well in the lake. Cheat Lake serves as a success story for the resilience of fish communities and the benefits of restoration efforts in acid-degraded watersheds. However, managers will continue to monitor populations in relation to water quality, hydropower operations, and fishing pressure to ensure the persistence of these populations.

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**3 Spawning characteristics of Yellow Perch during periods of water level fluctuations in a hydropower reservoir**

Yellow perch (*Perca flavescens*) is a unique freshwater fish species for many reasons, one of which is that they lay gelatinous eggs skeins during early spring in shallow waters. This unique life history trait makes Yellow perch eggs vulnerable to dewatering in hydropower reservoirs. This study looks at the use of spawning structures in Cheat Lake WV, by Yellow Perch in a hydropower reservoir. The objective of this study is to determine if water level fluctuations influence perch spawning. Artificial spawning structures were made from PVC pipe and artificial vegetation material. A total of 40 structures were placed over a range of depths and distances from the bank. Once spawning occurred structures were checked daily until spawning ended. Covariates were recorded for water temperature, lunar illumination, water depth, distance from shoreline,

and change in lake elevation. Logistic regression was used to analyze the data. Spawning was documented for 27 days. Over the course of the spawning event a total of 104 eggs skeins were deposited on the artificial structures. With this information fisheries biologists can make more educated decisions in proposed water level fluctuation regulations imposed on this aquatic system.

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**4 A Comparison of Aquaculture Production Methods for Optimizing Production of Fingerling Yellow Perch (*Perca flavescens*)**

Yellow Perch (YP) aquaculture has increased since the 1980's to reverse declines in wild populations and meet increased demands by anglers. Over the past 41 years, staff at the St. Marys State Fish Hatchery (SFH) in western Ohio used different methods to obtain YP eggs, support embryonic development and hatch eggs, and rear the fry in ponds to the fingerling stage for stocking. We used hatchery records from 1977 through 2017 to compare production outcomes among various rearing methods including: 1) natural vs manual spawning, 2) embryo hatching methods, 3) organic vs inorganic pond fertilization, and 4) fry duration in ponds before harvest. We found that the most reliable production of YP fingerlings consisted of placing hormone-induced females in tanks with males, hatching embryos in Heath trays, and stocking fry in ponds fertilized using liquid inorganic fertilizers. Over the course of 40 years at St. Marys SFH, adopting these methods increased harvest density of fingerlings produced from 13 ± 4 to 53 ± 6 fish·m$^{-2}$.

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**5 Evaluating a Statewide Yellow Perch Regulation for Michigan**

Michigan DNR recently evaluated a proposed statewide Yellow Perch bag limit change using creel survey data, fisheries independent assessments, and social survey data. The proposed regulation change was intended to achieve a more optimal balance between conservation and opportunity, reflecting the importance and popularity of Yellow Perch fisheries in Michigan. Our specific objectives for this review were threefold: 1) to describe the process involved in evaluating and recommending regulation changes, 2) to evaluate the potential effects – social and biological – of a specific proposed regulation change (reduction to a 25 fish per day bag limit), and 3) to provide a blueprint for future regulation evaluations in Michigan. Developing a statewide regulation that is effective across a variety of water bodies is a challenge for Michigan fishery managers, due to the vast differences in productive capacity among Michigan systems. Based on our review, we recommended a statewide 25-fish Yellow Perch bag limit for its effectiveness in terms of optimizing angler satisfaction across a range of fisheries, and balancing conservation with opportunity for Michigan resource users. We recommend a similar comprehensive review (including use of these tools and analyses) in developing other fishing regulations in Michigan.

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**6 Distribution and Abundance of Larval Yellow Perch in Lake St. Clair (US/Canada) and Adjoining Waters**

Yellow perch is one of the most sought-after species in the recreational fisheries of lakes St. Clair and Erie and is commercially important in lakes Huron and Erie. Long-term ichthyoplankton surveys revealed high densities of larval yellow perch originating from Lake St. Clair drifting through the Detroit River to Lake Erie. Genetic/microchemistry analyses showed that these fish greatly contribute to the western Lake Erie stock. We examined the distributions of larval yellow perch in Lake St. Clair to identify potential spawning and nursery areas and ecological factors influencing their early life history. We employed a weekly lake-wide sampling program in 2018 using paired bongo nets to sample pelagic larvae at 48 sample locations beginning in mid-March before they had hatched and continuing through mid-July when larvae were absent from samples. Yellow perch first appeared in samples on 08 May when lake temperatures reached 10°C and quickly peaked in density (14–21 May; 10–13°C). Density hotspots were present along the Canadian shore and northwest Lake St. Clair and were significantly correlated with areas containing high submerged plant biomass. Analysis of 2019 samples (in progress)

may reveal interannual differences in spatial/temporal larval yellow perch distributions in Lake St. Clair.

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**7 Yellow Perch Population Characteristics in Wisconsin Lakes**

Yellow perch *Perca flavescens* are one of the most ubiquitous panfish in Wisconsin and are highly sought by anglers fishing Wisconsin's inland waters. In addition to their role as a sport fish, yellow perch are also an important prey item for larger piscivores that support important fisheries of their own. Despite their recreational and ecological importance, relatively little is known about the status (i.e., demographics and dynamics) of many yellow perch populations in Wisconsin. Consequently, we evaluated population size and age structure, growth, recruitment, and mortality of 33 Wisconsin yellow perch populations and explored whether populations could be grouped into discrete categories based on similarities in population characteristics. Preliminary results suggest a

continuum of population types with substantial variation in demographic characteristics and rates of growth, recruitment, and mortality. Additional analyses will investigate relationships between yellow perch population characteristics and local- and landscape variables to determine drivers of perch population structure.

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**8 Assessing Abundance of Centrarchids and Juvenile Yellow Perch in Northern Wisconsin Lakes with Different Walleye Recruitment Histories**

As Walleye recruitment has declined in many northern Wisconsin lakes, adult Largemouth Bass abundance has increased. This may indicate abundance of all centrarchids has increased, but standard sampling gears used by the Wisconsin Department of Natural Resources do not effectively sample small fish (< 100 mm total length), which may interact with larval Walleye. Yellow Perch are another important component of these fish communities, yet perch recruitment data is lacking becausetargeted sampling is not conducted. Consequently, our goals are to identify gears that sample small centrarchids and Yellow Perch and to determine if current and historical relative abundance estimates for these species are related to Walleye recruitment history. I completed one sampling season during 2019 and will sample additional lakes in 2020 using multiple gears to target small fish. We will also assess the validity of a qualitative approach for estimating abundance of small centrarchids using observations made during boat electro fishing surveys. We will develop composite indices of centrarchid and juvenile Yellow Perch abundance and determine if those indices vary among lakes with different Walleye recruitment histories. Finally, we will use historical data from numerous lakes to assess whether centrarchid abundance was related to subsequent Walleye recruitment history.

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**Sauger #9**

**9 Sauger restoration in the upper Allegheny River, New York**

Sauger (*Sander canadensis*) were historically common in the Great Lakes, St. Lawrence River and Lake Champlain watersheds in New York State, but are now considered critically imperiled and in need of reintroduction. Sauger occur in the lower Allegheny River in Pennsylvania but upstream expansion into New York is blocked by the Kinzua Dam. Thus, in 2014 the New York State Department of Environmental Conservation (NYSDEC) began a stocking program to establish a self-sustaining Sauger population in the upper Allegheny River watershed. From 2014-2019, over 20,000 fingerlings and 700,000 fry were stocked in the Allegheny Reservoir and upper river. Annual NYSDEC fall boat electrofishing catch rates indicate good survival of multiple year classes. In addition, growth rates were high, with Sauger reaching 15 inches by age 3 and 21 inches by age 5. Successful recruitment combined with rapid growth has established an adult population likely capable of supporting reproduction. The occurrence of hybrid Saugeye during 2019 surveys provides the first evidence that Sauger are attempting to spawn. Despite challenges with hatchery production, unpredictable sampling conditions, and multi-jurisdictional management implications, preliminary results are encouraging and stocking is expected to continue through 2023.

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**Walleye #10-27.**
**10 Population Genetic Structure of Walleye in the Eastern Highlands and Adjacent Regions**

Walleye *Sander vitreus* populations across their eastern native range were screened to better understand evolutionary history and to inform fishery management. Population genetic variation at eight microsatellite loci supported differentiated stocks in Alabama, Mississippi River, the Eastern Highlands (New and Ohio rivers), and Great Lakes drainages. The geographic pattern of population genetic differentiation was consistent with a history of recolonization from glacial refugia in the lower Mississippi, Alabama and upper Teays drainages, with secondary contact and anthropogenic impacts from stocking. All estimates of effective numbers of breeding individuals were under 25, and all populations had ~15-20% inter-individual relatedness, likely effects of both unequal reproductive contribution and stocking. The New River population appears as a mixture of native and several stocked gene pools, and the upper Tennessee drainage populations as mixtures of native, Kentucky and Lake Erie stocks. We recommend that any stocking of walleye be restricted to restoring native gene pools.

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**11 Using Genomic Data to Guide Walleye Management in the Great Lakes**

New genomic resources for Walleye are being developed at a rapid pace making it difficult to know what resources are available of new studies. Between 2015 and 2020 we have developed one GT-seq (genotyping-in-thousands) panel and two RAD-capture (Rapture) panels. With these resources, we have genotyped over 5,000 Walleye from across the Great Lakes, Wisconsin, and Minnesota. Here we present a summary of the results already generated by these resources and discuss best practices for their application in future studies. In 2018, we identified complex population structure and stocking history of Walleye in Minnesota and Wisconsin using a 600 loci GT-seq panel. In 2019, we described the mixed-stock structure of Walleye harvest in the Eastern Basin of Lake Erie for the first time using a 12,000 bait Rapture panel. Presently, we are using a 100,000 bait Rapture panel to define the genetic stock structure of Walleye from 30 spawning sites across the Great Lakes. The marker panels used in these studies are already available and can be modified for use in new systems to identify population structure, estimate stock composition, evaluate parentage, and inform hatchery practices.
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**12 Dangers in cartography: the complicated case of Walleye designation in Montana**

Walleye *Sander vitreum* has long been designated as a nonnative species in Montana; however, in late 2018, the status was called into question after Walleye advocates presented information to suggest otherwise. Walleye distribution figures from peer reviewed literature depicted the species' native range to include large portions of Montana. While the inherent objectives from the literature presented were not focused solely on zoogeographical distribution of Walleye, and while no details specific only to Montana were found, the question of native/nonnative status was taken seriously. As such, an exhaustive review took place to verify the proper species' designation in the state. Ultimately, the review highlighted the species' absence in historical fish collections, lack of pre-glacial fossil records in the area, and a timing and extent of major zoogeographic processes that may have prevented the establishment of Walleye in Montana. No change in Walleye status was found to be warranted, although the repeated discrepancy highlighted in presented information made a complicated issue apparent; communicating the application of fisheries science to the general public needs improvement. If we as fisheries professionals are to retain the public's trust in managing our aquatic communities, we must provide accurate information and place that information into context.

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**13 Expansion of an Introduced Walleye Population in Western North America**

Walleye abundance rapidly expanded in the Pend Oreille drainage of northern Idaho following illegal introduction. Fall Walleye index netting was used to describe Walleye population expansion and life history characteristics in the system. Netting surveys were implemented on a three year rotation, completed in 2011, 2014, and 2017. Catch rate increased exponentially from 1.4 to 4.3 fish/net over the six year monitoring period. Population expansion was aided by fast growth, robust body condition, and early age-at-maturity at or near the biological maxima for Walleye. Mean length at age-2 varied among surveys for female (359 – 441 mm) and male (358 – 426 mm) Walleye. Relative weight varied from 91 to 98. Walleye matured at one to four years of age. We observed increasingly consistent recruitment as abundance increased, also aiding population growth. The expansion of this Walleye population may negatively influence the existing salmonid-based fish community and associated fishery in this system. Continued monitoring of this population will provide an evaluation tool for management actions aimed at controlling the expansion of Walleye into the future.

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**14 Does Ploidy Affect Mercury Bioaccumulation in Walleye?**

Mercury, a potent neurotoxin, bioaccumulates in aquatic organisms. Reducing mercury concentrations in fish is complicated by biophysical processes, and alternative strategies are needed. We compared mercury bioaccumulation in triploid and diploid Walleye *Sander vitreus* in Narraguinnep Reservoir, Colorado. We explored three potential explanations for the observation that diploids, when averaged over sex, had significantly higher mercury concentrations than triploids (difference = 13%, $p = 0.0396$): differences in diet, growth, or growth efficiency. Stable isotopes did not support diet differences. At age-10, somatic weight was 9% higher for diploid females relative to triploid females, while the difference between diploid and triploid males was minimal (0.7%). Triploids of both sexes showed considerably lower reproductive investment; this may have increased their growth efficiency and decreased bioaccumulation. During the spawning season, gonadosomatic index (GSI) for diploid males (0.024) was nearly 10x that of triploid males (0.003), while GSI for diploid females (0.133) was more than 40x that of triploid females (0.003). Bioenergetics modeling showed that diploid females had to consume more food (and therefore mercury) than triploids to compensate for their higher reproductive investment. From a public health perspective, stocking triploids could be a valuable tool for mitigating mercury bioaccumulation in harvest-oriented recreational fisheries.

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**15 Walleye Management in Saskatchewan: Past, Present and Future**

Saskatchewan has an estimated 50,000+ fish-bearing waters. Utilization of this resource is diverse and includes sustenance harvest by First Nations and Métis people for food and tradition, recreational anglers, commercial fishermen and outfitters. The Canadian National Angler Survey, conducted every 5-years, has identified Walleye, *Sander vitreus*, as the leading species caught and harvested by anglers. From the 1950's to early 1980's, Saskatchewan experienced considerable growth in recreational angling. As a result, multiple regulation changes were implemented across the province. The current general Walleye bag and possession limit is 4 (including only 1 over 55 cm) with more restrictive regulations on select waters. Walleye stocking peaked during the 1990's, averaging close to 40 million fry and 300,000 fingerlings per year. Over the past eight years, an average of 10.2 million fry have been stocked annually with efforts to heighten biosecurity during egg collection activities, implement both standardized stocking rates and frequency. Commercial harvest of Walleye peaked in the 1960's, averaging 946,027 kg and 178 waters per year. By the late-1980's, individual species commercial quotas were established to support sustainability. Since 2010, annual commercial Walleye harvest has averaged nearly 580,000 kg and 123 waters.

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**16 Recirculation Aquaculture Systems for Walleye Production from Egg to Advanced Fingerlings**

Iowa Department of Natural Resources fish hatcheries rely on surface water sources for Walleye (*Sander vitreus*) advanced fingerling production in single-pass systems. Aquatic invasive species are present in these water sources as well as some pathogens. Recirculating aquaculture system (RAS) technology with secure water sources is one solution to these challenges. Pilot-scale RAS was built at the Rathbun Fish Culture Research Facility for egg incubation, larviculture, and growout, where established Walleye production methods are applied to RAS. The incubation RAS produced 2.8 million fry with 62% survival to hatching. The larviculture RAS produced 121,555 fingerlings to 1.0 g size with a 75% survival rate. The grow-out RAS produced 8.4 g fingerlings with a 79% survival rate. In the final grow-out phase 16,582 fish were produced (96 g, 219 mm) with a survival rate of 91%. This was the first trial using RAS systems and municipal water for Walleye culture from egg fertilization to advance fingerling at this facility. Several bacterial and protozoan pathogens frequently infect Walleye during intensive culture in surface water. However, except for an outbreak of

bacterial gill disease, none of these diseases were observed on fish reared in RAS during the 2019 trial.

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**17 Large scale intensive culture production of Walleye *Sander vitreus* fingerlings in a Recirculating Aquaculture System (RAS)**

There has been an identified need to develop large scale production methods for phase I larviculture of walleye (*Sander vitreus*), R.C. Summerfelt et al (2011). Since 2011, intensive culture of walleye fry/fingerlings has been conducted at Ed Weed Fish Culture Station in Grand Isle, Vermont. Large scale intensive culture production has been the goal from the facility's program inception to supplement existing extensive pond culture efforts of fingerlings for sports fishing restoration. Tank volumes of 1,940 liters are currently being used in a RAS system dedicated exclusively for intensive walleye culture. Proof of concept techniques have been applied with successive production years to duplicate identified advances related to feed and feeding rates as well as various rearing environment conditions.

After two successive years of trialing four self-cleaning tanks (2018 and 2019), all eight tanks within the system as of 2020 are now self-cleaning, providing optimum rearing conditions. The blending of two closed formula dry diets through the entire culture run has also been continued to be applied since 2017. Larviculture survivals from day one post hatch (1dph) through 34dph in excess of 60% are being achieved averaging 50mm in length, providing recruitment to the fishery that can be documented.

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**18 Effects of Fungicidal Hydrogen Peroxide Treatments on the Hatching Success of Walleye Eggs and the Growth of Oomycete Pathogens**

Infections of Walleye eggs by organisms of the family Saprolegniaceae have been implicated in instances of poor hatching success experienced by the Georgia Department of Natural Resources. In 2018 and 2019, the effectiveness of various hydrogen peroxide treatment regimens on the hatching success of incubating Walleye eggs was tested at an experimental hatching facility at the University of Georgia, Athens, GA. Each combination of three hydrogen peroxide concentrations (100, 250 or 500 mg/L) and two exposure frequencies (once or twice daily) were tested in triplicate along with a sham water treatment. Results showed a significant effect of treatment concentration on hatching success in 2018 but not in 2019. Specifically, in 2018, eggs treated with 100

mg/L hydrogen peroxide hatched at a higher percentage (18.5 ± 3.69) than every other treatment concentration (mean range 0.02-4.58; $p$ = 2.65e-4). Treatment frequency and the interaction between concentration and frequency did not affect hatching success in either year. Quantification of zoospores during both experiments based on qPCR methodologies did not align with observed hyphal growth and was unaffected by any hydrogen peroxide treatment. DNA sequencing of hyphae revealed that *Aphanomyces laevis* is a naturally occurring pathogen associated with Walleye for the first time.

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**19 Larval growth and size-selective predation as potential drivers of Walleye recruitment**

Understanding early-life growth can provide insight into the conditions promoting recruitment to the adult population. To determine the extent to which juvenile Lake Erie Walleye (*Sander vitreus*) performance (i.e., growth, recruitment) is established by conditions experienced earlier in life (i.e., immediately post-hatching), we evaluated evidence for growth-selection and compared growth rates during the first 15-d of life among years with variable recruitment (1994-1999, 2011-2013, 2016-2018). We hypothesized years of poor recruitment would result from either overall slow early growth rates or from high early predation pressure (evidenced by selection against slow-growing individuals). Thus, strong recruitment would be predicted only during years of overall fast growth and the absence of selection against slow-growers. Preliminary results support our prediction; poor recruitment occurred during years in which we observed slow overall growth or selection for fast growers (2011-2013, 2016), whereas fast growth occurred during years with strong recruitment (2017-2018). We found an early-growth threshold of 0.17 mm/d, below which recruitment was consistently poor. Our analyses indicate the conditions experienced by larvae during early life can strongly influence individual survival and cohort recruitment. We are expanding this analysis to include 2019 and to evaluate what conditions drive early growth rates.

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**20 Mixed Stock Assessment and Movements of Green Bay Walleye**

Management of Walleye fisheries in Green Bay is complicated because fish spawn in many locations, but movements and the spatial distribution of fish spawning in different locations have not been thoroughly evaluated. Consequently, we implanted acoustic transmitters into 339 adult Walleye (≥ 457 mm TL) during fall 2017 and spring 2018 and are monitoring movements until June 2021 using an array of 192 stationary acoustic receivers positioned throughout Green Bay and its tributaries. Our objectives are to determine if 1) mixing of Walleye spawning in southern and northern Green Bay is apparent, 2) stock contributions in different areas of Green Bay vary among seasons, and 3) Walleye spawning within a region or specific tributary exhibit spawning site fidelity. Preliminary results suggest that Walleye fisheries in southern and northern Green Bay are primarily supported by fish spawning in or near each region with little mixing and that annual spawning site fidelity was approximately 85% among sites. Additional analysis will provide better resolution of fishery contributions and greater insight into seasonal movements and spawning site fidelity.

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**21 Seasonal Movement and Distribution of Walleye in a West Virginia Hydropower Reservoir**

Recently, Walleye were re-established in Cheat Lake, WV after decades of water quality impairment. However, little is known about the spatial ecology of this population. Seasonal movement and distribution patterns of Walleye in Cheat Lake were monitored using acoustic telemetry. In late winter/early spring, Walleye made upstream migrations to spawning areas in response to elevated water temperatures. Male Walleye were more likely to make upstream migrations earlier than females. Spawning occurred in shallow, riffle-run habitat in the headwaters of Cheat Lake. Spawning location and timing suggested susceptibility of eggs to dewatering due to hydropower driven lake level fluctuations. Although most females made post-spawn migrations back to the main lake in spring, most males did not make post-spawn migrations until fall. By fall, most Walleye returned to main lake areas and remained there throughout winter. Results suggest that both environmental factors and sex can influence movement and distribution

of Walleye in Cheat Lake. Specifically, large-scale movements were largely driven by changes in water temperature. Males and females also exhibited substantially different movement patterns and seasonal distribution. Knowledge of these spatial patterns will aid in management of this re-established population.

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**22 Managing Minnesota's 10 large Walleye Lakes in the Face of Climate Change and Invasive Species**

With a combined surface area of more than 825,000 acres, Minnesota's 10 largest lakes account for about 40 percent of the annual statewide Walleye harvest and make a significant contribution to the $2.4 billion spent each year on fishing in Minnesota. These lakes cover a broad range of size and other lake characteristics. The preferred habitat of Walleye, low water clarity and cool water temperatures, make them vulnerable to the effects of climate change and aquatic invasive species. Currently Minnesota's 10 largest Walleye lakes are in various stages of invasion by a variety of AIS, most notably Zebra Mussels and Spiny Waterfleas both of which have been shown to affect Walleye populations via multiple pathways. In addition, the warming climate has reduced the length of the ice-cover period, altered growing seasons, and increased peak summer temperatures. As a result, Minnesota's largest Walleye lakes are undergoing changes in water clarity and temperature. The observed effects of these changes vary among the lakes depending on factors, such as, baseline lake conditions and inherent lake characteristics. As a result management responses need to be lake specific. A key component to successful management is educating stakeholders and creating realistic expectations.

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**23 Managing Tribal Fisheries and Employees on the Reservation**

Tribal natural resource management agencies continue to provide employment opportunities within the fisheries field, and while much is known about Western ways of managing fisheries, tribal culture and its views on fishery management are largely unknown to non-natives. Thus, fisheries management on tribal reservations can present a set of unique challenges for fishery managers who are unfamiliar with the tribal aspect of natural resource management as well as the sovereign status of tribes and their ability to set their own regulations. In this presentation, we give guidance on how to prepare to work for a tribe, effectively manage employees, create fishery regulations, and maintain open communication within the tribal community. Working for tribes and managing their fisheries can be a life changing and rewarding experience. Therefore, it is beneficial to discuss the phases that many tribal employees experience (optimism, frustration, burnout, acceptance) and how to mitigate the frustration and burnout phases. This presentation aims to inform those who are interested in managing tribal fisheries so that they're better prepared to effectively manage fish populations and make a positive impact within tribal communities and workplaces.

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**24 Seasonal habitat, temperature, and depth of adult and juvenile Ogaa in Mille Lacs Lake**

Since 2000, thermal-optical conditions in Mille Lacs Lake have changed and adult Ogaa stocks have declined along with catches of juvenile Ogaa (age-0 and age-1). We hypothesized that a decrease in the volume of optimal Ogaa thermal habitat (~68° F) may be bringing juvenile and adult ogaa into closer proximity, potentially resulting in higher cannibalism. The objectives of this study were to: 1) assess the thermal niche of juvenile and adult Ogaa across seasons, 2) identify aquatic habitats that are key for adult and

juvenile life stages, and 3) identify temporal, spatial, and thermal overlap of juvenile and adult ogaa habitats. We used a stationary acoustic telemetry array with receivers that monitored juvenile and adult Ogaa which were implanted with temperature and depth transmitters. Additionally, light and temperature loggers were placed throughout the lake and bottom substrate was mapped to identify lake habitats. Overall, this study will provide insight into how habitat of juvenile and adult Walleye change seasonally as well as identify when they are in closer proximity to one another.

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**25 Can you hear me now? Design considerations for large lake, Multi-beings/Species Telemetry Projects**

Whole-lake telemetry projects that track movements of multiple beings/species are becoming more common as managers strive to understand food-web dynamics in changing ecosystems. Here we outline the steps we took to design a multi-species telemetry array for several life stages of fish in Mille Lacs Lake (536 $km^2$), Minnesota. First, we conducted range tests in different habitats with three VEMCO tags (V7, V13, and V16) of suitable size for abdominal cavity implantation in juvenile and adult Walleye, adult Northern Pike, adult Yellow Perch, and adult Tullibee. Second, we modeled efficiency and effectiveness of the different tags in virtual fish on high or low power settings that randomly swam in a 3 km gridded-array. Third, we evaluated the biological and physiological effects of using tags that weighed more than 2% of the fish's body weight (a commonly accepted guideline) by conducting behavioral assays and wound healing evaluations on juvenile Walleye in a wetlab. Together, these projects optimized the design of the telemetry array and guided our tag selection. We recommend all managers consider similar "pre-game" projects prior to initiating a whole-lake movement study.

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**26 Do Ogaa (Walleye) Stock-Recruitment Data Tell us Anything?**

Stock-recruitment data for Ogaa, are notoriously variable, making it difficult for managers to determine appropriate stock target levels. Theoretical Ricker and Beverton-Holt curves rarely fit these data well, especially when the range of stock sizes in the dataset is small. We conducted a meta-analysis of stock-recruitment relationships on a large dataset of estimates of adult walleye abundance, and subsequent catch of age 0 Walleye in fall surveys to evaluate stock-recruitment relationships on naturally reproducing **W**alleye waters in the WI Ceded Territory. Our objective was to answer three questions: 1. Is age 0 Walleye production best at low (under 2 adults per acre), medium (2-4 adults per acre), or high (over 4 adults per acre) adult densities? 2. Is the probability of year-class failure lowest at low, medium, or high adult densities? 3. What

is the minimum stock density for successful natural reproduction in Ceded Territory waters? High density populations produced the best year-classes and had the lowest probability of year-class failure. Walleye populations smaller than 0.8 adults per acre were unlikely to produce a good year-class. Overall, increased adult density could help improve recruitment and reduce the frequency of failed year-classes.

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### 27 Can an index of juvenile abundance provide advance warning of population decline?

Walleye year-class strength in exploited populations is often highly variable. While a single poor year-class can commonly occur as a result of sub-optimal environmental conditions in an individual year, several consecutive weak year-classes are likely to result in a population decline. Such a decline was documented in Mille Lacs Lake, a 132,500 acre walleye lake in central Minnesota on the western edge of the 1837 Ceded Territories. A single metric that identifies weak upcoming recruitment could be helpful in recognizing and softening upcoming population declines by giving managers time to modify regulations to provide additional protection to existing adult stocks. We developed an index of juvenile abundance for Mille Lacs Lake that included Walleye from ages 0-3. This index uses standardized scores (such as median catch per effort) for each year-class, and combines these scores into a single index. In our Mille Lacs

example, index values of less than one indicate poor incoming recruitment. This index could be modified for any population where juvenile year-classes are surveyed, and used in fisheries where knowledge of future adult abundance is useful. The recruitment index provides additional information for fisheries managers to consider when setting regulations.

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**Three more talks on Walleye in Other symposia and the Best AFS Student Paper (talking on a percid naturally!)**

1. **Michigan Walleye Populations Differ in Their Metabolic Response to Warming**

**Abstract:** Temperate lakes have historically provided habitats for cool-water fishes like Walleye (*Sander vitreus*), a commercially and recreationally important inland lake species in the Great Lakes region. Recent warming has led to declines in Walleye which are expected to be exacerbated by projected 2-5°C increases in lake temperatures over the next 50 years. Metabolic rates and aerobic scope reflect a species' basal energy demands and the number of oxygen-demanding processes that can be performed simultaneously and so constrain a fish's function in an ecosystem. To understand, mechanistically, their responses to climate change, we used static chamber intermittent respirometry to measure the metabolic rates and aerobic scope of fall fingerlings from Michigan's Upper (UP) and Lower (LP) Peninsula stocks under thermal regimes reflecting current and projected temperatures. During acute temperature exposure, both stocks saw increases in standard and maximum metabolic rates, leading to constant aerobic scope across temperature treatments. After acclimation, metabolic rates decreased but to different extents: the LP fish's rates returned to near-original levels, but the UP fish's standard metabolic rates remained slightly elevated. These findings suggest that some Michigan stocks may have resilience to warming and observed declines in Walleye populations may reflect differences in the stocks' metabolic plasticity.
**Authors:** **Kelsey Lucas** University of Michigan, Scott Jackson University of Michigan, Kevin Wehrly Institute for Fisheries Research, Karen Alofs University of Michigan

2. **The Implications of Intraspecific Variation in Walleye (*Sander vitreus*) Populations: A Sensitivity Analysis of Two Bioenergetics Models**

**Abstract:** Bioenergetics models are commonly used within fisheries management to predict and understand growth of fish populations. However, these models have a history

of inaccuracy when applied to natural populations. One potential source for this inaccuracy comes from using a single value for a species' trait that may not capture intraspecific variation present in a population. For example, single values are used for describing a species' rate of respiration whereas studies have shown that respiration rates between individuals of the same species can vary by a factor of three. Walleye (*Sander vitreus*), an important game fish in North America, are one such species whose models utilize single, invariant values. To investigate the impacts of intraspecific variation on current models, we conducted a sensitivity analysis on parameters used in the bioenergetics models of juvenile and adult Walleye. Based on previous sensitivity analyses of bioenergetic models in other species, we predicted that variations of some but not all of the parameters would have significant impacts on the growth of Walleye. The goal of this study is to improve our understanding of the implications of intraspecific variation within populations and its impacts on the conservation and management of a species in a warming climate.
**Authors:** **Scott Jackson** University of Michigan, Karen Alofs University of Michigan

3. **Combined Maternal and Environmental Effects on Embryo Development and Survival in Walleye**

**Abstract:** Older and larger females generally produce more eggs, but do they produce better eggs? Studies of walleye embryonic survival suggest that the nature and magnitude of maternal effects may depend, in part, on environmental conditions. We examined survival and developmental rates for embryo batches of individual female walleye of Lake Nipissing, Ontario, in relation to both maternal traits and incubation temperature. Females were spawned on multiple dates in each of three consecutive years and their embryos reared under three spring warming regimes (slow, seasonal, and rapid warming). Embryo survival varied significantly among spawn dates only in the first year, and did not vary with incubation temperature treatment in any year. Survival was more strongly related to egg characteristics than maternal age or size, and relationships between survival and these maternal traits shifted among years. Thermal units to 50% hatch ($TU_{50}$), measured as cumulative growing degree-days, tended to increase with spawn date for embryos in seasonal or slow-warming treatments but not in the rapid-warming treatment. Embryo $TU_{50}$ declined with female age and size but this relationship was also weaker in the rapid-warming treatment. Incubation temperature regime appears to influence maternal effects on developmental rate but not survival of walleye embryos.
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**<u>Winner of the Best AFS Student Paper:</u>**
**Aaron Coons**

**Habitat Associations of Longnose Darters (*Percina nasuta*) in the St. Francis River, Missouri**

**Abstract:** Longnose Darters (*Percina nasuta*) are rare across their range and endangered in Missouri. Following several extirpations, only one population is known to remain in the state. To investigate habitat associations of the last population in Missouri, an occupancy modeling framework was used to evaluate site-scale relationships and random forest classification trees were used to compare microhabitat occurrence points to availability points.

An *a priori* candidate model set was developed and the top model included both substrate and site configuration covariates. Of these, dominant and subdominant substrate size class had the greatest influence on the occupancy estimate, although confidence intervals were large and overlapped zero.

When random forest classification trees were used to compare microhabitat data, water velocity, depth, and substrate provided the most explanatory power between presence points and randomly selected availability points. These results suggest that large substrate in areas of minimal water velocity are disproportionately associated with Longnose Darter occurrence in the St. Francis River Missouri. However, these habitat associations are more strongly evident at smaller scales. Small scale habitat selection for this population is logical given the overall small spatial distribution of the species (~80 river KM) and the relative homogeneity of watershed attributes within the area.

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