S1-1

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Relations between Walleye (Sander vitreus) Spawning Habitat and Recruitment in Littoral Zones of Northern Wisconsin Lakes

The addition of rock spawning habitat to increase walleye recruitment has been an accepted management tool in Wisconsin lakes. However, an assessment of 20 artificial spawning habitat projects in northern Wisconsin showed that few projects have significantly increased recruitment. Determining which lakes would be most suitable for artificial spawning reefs is a prerequisite to managing walleye lakes and their habitat. Therefore, the objectives of this study were to develop a standardized method to quantify walleye spawning habitat in lakes and to determine the relation between spawning habitat and recruitment. Study lakes with varying amounts of walleye spawning habitat and naturally reproducing walleye populations were chosen in northeastern Wisconsin. Walleye spawning habitat was measured using three different methods: 1) direct measurement along 250 random transects, 2) direct measurement of shoreline gravel/cobble, and 3) direct measurement of the length of spawning habitat, preliminarily defined as at least 50% gravel and/or cobble substrate with low embeddedness. It is hypothesized that successful recruitment requires only a minimal amount of spawning habitat and that in most cases poor recruitment is linked to other potential limiting factors such as fish community structure, resource availability, and environmental year effects. A standardized method to quantify spawning habitat along with an understanding of the relation between habitat and recruitment will aid in determining whether spawning habitat is a limiting factor in lakes exhibiting poor recruitment.

S1-2

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Presentation

Counting Your Eggs Before They've Hatched: Sampling Protocols for Estimating the Fecundity of Walleye (Stizostedion vitreum)

Estimating fecundity is often an important component of assessing the status and reproductive potential of a population. At some level estimation of fecundity requires enumeration of eggs collected from individual fish; this enumeration process can be tedious and time-consuming when dealing with highly fecund species such as walleye. As part of a larger study examining walleye reproduction in multiple Minnesota lakes, estimates of fecundity are needed for large numbers of female walleyes (N > 100). Previous protocols used to estimate walleye fecundity were time consuming and these protocols had not been assessed to determine the relationship between the precision of fecundity estimates and the number of eggs enumerated for an individual fish. Using ovaries removed from 9 walleyes collected from Minnesota lakes we determined whether egg/ovary mass relationships varied spatially within ovaries from individual females. Additionally, we used re-sampling procedures to examine relationships between precision of fecundity estimates and the total number of eggs enumerated for an individual female walleye.

S1-3

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Potential of Osmotic Induction to Reduce the Immersion Period for Marking Walleye Fry with Oxytetracycline

A series of laboratory and pond experiments were conducted over a 3-year period to evaluate the effectiveness of pre-immersion of walleye fry in a salt solution (osmotic induction) in reducing the time necessary to produce Oxytetracycline (OTC) marks on the otoliths of walleye fry. Initial trials with pre-immersion in 1% NaCl solution for either 0, 20, 30, 60, 120, or 180 seconds followed by immersion in 700 mg OTC/L for 1 hour failed to produce consistent fluorescent marks on the otoliths of newly-hatched walleye fry. Increase of the NaCl concentration to 2.5%, the pre-immersion period to 30 seconds, and the OTC immersion period to 3 hours, however, resulted in readily visible marks on all the walleyes inspected. During the NaCl pre-immersion period, the fry became pale and lethargic but recovered quickly when transferred to the OTC solution. Both short-term laboratory and longer-term pond experiments confirmed that the stress induced during the pre-immersion NaCl treatment was indeed temporary and that osmotic induction did not increase the mortality of the treated walleye fry.

S1-4

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Retention and Detection of Calcein Marks on Extrernal Strucrtures of YOY Walleyes

Calcein is a fluorachrome dye that is used to produce external fluorescent marks on the calcified structures of fish. To evaluate the retention of calcein marks on YOY walleyes, we stocked two ponds at the Waterville hatchery with calcein treated fish. Then inspected samples of walleyes from each pond, weekly, throughout the summer with a SE Mark detector and compared the intensity of the mark with a standardized colorimetric key. At the end of the study we then collected scale samples from the ventral surfaces of known-marked walleyes to determine if scales would retain their marks when removed from the fish and stored for later inspection. Our results indicated that calcein marks on the external surfaces of walleye faded progressively over the summer, with the structures on the dorsal surfaces of the fish fading the fastest. At the end of 15 weeks, marks on many of the dorsal surfaces of the head, upper body scales, and pectoral fin were undetectable, whereas, marks on ventral surfaces such as pelvic fins, lower body scales, operculum and jaw were still readily visible with the handheld SE Mark detector. Marks were also visible on the individual scales after storage for 2 weeks in either distilled water, mineral oil, glycerol, alcohol, or dry and inspected under an epi-fluorescent microscope with a wideband blue filter set.

S1-5

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Walleye Exploitation, Population Demography, and the Effective Population Size

To minimize the risk of overexploitation, the State of Wisconsin employs a management system for the mixed walleye (Sander vitreus) spearing and angling fishery based on estimates of stock size and total allowable catch, with the goal to maintain adult walleye exploitation rates less than 35%. Research evaluating the effects of sustained 35% exploitation on the population demography of the Big Crooked Lake walleye population resulted in an increase in growth rates and a decline in age-at-maturity. Questions remain as to the potential effect changes in population demography may have on the genetic integrity of harvested walleye populations. The objective of this study was to determine how changes in the age structure of the walleye population in Big Crooked Lake influenced the genetic effective population size (Ne). Genetic analysis was performed using DNA extracted from archived scale samples collected from individual walleye cohorts before (1996 cohort) and after (1999 and 2002 cohorts) implementation of the 35% exploitation rate. Estimates of the effective number of breeders (Nb) increased from 106.9 (1996) to 185.6 (2002) leading to a subsequent increase in the Ne to census size ratio from 0.02 to 0.09, respectively. Temporal changes in Nb related to changes in population demography indicate walleye, which typically exhibit high fecundity, high juvenile mortality, and relatively low adult mortality are able to compensate for the increased adult mortality brought on by increased exploitation. Understanding how different harvest strategies influence the genetic integrity of naturally recruiting populations is essential for developing sustainable harvest policies.

S1-6

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Evaluation of a 14 to 18 inch protected slot for walleye in 14 northern Wisconsin waters.

A protected-slot walleye (Sander vitreum) regulation has been in effect on selected northern Wisconsin waters since 1996 or 1997, depending on the lake. On these lakes there is no minimum length limit for walleye but fish from 14 through 18 inches may not be kept. The daily bag limit is three walleye with only one fish over 18 inches allowed. Fourteen lakes or lake chains were surveyed before and at least four years after implementation of the regulation and adult walleye populations were estimated using mark-recapture methods. Angler creel surveys were also conducted both before and after implementation on seven lakes or chains. Adult walleye abundance remained stable, but the ratio of fish larger than 15 and 20 inches increased significantly after implementation. No significant changes were detected in angler catch, harvest or effort, but on individual lakes the length of fish in the harvest changed in response to the slot limit and changing walleye size structure. Lake-specific results suggest that strong recruitment is important in lakes where the regulation is most successful. These results suggest that a 14-18 inch protected-slot regulation can be effective in improving walleye size structure in lakes with strong recruitment.

S1-7

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Walleye forage in Mille Lacs Lake: a preliminary measure of mayfly abundance

Mille Lacs Lake in Minnesota is popular with walleye anglers and is important for Ojibwa Native American Bands. The Minnesota Department of Natural Resources (MN DNR) manages the lake using walleye population estimates and diet studies to predict future numbers of walleye and set angling harvest regulations. Burrowing mayflies of the genus Hexagenia are part of walleye diets, particularly during an annual emergence that occurs from the middle of June to the beginning of July. In collaboration with the MN DNR, we measured the abundance of mayflies to quantify their potential as a food source for walleye. As a preliminary step in June 2007, we mapped the distribution of mayflies in Mille Lacs Lake with the aid of an underwater camera along numerous transects. The presence of mayfly burrows was recorded with a GPS unit and a geo-referenced map was created. In June 2008, we sampled mayflies by using a Ponar grab sampler at randomly selected locations within the expected range of mayfly burrows. Numbers of mayflies per grab were recorded and specimens kept for verification of species identity. Correctly sampling all elements of the walleye diet will enhance the ability to predict angling catches and provide stronger tools for management on Mille Lacs Lake.

S1-8

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Evaluation of short-term gill netting to sample walleyes in a large Minnesota Lake

Monofilament gill nets set for short time periods were evaluated as a non-lethal method of sampling walleyes in Mille Lacs Lake, Minnesota. Gillnetting was conducted from 18 May 2008 through 18 June 2008 in a wide range of habitats throughout the entire lake using monofilament nets constructed of three one-hundred foot panels of 1.5, 2.0, and 2.5 inch bar measure mesh. Some nets were modified by adding meshes, typically a second three hundred foot net. Overall, 2,163 net lifts were made. Set times ranged from 10-124 minutes and averaged 38 minutes. Initial mortality ranged from 0-33% for individual net sets and overall was 7%. During the day (0600-1759) 1,466 net lifts were made, of which 1,459 were 300 ft nets and 7 were 600 ft nets. At night (1800-0559), 697 net lifts were made, of which 568 were 300 ft nets, 121 were 600 ft nets, and 8 were other configurations. Comparing only the 300-ft net lifts, 38% of the daytime lifts caught no walleyes compared to 16% of the nighttime lifts. Only 5% of the daytime lifts captured more than five walleyes compared to 20% of the nighttime lifts. Walleye catch rate (fish per foot*minute) was 2.3 times higher at night compared to daytime. Short-term monofilament gill nets proved to be a useful method for non-lethal sampling of walleyes over a wide range of habitats. Additionally, it appears that utilizing the method at night can improve efficiency.

S1-9

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Non-lethal Sampling of Walleye and Yellow Perch for Stable Isotope Analysis: A Comparison of Three Tissues

Stable isotope analysis (SIA) has become increasingly useful in identifying energy flow and trophic relationships in aquatic and terrestrial environments. SIA is currently used to address a variety of topics, such as determining dietary shifts from pelagic to benthic prey, modeling contaminant bioaccumulation in piscivorous fishes, and monitoring the effects of eutrophication on aquatic food webs. Additionally, SIA can reveal feeding interactions not detected by traditional gut content analysis. Traditionally, SIA has utilized lethal techniques which may be undesirable when working with sport fish or species of conservation. Therefore, the objective of this research was to determine if non-lethally obtained tissues (i.e., fins and scales) could be readily substituted for lethally obtained tissue (muscle) for SIA in walleye Sander vitreus and yellow perch Perca flavescens. Stable carbon (13C) and nitrogen (15N) isotope signatures were compared among the three tissues obtained from individual fish. Results from linear regression showed that 15N signatures of both fin and scale tissues were highly correlated with muscle tissue (r^2= 0.76 to 0.96) in both walleye and yellow perch. 13C values were also highly correlated (r^2= 0.75 to 0.94) between non-lethal tissues and muscles samples for both walleye and yellow perch. Variability analysis indicated that overall, isotopic signatures from fin tissue was less variable relative to muscle tissue than were scales, indicating fins may be the better surrogate tissue. The ability to readily utilize non-lethally sampled tissue for SIA of economically and ecologically important species will provide fisheries scientists with the ability to track trophic dynamics and predator-prey interactions without inflicting undue mortality or performing cost prohibitive gut content studies.

S1-10

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Modeling double-crested cormorant predation of walleye in Leech Lake, Minnesota

Leech Lake has supported a relatively large colony of double-crested cormorants since the late 1990's, with a period of low walleye recruitment coinciding with a peak in the colony around 2004. Recent management actions have led to dramatic improvements in the walleye population and its fishery. As part of a comprehensive effort to evaluate these efforts, including cormorant control measures to date, we are constructing a simulation model that combines the dynamics of the walleye and cormorant populations and the walleye fishery. Modeled components of the cormorant population include estimates of abundance and predation rates on walleye. For walleye, we were able to model both recruitment and angler fishing effort dynamically. We are also evaluating uncertainty in bird predation by comparing Type 1 and Type 3 predatory-prey functional responses. Stochastic simulation will allow us to identify key sources of uncertainty in our current understanding of the system and we are hopeful that future improvements will allow us to draw some inference on the efficacy of cormorant control scenarios.

S1-11

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Investigation of white-tail syndrome in yellow perch, walleye and two minnow species in Wisconsin.

"Whitetail syndrome" has been observed in cultured yellow perch (Perca flavescens) and walleye (Sander vitreus) in Wisconsin by numerous aquaculturists. "Whitetail Syndrome" has not been defined in the literature or in research. Fish that are affected exhibit a whitish lesion(s) in the tail area, and shortly after have been found dead. Samples were sent to the state veterinarian, and came back negative for bacterial or fungal infections. We examined two series of infected fish. The first were yellow perch (Perca flavescens), walleye (Sander vitreus),Spottail shiner (Notropis udsonius), and fathead minnow (Pimephales promelas) that were preserved in the summer of 2007 at the UWSP-Northern Aquaculture Demonstration Facility in Bayfield, Wisconsin. The second series were yellow perch (Perca flavescens) that were preserved from the summer of 2008 at the UWSP-Northern Aquaculture Demonstration Facility in Bayfield, Wisconsin and the Lake Mills State Fish Hatchery in Lake Mills, Wisconsin. The specimens were then prepared using histological methods and examined using light microscopy. All of the infected fish had a whitish lesion near the posterior area of the mid-sagital section. All lesions appeared after the dorsal fin and before the tail fin and were on the dorsal side of the fish. We have observed that the scales of infected fish in and around the lesion appear to be raised from the skin, rather than flat against the skin. We hypothesize that because of raised scales, the osmoregulatory system in affected fish may be inhibited, which could eventually cause death.

S1-12

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Blue walleye of Canada: insights into morphometric variation,age and growth, and spectral color analysis.

We describe the biology of a blue morphotype of walleye,Sander vitreus, from Ontario, Canada. The blue walleye we examined lacked yellow skin pigment and produced a novel blue protein in their skin mucous, which we described and named Sandercyanin. Gold walleye morphotypes within these same lakes also produced Sandercyanin. Solutions of the purified protein were deep blue in color and showed absorbance maxima at 383nm and 633nm respectively. Observations showed that Sandercyanin is produced in membrane-bounded structures that we believe to be mucous cells. Analyses of three years of mucus samples indicate variation in the seasonal production of Sandercyanin, with the highest quantities produced in late summer. The function of Sandercyanin is still under investigation but the protein does absorb UVA radiation and may aid in photoprotection against increased UV radiation resulting from depletion of stratospheric ozone. Morphometric comparison of color forms includes analysis of 15 head measurements and 17 whole-body landmark locations per specimen on over 200 walleye. Age and back-calculated length at age data was obtained from analysis of dorsal fin spines. In order to assess the effect of Sandercyanin on overall color, spectral analysis was conducted on both color forms using an Ocean Optics USB4000 spectrometer. Color reflectance values were obtained on 6 points, each with and without the blue mucus present. Sightings reported by fishermen to our web site bluewalleye.com, indicate that blue walleye are broadly distributed from northwestern Ontario to west central Quebec between latitudes 45 and 60.

S1-13

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Late-Summer Movements of Adult Flathead Catfish in the Minnesota River

The flathead catfish Pylodictis olivaris is a popular trophy game fish in the lower Minnesota River, and may also play a keystone ecological role as the top predator. However, little information is available to help fisheries managers conserve the abundance and quality size structure of the population. Evaluation of movement of flathead catfish across boundaries of geographically open, reasonably small study reaches is necessary to determine whether precise and accurate estimates of population abundance and density are feasible in the future, and if so, what methods of estimation are most appropriate. We focused on the late-summer post-spawning period in a 3.5 km study reach near LeSueur, Minnesota. We collected 19 adult flathead catfish by trotlining in early August, 2008, implanted them with both radio and acoustic tags, and released them within 100 m of their capture locations. We attempted to manually locate all fish regularly through the end of September. Most fish had relatively small home ranges during late summer, but nonetheless 32% of the tagged fish permanently emigrated from the study reach. Behavior of some remaining fish suggested the potential for temporary emigration. Only one tagged fish was strongly suspected to have died during the two-month period. Closed-population mark-recapture models would not be appropriate at the scale of our study reach due to the likelihood of substantial emigration even over short time periods. Open-population models might be applied successfully if the issue of temporary emigration could be overcome and high enough capture probabilities could be achieved.

S1-14

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Muskellunge Spawning Habitat: Site Characteristics and a Predictive GIS Model

Naturally reproducing populations of muskellunge Esox masquinongy are declining across their home ranges. Declines in spawning habitat have contributed to this trend. The objectives of the project were to: 1) determine important spawning habitat characteristics and 2) create a spatially explicit GIS model which predicts the location of spawning sites in each lake. Spawning sites were identified using spotlighting surveys during the spawning period and verified using egg surveys within two weeks of the spotlighting survey. The type of substrate and presence of vegetation or woody habitat were recorded at each spawning site. This study gives evidence that muskellunge spawn more commonly over sandy substrates than the existing literature suggests. There is also evidence that muskellunge are selecting for certain types of submerged and emergent aquatic vegetation. Visual surveys from a boat were used to map substrate, emergent vegetation, and submersed vegetation in water less than 1.5 m. GIS maps of surficial geology, groundwater flow potential, proximity to streams, shoreline land cover, bathymetric slope, aspect, and curvature were utilized to create the spawning habitat model. Important contributing factors to the spawning habitat model include substrate, vegetation, slope, and proximity to streams. The model provides a feasible method for management agencies to identify and protect muskellunge spawning habitat.

S1-15

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Muskellunge Recruitment Dynamics in Northern Wisconsin Lakes

The stock-recruitment relationship is one of the most important yet most difficult topics in fisheries. The relationship describes the ability of an organism to replace itself with offspring. Despite its importance, the stock-recruitment relationship can be obscured by errors in the measurement of parental and recruit abundances. In addition to measurement errors, the relationship is also influenced by recruitment variation caused by environmental conditions. The muskellunge Esox masquinongy is an important sport fish species in North America and especially in Wisconsin. Some populations of muskellunge are in decline despite a reduction in harvest rates by anglers, due largely to a growing catch-and-release ethic. My objectives were to: (1) determine if muskellunge stocking enhances natural recruitment and (2) quantify the effect of environmental variables on muskellunge recruitment. To accomplish these objectives, I used Ricker stock-recruitment models. To address my first objective, I constructed two models using data from lakes in northern Wisconsin that were stocked and lakes that were not stocked with muskellunge. Analysis of covariance (ANCOVA) was used to test for significant differences in the alpha parameters of the Ricker models. To address my second objective, I incorporated environmental variables into the models in an attempt to explain residual variance. Akaike's Information Criterion (AIC) was used to compare candidate models. This project served as an assessment of stocking success in northern Wisconsin lakes and identified and quantified environmental variables that influence muskellunge reproduction.

S1-16

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Factors Affecting Recruitment of Self-sustaining Muskellunge Populations in Northern Wisconsin Lakes

We modeled recruitment variation of age-0 muskellunge Esox masquinongy to identify factors influencing their abundance. Density-dependent along with density-independent parameters were incorporated into analyses. We developed a spatial, lake-specific model, and a regional, multiple-lake model to predict age-0 muskellunge recruitment. The spatial model explained 77% of annual recruitment variation, and predicted that bluntnose minnow Pimephales notatus abundance, size structure of the adult muskellunge population, northern pike Esox lucius abundance, and variability in May water temperature were influential in age-0 muskellunge recruitment variation. The model concluded that maximum numbers of age-0 recruits were produced when bluntnose minnow abundance was high, the size structure of the adult muskellunge population was relatively small, northern pike abundance was low, and variability in May water temperatures was low. The regional model explained 61% of annual recruitment variation, and predicted that adult muskellunge abundance, average May water temperature, and total forage abundance were significant factors in determining age-0 muskellunge recruitment success. The model concluded that maximum numbers of age-0 recruits were produced when adult muskellunge abundance was high, average May water temperature was high, and total forage abundance was high.

S1-17

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Identification of Muskellunge Management Units based on Microsatellite Genetic Data

The Wisconsin Department of Natural Resources' (WDNR) muskellunge (Esox masquinongy) management goals include preserving the genetic integrity of naturally reproducing populations. Supplementally stocking fish can negatively impact the genetic integrity of a receiving population due to introgression, homogenization, and/or outbreeding depression. Current management zones (MZ) are based on watershed boundaries and a previous study of muskellunge genetic structure. Our objective was to more accurately delineate the contemporary genetic structure of WI muskellunge and determine if current MZs represent genetic management units. Genetic diversity at 14 microsatellite loci was assessed in 43 naturally recruiting populations (n ≈ 50/population). Genetic stock identification revealed high levels of genetic diversity and 31 stable genetic groups. To determine a more acceptable management strategy aimed at minimizing genetic risk while prescribing less than 10 genetic units, we iteratively examined the formation of more inclusive genetic groups by comparing the ratio of among group genetic variance (Va) to within group genetic variance (Vb). We identified eight groups that were mostly consistent with geography and showed a ratio of Va:Vb >1. We suggest this represents a balance between genetic structure and feasible management effort. Tests of current management units (AMOVA) showed the current zones fail to represent defendable genetic management zones. Key exceptions to the current watershed scenario mostly occurred in the headwaters of the Chippewa River watershed. Possible explanations for this structuring include geological processes and propagation. Further research on this issue will include the pursuit of non-gamefish genetic structure in the region.

S1-18

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Muskellunge ancestry in stocked Minnesota lakes

The Minnesota Department of Natural Resources (MNDNR) has stocked several strains of muskellunge into native or introduced waters, but the contributions of strains to current populations was unknown. The strains derived from two Minnesota Lakes, Shoepack Lake and Leech Lake, and Wisconsin and Iowa hatcheries. The Shoepack strain was of particular interest because MNDNR discontinued stocking it when it displayed poor growth in stocked waters. We used 13 microsatellite DNA markers to determine ancestry of muskellunge in 12 stocked populations and assessed effects of Shoepack strain ancestry on fish size. Shoepack ancestry was not detected in five lakes despite years of stocking up to the early 1980's. When present, Shoepack strain ancestry was relatively low (3-18%) but appeared to affect fish size. For example, in two lakes, fish with Shoepack strain ancestry had a median length 95-170 mm less than fish without Shoepack strain ancestry. Wisconsin ancestry was relatively high, given the few years the strain was stocked, but was not detected in one lake. Iowa strain ancestry, deriving from a single year of stocking, was present in Lake Mille Lacs. Our study also revealed that considerable genetic diversity existed among native muskellunge populations in Minnesota, and is often still relatively intact. Managers can use our findings to guide efforts to reduce Shoepack ancestry where present, exclude Shoepack ancestry as a potential cause of poor size-structure where absent, and guide decisions on future stocking that may affect natural genetic structure.

S1-19

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River or reservoir? An evaluation of muskellunge stocking in a southern Minnesota impoundment.

Fingerling muskellunge (Esox masquinongy) have been stocked annually in Lake Zumbro, a southeast Minnesota reservoir, from 1993 to 2008. Muskellunge have escaped from the reservoir and established a population downstream in the Zumbro River, but the population status in the reservoir was unknown. Large frame trapnets and electrofishing have been used in the spring to evaluate the muskellunge population with little success. We used radio telemetry to determine if fish congregated in certain areas of the reservoir in spring where sampling was feasible. Ten adult muskellunge were collected by electrofishing in the plunge pool below the Lake Zumbro dam in early November 2007. Radio transmitters were surgically implanted and the fish were released above the dam in the reservoir. After spring ice-out, fish began to move as water temperature approached 10 °C and flows increased. Large frame trap nets were set in locations muskellunge frequented. A total of four muskellunge were captured, three of which had radio tags and one was a juvenile stocked the previous fall. By late April, one fish was located in the plunge pool below the dam and by late May eight of the ten tagged fish were found below the dam from the plunge pool to 21 km downstream. One other fish had moved about 13 km upstream to the riverine portion of the reservoir. Of the 10 tagged fish, nine had moved back to riverine environments by late May. We have discontinued muskellunge stocking in Lake Zumbro as a result of this study. We will be monitoring seasonal muskellunge movement and habitat use in the Zumbro River in 2009 to aid our management of this riverine muskellunge population.

S1-20
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Status of the Great Lakes spotted muskellunge reintroduction in Green Bay, WI

The Wisconsin Department of Natural Resources (WDNR) in cooperation with several local musky clubs and the Musky Clubs Alliance of Wisconsin initiated a Great Lakes strain muskellunge reintroduction program in 1989 in the Green Bay waters of Lake Michigan. Muskellunge in Green Bay were decimated during the early to mid 1900s by habitat destruction, pollution, and over-exploitation. The need to re-establish a native inshore predator fish species was identified in several planning efforts including the Lake Michigan Integrated Fisheries Management Plan and the Lower Green Bay Remedial Action Plan. A three-phase plan was enacted to re-establish a self-sustaining population of muskellunge in Green Bay: (1) identify a genetically appropriate egg source, obtain eggs, and successfully rear and stock fish, (2) establish an inland lake broodstock population, and (3) develop a self sustaining population in Green Bay. To date a total of 135,738 fingerling and yearling muskies have been stocked into the Green Bay system. Current assessments of the population include spring fyke netting and fall electrofishing. A total of 4152 fish have been tagged, using both PIT and Floy tags. Analyses of survey and recapture data provides estimates of movement patterns, growth rates, density and abundance. WDNR is using these and previous analyses to adaptively manage this population of fish, including increasing the minimum length limit and modification of stocking strategies. Future directions of this program include conducting a spawning habitat study and increasing the genetic diversity of the population by stocking fish from Georgian Bay, Lake Huron.

S1-21

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Evaluation of a Slot Length Limit for Northern Pike in Pelican Lake

Pelican Lake in northern Minnesota has a diverse fishery and a history of excellent northern pike Esox lucius fishing but recent surveys and angler reports indicated a decline in quality. A new regulation that protected fish 600 - 950 mm (24 - 38 in) was implemented in 1998. The management objective was to improve northern pike size structure during a 10-year trial period. Due to immediate public opposition, the regulation was modified in 2000 to a protected slot from 24 to 32 inches. Abundance of northern pike in 2007 was 22.2 fish/gill net, which was more than a 100% increase compared to the 1959-2001 average, and well above the 75th percentile (3.59 fish/gillnet) for similar lakes. Mean length of northern pike captured in gill nets in 2007 (21.7 in) increased 19% compared to 1995. Likewise, mean length of northern pike captured by anglers in 2007 (17.9 in) increased 7% compared to 1994. Although abundance and size increased, growth did not decline; mean total length of age-4 northern pike in 2007 was 6.5 inches greater than in 1995. Although anglers and fisheries staff agreed that the regulation was successful, some public opposition to a long-term length regulation still occurred after the trial period ended in 2007.

S1-22

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Presentation

Long-term Evaluations of Length Limit Regulations for Northern Pike in Minnesota

The effects of maximum, minimum, and slot length limits on sizes and relative abundance of northern pike were evaluated in 23 lakes. The regulations began in 1989-1998 and lasted 9-15 years. Pre regulation information was available back to the 1970's so that evaluation periods covered 21-37 years and comparisons were made with reference populations from 47 ecologically similar lakes. Although regulations did not work in every lake, the broader-scale statewide finding was that regulations improved size structure of northern pike populations but produced no consistent trends in relative abundance. Maximum length limits protecting fish over 20, 22, or 24 inches produced significant long-term increases in percentages of northern pike > 24 inches and > 30 inches compared to reference populations. The 30 inch minimum length limits increased percentages of fish > 20 inches, but improvements did not carry over to fish > 30 inches. A mix of Slot length limits produced results more difficult to interpret, but generally improved fish sizes. A meta-analysis demonstrated that length regulations in general had a very large effect. Altered size structure at levels caused by the regulations did not seem to affect yellow perch and walleye populations. Length limits protected large northern pike with the expectation that reduced yields were an acceptable trade-off for producing larger fish for recreational fisheries. This study revealed the range and magnitude of responses we can reasonably expect from length limits, as well as the substantial value of conserving large fish when the goal is improved population size structure.

S1-23

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Presentation

Comparison of relative binding affinities for trout and human estrogen receptor based upon different competitive binding assays.

The US EPA has been mandated to screen industrial chemicals and pesticides for potential endocrine activity. To evaluate the potential for chemicals to cause endocrine disruption in fish we have previously measured the affinity of a number of chemicals for the rainbow trout estrogen receptor (ER). To partially address the question of interspecies differences, relative binding affinities (RBA) for sixteen chemicals were compared among three separate competitive ER binding assays. The ERs were from rainbow trout hepatic cytosol, recombinant rainbow trout ERα, and recombinant human ERα. The two trout-based assays used displacement of 3H-estradiol from ER, and the human ERα-based assay used displacement of a flourescent ligand from ER. The RBAs determined using the trout hepatic cytosol were lower than those determined using the recombinant trout or recombinant human ERα. In all cases but one, RBAs determined using the trout recombinant ERα and the human recombinant ERα were more similar to each other, than either was to RBAs determined with the trout cytosolic ER preparation. This suggests that interspecies differences in receptors may contribute less to differences in RBAs than the differences between other parameters of the competitive binding assays. Matrix differences such as higher protein concentration in the cytosolic preparation may lead to differences in the bioavailability of a test chemical to interact with the receptor. Thus chemical parameters such as the free fraction of test chemical may be critical for accurately comparing the same endpoint among different assays. This abstract does not necessarily reflect EPA policy.

S2-1

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Presentation

A Model for Testing the Efficacy of Artificial Habitats in Fisheries Management

Artificial habitats have a presumed role in enhancing fisheries resources. Nevertheless, few reliable examples exist that clearly make use of artificial habitats as a normal part of fishery management practices, plans or protocols. This is surprising given the impression by the general public of the utility that artificial habitats have in fisheries management. A model is presented that offers a series of procedures or steps to be taken to help fisheries managers make decisions regarding species that are more likely to benefit from management plans that include artificial habitats as part of their overall management strategy. Using an attraction/production model, specific life history attributes can be identified to help select target species that directly benefit from artificial habitats. Once target species have been identified, a series of tests are applied using data gathered by implementing specific study designs and from previous studies directed toward either target or non-target species. Once a general test has been substantiated, a follow up study is implemented that specifically evaluates the efficacy of the artificial habitat as part of a management strategy. Evaluating the model relative to several fisheries will help firmly establish the efficacy of artificial habitats as a fisheries management option.

S2-2

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Presentation

Public acceptance of shoreland restorations in Minnesota

Shoreland owners in Minnesota experience social pressure to mow to the water's edge. Public acceptance of mowing suggests resistance to restoring natural vegetation to shorelines and a lack of acceptance for the appearance of restored shorelines. We evaluated acceptance of shoreland restorations among individuals in northern and southern Minnesota communities and between the public and Minnesota Dept. of Natural Resource (DNR) professionals. Close to 80% of the public interviewed accepted the appearance of restored shoreline, frequently citing their appreciation of the 'wild, natural look' of restorations. There was little difference between the opinions of northern and southern Minnesotans. Most of those interviewed did not prefer the appearance of cleared to restored shoreland. Almost 67% of the public supported restrictions against clearing all shoreland vegetation and 73% supported tax credits for maintaining shoreland vegetation. Close to 95% of DNR professionals liked the appearance of restored shoreline, supported restrictions to clearing, and supported tax credits. DNR professionals were slightly more knowledgeable than a public knowledgeable of most values of shoreland vegetation to fish populations and lake water quality.

S2-3

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Presentation

Effects of Increased Nesting Cover on Nesting and Recruitment of Smallmouth Bass in Northern Wisconsin Lakes

I studied the effects of increased nesting cover on nesting, reproduction, and first-year recruitment of smallmouth bass in northern Wisconsin lakes to determine if increased nesting cover resulted in increased recruitment. The study was designed so that there were three years of pretreatment data on each of the three treatment lakes, and three years of study after the treatment occurred (i.e., installation of nesting cover devices). The study design also incorporated the use of two control lakes (lakes that did not receive nesting devices). Analysis of the reproduction data using ANOVA showed that there was no significant interaction between treatment lake and time period (pretreatment or post-treatment), so the effects of lake and time period were able to be interpreted independently. In the treatment lakes, there was a highly significant increase in reproduction of smallmouth bass after the habitat improvement. In the control lakes there was no significant dif ference in reproduction between the periods. Because this study used pretreatment and post-treatment periods of three years and replicate treatment and control lakes, I was able to show that smallmouth bass nesting and reproduction was improved due to the increased amount of nesting cover in the treatment lakes. The results of my applied research on habitat associations of smallmouth bass have been widely used, so the results are of value in rehabilitating smallmouth bass populations and managing critical habitat for this species that has declined within portions of its native range

S2-4

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Presentation

Shoreline development and growth of largemouth bass: a cross-lakes comparison

Lake shoreline development is associated with decreases in riparian zone vegetation and littoral zone structure, altered littoral zone sediment, and increased in angling effort. Fishes of different species and body sizes may respond differently to these changes. Responses are particularly difficult to predict for species that undergo marked changes in habitat use and diet over ontogeny such as largemouth bass (Micropterus salmoides), a popular sport-fish. To quantify the relationship between shoreline development and largemouth bass growth across ontogeny we performed a cross-lakes comparison of largemouth bass size-specific growth rates from 16 lakes that span a wide range of shoreline development (0 to 45.8 buildings km -1) in Wisconsin's Northern Highland Lake District. Using a longitudinal multilevel model, the relationship between shoreline development and largemouth bass growth was identified and related to body size. Largemouth bass growth rate was positively correlated with shoreline development for fish smaller than 164 mm and was negatively correlated for larger sizes. While we cannot infer mechanism from our study, we believe the relationship between shoreline development and largemouth bass growth is likely the result of human impacts on these aquatic ecosystems in the form of both habitat manipulation as well as angling effort.

S2-5

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Presentation

Development of Multi-Dimensional Littoral Zone Habitat Fingerprints For Classification and Management of Lakes

Littoral zones can be structurally diverse among and within lakes providing a wide array of habitat for aquatic organisms. However, little work has been done to assess littoral zone structure and integrate findings into generalized management applications. In particular, research is lacking on the complexity of littoral zone habitats and how typologies can provide frameworks for lake and fisheries management. Despite the importance of littoral zone habitats and our lack of quantitative and qualitative knowledge, human alteration of littoral zone structure continues as human development in riparian areas increases. The objective of this study is to create multi-dimensional littoral zone fingerprints of lakes in order to display habitat complexity and to establish metrics for classification. We quantified littoral zone habitat in north temperate lakes along transects from shore to 3m depth; depth, size and percent substrate cover, macrophytes, and coarse woody structure were measured using snorkel gear. Multi-dimensional ordinations, or fingerprints, of habitat features display the variation in habitat occurring within and among lakes. Results indicate that fingerprints reveal clear patterns of littoral zone habitat, variation in habitat structure among lakes, and rare habitats within lakes. Applications of fingerprints for fisheries management may identify likely fish communities most suited for a particular lake based on habitat structure available in the littoral zone. Defined patterns can aid in classifying, protecting and restoring littoral zone habitats in lakes.

S2-6

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Presentation

An Integrated Approach to Road Stream Crossing restoration

Fish passage and sedimentation at road stream crossings have been identified as concerns for the Bad River watershed. To address these concerns, the Bad River Watershed Association has developed an integrated and collaborative Culvert Program with the following objectives:
1. Implement a basin wide survey of the over 1,000 culverts in the basin,
2. Develop a basin wide, systematic approach to prioritize problem road crossings with respect to fish passage and sedimentation.
3. Work with local partners to remediate problem sites by assisting with funding and/or by encouraging coordinated action between local, state and federal agencies
4. Conduct site specific monitoring to evaluate the effects of culvert restoration, and
5. Educate the community about crossing concerns and increased the knowledge and capacity of town governments to improve fish passage and habitat when doing roadwork.

To date, the BRWA and partners have inventoried 740 crossings in the basin. Critical criteria were developed to identify sites with accelerated erosion and sediment loading, or sites that create fish passage problems, or both. Results were summarized into a Needs Assessment to provide local road and fish managers with information that can be used as a planning tool for crossing replacements. A strategic plan for culvert replacements was developed that identifies priority sites, and coordinates funding and activities of local partners to fix priority sites. Monitoring protocols will be developed to evaluate the effectiveness of these installations both at a specific project site and on a broader spatial scale.

S2-7

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Presentation

Identifying strategic opportunities for road crossing improvement to benefit stream fishes

Road crossings over streams can act as barriers to fish movement, and may thereby prevent recovery of populations following disturbance and increase extinction risk by fragmenting populations. The objective of this study was to create a method for identifying road crossings whose reconstruction would most benefit stream fishes by restoring stream network connectivity. We demonstrate the method through a case study in the 2,500 km2 Pine-Popple watershed in Wisconsin. We first conducted a comprehensive field survey of road crossings in the watershed to identify crossings that are likely to impede fish movement. We then used a GIS to evaluate the influence of each crossing on the connected neighborhood size of all streams in the watershed. This measure is an index of the potential benefit of eliminating each barrier. The benefit index was then divided by a reconstruction cost estimate to create a benefit/cost ratio that could be used to prioritize projects. Sixty-seven percent of the 169 surveyed road crossings were determined to be a barrier to movement of at least some species or life stages of fish. The most common problem was a low constriction ratio (structure width/stream width). The probability of a crossing being a barrier was strongly negatively related to the size of the stream at the crossing. The distribution of benefit/cost ratios was strongly skewed, which supports the utility of prioritizing projects in this watershed. The methods developed in this study can be applied elsewhere using widely available spatial data, and commonly used GIS and database software.

S2-8

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Presentation

Effects of dam removal on fish in the Pine River, Michigan

Dam removal poses as a beneficial fisheries restoration technique, yet the extent and manner of coldwater fish community responses to removal remains unclear. We documented changes in the fishes of the Pine River, Michigan, prior to, during, and following the removal of Stronach Dam (1997 - 2007). Our objectives included documenting changes in fish distribution and abundance of brown trout Salmo trutta. Within three years of the barrier to passage being removed, 17 species of fish formerly found only below the dam were found upstream. Throughout the removal process densities of brown trout increased up to five fold within all zones of the study area. Densities of brown trout throughout Michigan also increased during the same time period yet not to the extent within the Pine River. Recruitment of brown trout increased concurrently with the increases in abundance yet recruitment success as a function of the spawning stock did not increase. Brown trout survival showed no discernible change. This long-term case study documented substantial increases in brown trout densities throughout a dam removal process in addition to showing the ability of fish to utilize newly available river reaches. The mechanism for the increases in densities remains unclear yet the massive habitat changes taking place suggest an increase in the overall carrying capacity of the study area. The physical changes resulting from dam removal can facilitate community and population level changes beneficial to a recreational fishery.

S2-9

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Eighteen Mile Creek Fish Passage Restoration

Multiple partners in northern Wisconsin worked together to restore fish passage at the junction of Eighteen Mile Creek and North Sweden Road in Bayfield County, Wisconsin. The culvert located within the Bad River watershed was both perched and a velocity barrier to brook trout and other fish passage. The Bad River watershed is a high priority for restoration and evaluation by the area's landowners, conservation organizations, government agencies and the Bad River Band of Lake Superior Chippewa. The Ashland National Fish and Wildlife Conservation Office and the Bad River Watershed Association are evaluating the status of nearly 1,100 road crossings within the watershed. The Town of Grandview, Bayfield County Land Conservation Department, Wisconsin Department of Natural Resources, and the U.S. Fish and Wildlife Service partnered to install and imbed a 12 foot diameter culvert to restore the site for native brook trout passage. This opened 16.5 miles of habitat above the barrier. Many challenges were overcome in planning and installation of the project. Assessment of the new culvert's ability to pass fish was conducted by the Ashland NFWCO, with the assistance of Northland College.

S2-10

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Presentaion

Getchell Creek Highway Culvert Trout Passage

Fish, trout in particular, have not been able to navigate past the culvert on Getchell Creek at STH 55 for a long time due to it being perched. This stream is home to a naturally reproducing population of brook trout and is a valuable coldwater tributary to the Wolf River. It is important that brown trout are able to use this stream when water temperatures in the Wolf River get warm, and also possibly for spawning. In 2005, the Wisconsin Department of Transportation (DOT) reconstructed a portion of the highway and the old culvert was replaced. Originally, a clear span bridge was recommended at this site, but the final plans called for an 8-foot concrete culvert. The new design, which was supposed to correct and allow for fish passage, also turned out to be a barrier to fish passage due to fast laminar flows over a 64-foot stretch of the culvert. Wisconsin Department of Natural Resources personnel (Environmental Analysis and Review and Fisheries) worked together with DOT to evaluate the situation and correct it. Through marking and recapture electrofishing studies, we documented that trout were unable to move upstream through the new culvert. Engineers with DOT came up with a "baffle" design that slowed water down in the 64-foot section of the culvert and created resting areas for trout. Another marking and recapture electrofishing study determined that following installation of the "baffles", trout were able to navigate through the culvert. For the first time in many decades, trout are able to access all of Getchell Creek to carry out important life history movements and functions.

S2-11

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Presentation

Response of riparian fish and invertebrate assemblages to timber harvesting in northern Minnesota streams

In forested headwater streams, instream processes and aquatic communities are closely coupled with the adjacent terrestrial environment. Timber harvesting in the adjacent forested riparian management zone has potential to disrupt the intimate connection between the terrestrial and aquatic ecosystems. We examined the response of fish communities, aquatic invertebrate communities, and stream habitat to forest harvesting treatments along nine northern Minnesota headwater streams to understand the ecosystem effects of forest management guidelines in the riparian management zone. We documented changes in aquatic ecosystems one year pre-harvest and up to nine years post-harvest. General trends indicated increases in tolerant fish, tolerant invertebrate taxa, and increases in fine sediments following the highest degree of removal of the riparian forest cover. Alternatively, water quality and other habitat parameters exhibited a large degree of year-to-year variation and did not exhibit significant ($P>0.05$) harvest effects. These results suggest that forest harvesting which leaves a minimal amount of residual timber along a stream may be adequate to minimize disruption to the aquatic ecosystem in northern Minnesota streams.

S2-12

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Presentation

Impingement studies at multiple power plants on the Ohio River and one plant on L Monona, Madison, WI

As part of a national rule-making effort, US EPA requested information regarding impingement, and in some cases, entrainment rates at the nation's roughly 450 once-through power plants. To address this request, EA Engineering conducted impingement studies at 15 power plants throughout the length of the Ohio River during 2005-2006. Second year studies were conducted at 13 of these plants. Collectively, the two-year study revealed the following:

. Impingement rates varied dramatically among plants
. Impingement was overwhelmingly dominated by clupeids (mainly gizzard shad) and freshwater drum
. Except for sauger and channel catfish, sportfish were rare
. The catch was strongly dominated by YOY fish
. Catches were somewhat higher at night
. Annual impingement estimates were driven by a few very high catch "episodes"
. Few significant correlations were found between various physicochemical parameters and impingement rates.

I will also describe results from a one-year impingement study at the Blount Street Station located on Lake Monona in Madison, Wisconsin.

S2-13

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Presentation

North American Perspectives on the Future of Recreational Fishing: Insights and Opinions from Fisheries Researchers, Managers and Anglers

Recreational fishing activity provides a suite of social, economic and ecological benefits to society, and in many regions the recreational sector is more economically valuable than the commercial fishing sector. To better understand the perspectives of various stakeholder groups in the recreational fishing sector regarding key issues related to the sustainability of recreational fisheries, we distributed a web-based open access survey to fisheries researchers, fisheries managers, and anglers in North America. Questions focused around the recently developed "Code of Practice for Recreational Fisheries", with key issues such as fish welfare, regulations, and biological impacts being addressed. Our exploratory survey provided information on the opinions of different fisheries stakeholders on contentious issues. We also assessed their perspectives on future research opportunities and priorities. For some issues the three groups had fundamentally different opinions (e.g., the goals of recreational fisheries management), however, for other issues their opinions were nearly identical (e.g., fish pain and welfare). The survey elucidated the variation in opinions and potential source of conflict among anglers and between the different stakeholder groups for some issues, but due to lack of random sampling study results cannot be extrapolated to the broader population. We conclude that attempts to improve communication and understanding between fisheries researchers, managers, and anglers are sorely needed, to ensure the sustainability of recreational fisheries and the associated industry.

S2-14

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Presentation

Population Dynamics of Bull Trout in Lake Pend Oreille, Idaho

Introductions of invasive species as well as loss of habitat and stream fragmentation have caused bull trout numbers to significantly decrease throughout their native range. As a result of this, bull trout were listed under the U.S. Endangered Species Act as a threatened species in June, 1998. Bull trout have existed in Lake Pend Oreille and its surrounding tributaries since the last ice age and the lake was once a world renowned bull trout fishery. However, non-native species introductions and stream fragmentation in the Lake Pend Oreille system have resulted in the decline of bull trout. To effectively manage bull trout in Lake Pend Oreille, population dynamics of the species must be understood. Bull trout were captured, marked and recaptured in gill and trap nets during an ongoing lake trout extraction effort. An abundance estimate was calculated using the Schumacher-Eschmeyer mark-recapture model. Mortalities caught during sampling were used to model age structure, growth and maturity. A genetic mixed stock assessment was carried out by comparing fin tissue samples to tributary genetic baselines developed at the Conservation Genetics Lab at the USFWS Abernathy Fish Technology Center in Longview, WA. This research improved understanding of bull trout within the Lake Pend Oreille system. Results suggest that current management techniques are improving the status of bull trout in Lake Pend Oreille.

S2-15

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Presentation

Central Wisconsin Trout Stream Temperature Changes Related to Riparian Vegetation

Various riparian vegetation types in Wisconsin directly influence thermal habitat in streams and elevated summer stream temperatures limit the distribution of trout and available habitat. Managing for the riparian vegetation that promotes cooler more suitable stream temperatures offers possibilities for increasing brook trout distribution and thermal habitat suitability. A range of vegetation shading (0, 50, and 75%) was modeled for the period when weekly-mean maximum stream temperatures occur. A steady state one-dimensional heat budget model that predicts the length of stream suitable to trout that could be gained/lost from a reduction/increase in solar radiation received by a stream was used. Decreasing stream shading to 0% on streams with substantial shading resulted in a decrease of thermally suitable trout water up to 97.6%. Increasing stream shading to 50% on streams with minimal shading from riparian vegetation (~10%) has been shown to increase the length of stream suitable to trout by as much as 128.6%. When 75% shading was modeled for six study streams in 2007 the temperature that weekly-mean stream temperature approaches when meteorological conditions remain the same as you proceed downstream did not exceed the trout suitable threshold of 22.3°C. When change in stream temperature per kilometer was compared among riparian vegetation types, grasses warmed significantly faster than forested stream segments. This study provides predictions of increasing the amount of water suitable to trout and creating more trout fishing opportunities statewide by managing riparian areas differently.

S2-16

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Presentation

Survival and demographics of wild brook trout and brown trout in source populations for Wisconsin's wild trout stocking program

Wisconsin's wild trout stocking program is predicated on the annual removal of an unknown proportion of reproductive output from a population of brook trout in Ash Creek and brown trout in Timber Coulee Creek. We do not fully understand how our use of these populations impacts population dynamics and hence program sustainability. We surveyed each stream in spring and autumn from 2004 to 2008 to obtain demographic data for trout populations comprising two strata: in-stream spawners and those temporarily removed for in-hatchery spawning. The number of female trout removed annually for spawning was relatively high for Ash Creek brook trout (39% to 82%) compared to Timber Coulee Creek brown trout (<20%). Average annual apparent survival was about 2.5 times higher for Timber Coulee Creek brown trout (0.38) than for Ash Creek brook trout (0.15). Multi-strata tag-recapture models showed no significant difference in apparent survival of brook trout for in-stream versus in hatchery spawners in Ash Creek. In Timber Coulee Creek, however, apparent survival of brown trout was consistently lower by an average of 25% for in-hatchery versus in-stream spawners. Annual variability in abundance, size structure, and average fecundity resulted in variable potential egg production in each stream (e.g., 47,000 to 254,000 eggs per year in Ash Creek). Recruitment, however, did not vary as a function of egg production. But annual variability in trout demographics has affected our ability to meet program objectives. I will discuss risks to the wild trout stocking program and management options for ensuring program viability.

S2-17

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Presentation

A Selective Wood Removal Method to Expose Coarse Spawning Substrate in Small Sand-laden Trout Streams

Many Wisconsin Lake Superior tributaries contain heavy sand bed loads which are retained in channels by abundant woody debris and beaver dams. A selective wood removal method has been developed and used by Wisconsin Department of Natural Resources staff in the Northern Region to specifically target the embedded spawning habitats of headwater trout streams. This study evaluated the changes induced by the novel method on sand content, channel morphology, macroinvertebrate and fish populations over one year. Primary objectives were to (1) show that the wood removal method reduced local sand content, (2) detect a significant increase in available coarse substrate, and (3) observe a positive response from stream biota. A treatment station was compared to an upstream reference station, as well as a downstream reach to monitor the effects of transferred sediment. Channel morphology measures were sampled before, and at 10 and 12 month post-removal. Macroinvertebrate and fish populations were sampled before and at 12 months post. Treatment station wood removals induced fine sediment transport, exposed underlying coarse bottom substrates, and narrowed stream widths. Numbers of fall redds and habitat for macroinvertebrates also increased over initial conditions. Reference station physical conditions were unchanged. After the treatment station wood removal the released sediment flux caused aggradation of the downstream reach, but near pre-treatment conditions returned by one year post removal. The findings presented in this study support the selective wood removal method as a viable technique for increasing spawning habitat in headwater reaches of small sand-laden trout streams.

S2-18

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Presentation

Protection of a trout stream from thermal pollution by market based trading of mitigation

Market-based cap-and-trade systems for controlling pollution have recently become popular as a more economically sound option vs. traditional regulation (e.g. sulfur-dioxide from power plants, phosphorous in lakes and rivers). Could a similar system be used to protect trout streams from thermal pollution by storm water runoff from development? The Vermillion River Watershed Joint Powers Organization, in partnership with the University of Minnesota, MN Pollution Control Agency, and MN Department of Natural Resources, received a grant from the U.S. Environmental Protection Agency to study this question. The grant allowed the study of what parameters control temperature in the stream, how different land uses affect stream temperature during storm events, and focus groups with relevant parties to discuss their interest in a market-based system.

Findings were that land uses with high impervious area (e.g. commercial) contributed the most heat to the stream, and un-shaded storm water ponds were also a significant source. Other land uses did not significantly warm the stream during small storms such as the one studied. Off-site mitigation is complicated by the tendency of water to trend toward air temperature with any travel time to the stream. Shading is not an effective best management practice for mitigating storm water runoff. Developers and municipalities were also reluctant to embrace an uncertain mitigation system. All of these factors limit the number of potential participants for trading, and make it unlikely that the market would be large enough to make such a system viable.

S2-19

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Functional constraints on nest construction by male hornyhead chub, Nocomis biggutatus, in the headwaters of the Mississippi River

Male hornyhead chub construct pebble mounds comprising thousands of individually-placed pebbles. Spawning occurs over these piles. Eggs settle into the interstitial spaces of the rock pile where they are protected from predators. Water currents that percolate through the rock pile keep the eggs oxygenated. Thus, pebble selection and nest location present nest-building males with three functional constraints: (1) pebble size - transportation: pebbles must be large enough to resist erosion by water currents but small enough to fit in the fish's mouth, (2) pebble size - internal water flow: percolation rates must be sufficient to supply oxygen, which a narrow range of conditions; if percolation rate is too slow the eggs will become silted and asphyxiate; if percolation rate is too high the eggs will be flushed from the nest, and (3) nest site location: enough current to force water percolation but not enough to erode the pebble mound and expose eggs to predators. We quantified water flow and pebble characteristics of 14 Nocomis nests in the Mississippi River at its headwaters in Itasca State Park. Nests were located in areas with significantly higher than average flow rate (29.1 ± 1.8 cm/s) and significantly deeper (34.9 ± 3.7 cm) than average water depth. On average, nests measured 35 x 26 x 5 cm for an estimated volume of 4.2 L, comprising approximately 3000 pebbles and a total (above water) mass of about 11 kg. Males selected pebbles of significantly smaller diameter but significantly higher density than pebbles in the immediate vicinity of their nest. Pebble diameter was not correlated with current speed in front of the nest. The rate of water percolation through the pebble mound, as revealed by dye tests, was 2.2 cm/s and was not correlated with current speed in front of the nest. Taken together, these data indicate that male hornyhead chub select small, dense pebbles for nest construction that resist mound erosion and provide a stable internal flow rate for oxygenation.

S2-20

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Spring reproductive potential of slimy sculpin after catastrophic August floods

We examined the possible effects of the August 2007 floods in southeastern Minnesota on the condition and reproductive potential of slimy sculpin populations in 4 streams during March/April 2008. Adult sculpin collected from each stream (Gilmore Creek, Garvin Brook, Trout Run, and Middle Branch Whitewater River) during March/April 2008 were weighed and measured to determine a condition factor, and sacrificed individuals were dissected to determine gonad (ovaries or testes) weight, liver weight, and egg number. Average egg weight, a gonadosomatic index (GSI), and a hepatosomatic index (HSI) also were determined for individual fish. Male and female sculpin from the least-impacted Gilmore Creek unexpectedly had the poorest condition ($K < 1.4$) of any stream examined. Males and females from Gilmore also had the lowest average GSI (males = 1.82%, females = 14.74%) and HSI (males = 1.47%, females = 2.72%) of any population, and females from Gilmore contained on average the fewest (220 eggs/fish) and smallest (3.7 mg wet weight) eggs. August flooding had no obvious, negative effects on the reproductive potential of slimy sculpin in streams with the most severe floods.

S2-21

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Directional sensitivity in primary utricular afferents in the toadfish, Opsanus tau

Male toadfish acoustically attract females to nesting sites by producing "boat-whistle" calls. To determine how the fish localize sound underwater, inductive neural telemetry was used to record from microwire electrodes chronically implanted into the utricular nerve of the toadfish, Opsanus tau. The telemetry tag allowed both laboratory and field monitoring of unrestrained, naturally behaving fish. The sensitivity of utricular afferent nerve fibers to male toadfish boat whistle calls and pure tone stimulus was determined in water depths ranging from 0.4 to 1.0 meters via underwater speakers. Hydrophones were placed approximately 5 cm above the otoliths to determine the physical characteristics of the sound impinging on the utricle. Approximately half the afferents fiber exhibited increased firing to sound stimulus with many showing directional sensitivity. Thus, toadfish may be able to use information from the utricular afferents to localize sound underwater.
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S2-22

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Presentation

Elucidating mechanisms that regulate the abundance of common carp populations in Minnesota lakes with implications for an integrated control of this species

This paper presents results which suggest that carp populations in interconnected lake systems in Minnesota can be explained by the propensity of migratory adult carp to exploit unstable, interconnected basins as nurseries. By studying carp movement and spawning site selection using telemetry, we have learned that as much as 40% of adult population found in relatively deep and stable lakes leave these systems each spring and move into shallow peripheral basins which frequently experience winter hypoxia and winterkills to spawn. The adaptive significance of this behavior was explained by ageing analyses which showed that carp populations are comprised of very few age classes which correlate with winterkills in the watersheds. Presumably, carp reproduce successfully only in habitats which experience winterkills and which lack predators. A survey of young-of-year (YOY) carp abundance this past summer in 12 lakes of which 6 winterkilled and 6 did not supported that hypothesis. No YOY carp were found in lakes which did not winterkill, but all lakes which did winterkill contained YOY carp, some in very high densities. Using CarpSim2.1 software, a spatial carp population dynamics model developed originally for carp populations in Australia and now adopted for carp in Minnesota using our data, we demonstrate that an integrated management of carp populations is possible, and needs to include barriers to reduce adult movement and winterkill prevention schemes.

S2-23

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Presentation

Trapping Schemes For Common Carp Control Using Pheromonal Attractants and Food

The common carp (Cyprinus carpio) is one of the most damaging fishes in North American and Australian shallow lakes, wetlands, and rivers. Present efforts to control this species focus on draining and poisoning using rotenone and neither inexpensive nor easily sustained. Pheromones, chemical signals that mediate behavioral interactions between conspecifics, have special promise for use in targeted trapping of this olfactory-driven species. We have found that common carp release at least three pheromones: 1) a male-derived pheromone which specifically attracts receptive females, 2) a female-derived pheromone which specifically attracts receptive males, and 3) a species-identifying pheromone which compliments the other cues and is released by all carp. All of these can be concentrated and purified, so chemical identification and large-scale application should eventually be possible. As a first step in developing protocols for testing these attractants in the field, we have been testing carp traps using pheromonal and food odors in the laboratory and field. Field studies suggest trap entrances must be designed to allow carp to enter without touching ($P < 0.05$) and that carp learn from trapping experiences. Recent laboratory studies have discovered that male carp can be lured into traps using a female pheromone ($P < 0.05$) but only when fully mature and that the visual image of fish accentuates activity ($P < 0.05$). Ongoing studies focus on using these procedures as part of an IPM program (Bajer and Sorensen, this conference) (Funded by the Invasive Animals Cooperative Research Centre, Australia).

S3-1

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Presentation

Adjusting Age Versus Otolith Mass Relationships for Variable Body Growth In Lake Trout

Estimation of fish age from otolith weight is gaining acceptance as an efficient alternative to traditional annuli enumeration. Generally, otolith weights serve as an age surrogate, and ages in one sample are estimated from a second aged "reference sample". These methods assume growth rates between samples are the same and will be biased when growth is spatially or temporally different. We propose a simple method based on the Templeman-Squires relationship which states: 1) for two fish of the same size the slower growing fish tend to have heavier otoliths, and 2) for two fish of the same age the faster growing fish tends to have heavier otoliths. Using the otolith weight vs total length (OW:TL) curves for each sample we calculate a growth-rate adjustment for the reference sample's linear age vs otolith weight equation. We test this method on known age lake trout (Salvelinus namaycush) sampled from four regions in western and southern waters of Lake Michigan between 2006 and 2008. Somatic growth rates among fish samples differed by capture year and capture region however an analysis of covariance suggests that neither of these factors act independent of age and fish length to affect otolith weight. We demonstrate this OW:TL adjustment to obtain estimates of the true age vs otolith weight function for two samples with differential growth rates. This new method appears to hold great promise as an efficient, less subjective alternative to annuli enumeration and also can be used to evaluate spatial and temporal changes in fish growth.

S3-2

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Presentation

Decline of brown trout in a changing Green Bay ecosystem

Wisconsin and Michigan DNR have created a brown trout fishery in Green Bay (Lake Michigan). Despite decades of aggressive stocking efforts, harvest rates and return to creel of brown trout stocked into Wisconsin waters of Green Bay have declined sharply since 2000. Despite steady stocking rates, return to creel has hovered around 1% during the past 7 years, down from 5% in the 1990s. A number of factors may be contributing to poor survival of brown trout. Bottom trawl catch per unit effort (CPE) of smelt and alewives has decreased significantly, suggesting the historical forage base is no longer available and brown trout must find alternate prey. Double-crested cormorant populations have quadrupled over the last 15 years in Green Bay, and current management practices will take several years to see results. Cormorants likely compete with brown trout for food and have been observed consuming stocked brown trout. Several recent strong year classes of walleye may also contribute to brown trout declines, as they share the same nearshore niches. Lastly, adult sea lamprey trap assessments indicate localized increases despite efforts to reduce their numbers. Besides sea lamprey, Green Bay is home to many other exotic species whose impact on brown trout and the entire ecosystem are unknown. Possible management options for brown trout include offshore stocking, stocking more yearlings and fewer fingerlings, adjusting stocking locations, or reducing the number of fish stocked to match the available forage base. Recent declines in creel harvest of brown trout in Green Bay mandate changes in management strategies.

S3-3

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Identification, population structure, and migratory dynamics characteristics of Pinook Salmon (Onchorhynchus gorbuscha x. O. tshawytscha) in the St. Marys River, Michigan

Natural hybridization between pink salmon and Chinook salmon in the Laurentian Great Lakes was first detected in 1992. Since that time, many St. Marys River anglers have reported capturing hybrid salmon to the Lake Superior State University Aquatic Research Laboratory. Pink, Chinook, and hybrid salmon were captured during each sampling year from 1998 to 2002. Fish were collected using a 102-mm stretch mesh monofilament gill net twice each week from late august to early October. A total of 74 hybrid salmon were captured during the study period. The body size of pinook salmon was intermediate to pink and Chinook salmon. The proportion of the catch that was female ranged from 0 to 0.23 during each sampling year. Age determinations ranged from ages 2 to 5. In addition, meristic and morphometric data were collected from both parent species and their hybrids. Multivariate techniques were used to assign individual fish to each group (i.e., species). Our results provide fisheries managers with information to better identify and understand hybrid salmon.

S3-4

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Presentation

Population Dynamics of Lake Whitefish in Apostle Islands Region, Lake Superior, Wisconsin, 1970-2006.

Lake whitefish (Coregonus clupeaformis) have been and are currently the primary commercial species in the Apostle Islands, Lake Superior. Beginning in the mid 1800s, commercial lake whitefish harvest gradually increased until the 1950s when populations collapsed due to overfishing and sea lamprey predation. The objective of this study was to consolidate commercial and fishery independent survey data to asses the current population dynamics of lake whitefish. Data were consolidated from commercial records, recreational creel surveys, and fishery independent surveys. Catch per effort from fishery independent surveys and total commercial harvest indicated that abundance has increased dramatically since the 1970s. Total annual mortalities ranged from 0.16 to 0.57 from 2002 to 2006. Diet composition primarily consisted of benthic organisms such as amphipods and bivalves but also seasonally included cisco (Coregonus artedi) eggs and rainbow smelt (Osmerus mordax). Since 2002, growth and condition of lake whitefish have declined slightly. Recent sampling in the Apostle Islands has not indicated a change in the benthic community thus reduced growth and condition may be a density dependent response. Management actions aimed at rehabilitating lake trout (Salvelinus namaycush) populations such as sea lamprey (Petromyzon marinus) control, commercial fishing restrictions, and fish refuges have aided the recovery of lake whitefish populations in the Apostle Islands region.

S3-5

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Presentation

Status of Coaster Brook Trout on the Minnesota Shore of Lake Superior

Coaster brook trout Salvelinus fontinalis are an ecological variant of inland brook trout that spend part of their lives in the Great Lakes. Anecdotal angler reports indicate, by the mid to late 1800's, coaster brook trout abundance along the Minnesota shore had been substantially reduced, likely due to exploitation and habitat degradation. Populations have remained low for nearly a century. A resurgence of interest in coaster brook trout by Lake Superior fish management agencies, led to the formation of a Brook Trout Subcommittee in 1993. This group investigated the status of coaster brook trout in Lake Superior and developed a rehabilitation plan that was published by the Great Lakes Fishery Commission in 2003. In 1997, in an attempt to protect and enhance remnant coaster brook trout populations, Minnesota enacted more restrictive regulations. New regulations included a 508-millimeter minimum length limit (20 inch) below barriers on the Minnesota shore of Lake Superior and a season closure between Labor Day and inland trout opener. In addition, a fall electrofishing survey was initiated with a plan to repeat the survey every five years to monitor population responses. Surveys were conducted in 1997, 2002, and 2007/2008. The 2007/2008 survey indicated a shift in the population's age-structure, size-structure, and CPE of fish greater than 356 mm (14 inches). Based on data collected over the past twelve years, we are cautiously optimistic that current regulations are having a positive effect on coaster brook trout rehabilitation along the Minnesota shore.

S3-6

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Presentation

Movement of Individual Brook Trout Within and Between Tributaries to Lake Superior

Brook trout (Salvelinus fontinalis) stocks in the Lake Superior basin were systematically degraded over the past century by habitat loss, over-fishing, and exotic species. Coaster brook trout, a migratory lake-dwelling ecotype, were diminished to the point where only a few viable populations now remain. Recent evidence suggests that anadromy in brook trout populations on the Atlantic coast may be influenced by differences in individual growth potential; therefore, in 2004 we initiated a long-term PIT (passive integrated transponder) tagging study in tributary streams along the north shore of Lake Superior, to investigate whether growth patterns influence brook trout movements. In-stream antennae were located near the stream mouths of the Cypress, Little Cypress, MacInnes and Jackpine Rivers and Clearwater Creek to track the up and downstream movement of individual fish. Stream discharge and water temperature were also recorded. A discussion on the use of this technology to monitor anadromy in brook trout and the results to date will be presented.

S3-7

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Using PIT/RFID with brook trout on the south shore of Lake Superior: Tales and Tips

Passive integrated transponder (PIT) technology has rapidly advanced in recent years and has seen a surge in use for aquatic applications. In our work, we use half-duplex radio frequency identification (RFID) PIT telemetry to track coaster brook trout (Salvelinus fontinalis) in three southern Lake Superior tributaries with the goal of characterizing movement patterns between habitats. To date, we have shown a bimodal activity pattern by juveniles of movement between the lake and stream habitat with peak activity in the fall. Coaster-type movements are variably expressed (2-50%) within local populations and suggest substantial differences in the expression of the life history depending on local habitat. Additionally, we have identified significant overwinter losses of tagged fish suggesting substantial winter-induced mortality. We are currently using PIT-RFID technology to evaluate habitat use in winter environments using portable wanding within the streams. This talk will focus on PIT/RFID techniques used in these studies as well as scientific results and will include some suggestions for continuity of techniques across the Lake Superior basin.

S3-8

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Presentation

Survival and Growth of Juvenile Coaster Brook Trout following Surgical Implantation of 23-mm Passive Integrated Transponders

We evaluated survival and growth of tagged and untagged juvenile (range; 98 - 157 mm TL) coaster brook trout Salvelinus fontinalus (Lake Nipigon strain) following surgical implantation of a 23-mm Passive Integrated Transponder (PIT) tag. Forty five coaster brook trout (means: 125.8 mm TL, 19.4 g) were implanted with a PIT tag, while an additional 45 brook trout were left untagged and served as controls. After 140 days, tag retention was 95.5% (two fish lost tags), and survival of tagged and control fish was 93.3% (three fish died) and 100%, respectively. Tag shedding appeared to be random with one fish losing its tag 10 d post-surgery and the other approximately 5 m post-surgery. Similarly, mortality appeared to random, with two fish dying within 5 d post-surgery and the other after 2 m post-surgery. We detected no significant differences ($p<0.0001$) in growth (both TL and g) between tagged and untagged fish at 0, 30, 60, 90, and 120 d post-surgery.

S3-9

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Post-stocking dispersal of fingerling Coaster brook trout in Whittlesey Creek, WI

As part of an ongoing experiment to re-establish a self-sustaining migratory population of coaster brook trout into Whittlesey Creek, WI, the U.S. Fish and Wildlife Service stocked 2,000 fingerling coaster brook trout after surgically implanting them with 23-mm Passive Integrated Transponder (PIT) tags. Prior to stocking, a solar-powered, remote PIT tag station with a 3 antennae array was deployed near the mouths of Whittlesey (2 antennae) and Little Whittlesey (1 antennae) creeks. To date, 75 brook trout have been detected by the antennae array on Whittlesey Creek, 52 of which have left Whittlesey Creek. Five of the 52 that have left Whittlesey Creek were subsequently detected by the antennae in Little Whittlesey Creek, and 3 of those 5 later returned to Whittlesey Creek. The whereabouts of the other 46 fish that have left Whittlesey Creek remain unknown. Preliminary results indicate that timing of movement appears to be random and not coinciding with a high flow event or time of day.

S3-10

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Presentation

History, Rehabilitation, and Current Management of the Cisco Fishery in the Minnesota Waters of Lake Superior: A Case Study.

The historic cisco Coregonus artedi fishery in the Minnesota waters of Lake Superior remains the largest commercial fishery (kg harvested) in Minnesota. The fishery yield was over 2.3 million kg annually from 1924 - 1941 and supported over 400 licensed operators. Eventually, over-fishing resulted in a rapid decline in harvest. Similar trends occurred in other Lake Superior jurisdictions. In the early 1970s, most Lake Superior fish management agencies placed harvest restrictions on cisco. In Minnesota, a spawning period fishing closure was imposed along with effort and gear restrictions. In 1984, the first strong cisco year class in over 40 years was documented, which began the rehabilitation of cisco lake-wide. By 2005, abundance was considered high in some areas of Lake Superior, and harvest increased. In 2003, hydro-acoustic surveys began that targeted pelagic prey fish, and biomass of large (> 305 mm) cisco in Minnesota waters was estimated. Minnesota changed from an unlimited harvest fishery with a spawning period closure, to a total allowable catch (TAC) based fishery in 2006. This presentation highlights important aspects of the history, rehabilitation and current management of the cisco fishery in the Minnesota waters of Lake Superior with potential application to rehabilitating coregonid fisheries in other areas.

S3-11

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An Overview of Lake Herring (Coregonus artedii) propagation and production techniques at the UWSP Northern Aquaculture Demonstration Facility and Red Cliff Tribal Fish Hatchery

Lake herring (Coregonus artedii) has historically been a valued species for commercial fisheries in the Great Lakes. Lake herring are an important forage fish for lake trout and other pelagic piscivores in Lake Superior. The Great Lakes Fishery Commission has established that lake herring is a "species of interest" to state and federal agencies and that rehabilitation of the historical lake herring populations through augmentation programs in Lake Ontario and Lake Erie are needed. The University of Wisconsin-Stevens Point Northern Aquaculture Demonstration Facility and the Red Cliff Tribal Fish Hatchery conducted a joint project to evaluate and demonstrate different culture parameters to maximize lake herring production on a commercial scale. The project consisted of six different areas including; 1) Egg collection and disinfection 2) Egg incubation at various flows, temperature and water conditions 3) Fry production at various temperatures and with several different fry diets 4) Fingerling and grow out production 5) Economic analysis and 6) Outreach/extension. This presentation will be covering the hands on rearing and production techniques from 1-4.

S3-12

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Sources of variability in Salmonid isotopic analyses: identifying an appropriate sample

The objective of this study was to use a large data set (n= 284 total) of δ13C and δ15N and stomach content samples collected from fishes in the Green River, Utah to evaluate sources of variability and to estimate appropriate samples sizes to improve food web study designs. Both δ15N and δ13C values were highly similar among repeated muscle tissue collections from individual fish and there were no significant differences in muscle tissue as compared to tissue collected from the adipose fin from the same fish for brown and rainbow trout, but mean δ13C values were significantly higher from adipose samples as compared to muscle samples in whitefish. Variance around mean isotope values increased substantially below sample sizes of 10 fish for both δ13C and δ15N samples and on average for the 3 species, the coefficient of variation in δ15N increased more rapidly with declining sample size, almost 4x the rate, as compared to &#9 48;13C. These results suggest that the assignment of species to trophic levels in stable isotope food web analyses can be enhanced by collecting a few more samples than the 3 to 5 individuals within a population that are most typically sampled.

S3-13

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Isotopic change in fishes during a whole lake 13C addition

Quantifying energy flow to fishes using carbon stable isotopes requires information on the dietary legacy represented by a δ13C value. A 56-day whole lake 13C addition created contrast between fish diet and dorsal muscle tissue δ13C of multiple age classes of bluegill Lepomis macrochirus, largemouth bass Micropterus salmoides, and yellow perch Perca flavescens. We used bioenergetic and dynamic δ13C models to evaluate the importance of tissue replacement and growth processes in contributing to δ13C change. Models that included a tissue replacement term had markedly better support than a model that predicted isotopic change from growth alone except when relative growth rates were high (age 0 bluegill). Estimated tissue half-life in age 0 fishes (6-15 days) indicated their δ13C would represent dietary δ13C from the previous weeks whereas adult muscle tissues would reflect multiple years of dietary information. The positive relationship between standard metabolic rate and δ13C half-life, from this and previous studies, indicates the dietary legacy of a δ13C measurement can be approximated using fish body size and water temperature.

S3-14

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Influence of macrophytes on diversity and abundance of invertebrate communities in Minnesota shallow lakes

Research has shown positive relationships between abundance of submerged macrophytes and aquatic invertebrates in shallow lakes. However, few studies have assessed whether these influences depend on fish community composition, or vary among geographic areas. We sampled 70 lakes in two areas of Minnesota (Polk and Grant counties), and tested for relationships between abundance of macrophytes and several groups of invertebrates. We also assessed whether relationships differed between planktivore-only lakes (P) versus lakes with planktivores and benthivores (P+B). In P lakes, significant trends were limited to negative relationships between macrophytes and copepods and large cladocerans, but only in Grant County. In contrast, macrophytes in P+B lakes showed positive relationships with insects and snails, negative relationships with most zooplankton, while no relationships were detected in Polk County. Our results show that macrophytes may have significant effects on invertebrate abundance, but relationships vary according to taxonomic groups of fish, invertebrates, and geographic areas.

S3-15

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Contrasting littoral and pelagic zooplankton diversity and abundance in northern temperate lakes

Zooplankton play an important role in aquatic food webs, yet knowledge of their distribution, abundance, and diversity in nearshore areas of lakes is limited. We compared zooplankton in the littoral and pelagic zones of two northern temperate lakes to determine how diversity, abundance, and biomass differed among lake habitats and between lakes with different densities of planktivorous fish. In piscivore-dominated Paul Lake, abundance and biomass in were significantly higher in the littoral zone than in the pelagic. In planktivore-dominated Peter Lake, there were no significant differences in abundance or biomass between littoral and pelagic samples. High zooplankton densities in the littoral zones of both lakes suggest planktivorous fish may not need to move to pelagic habitats in order to forage on zooplankton. The observed differences between littoral and pelagic abundance and biomass indicate that characterizing only pelagic habitats may not accurately estimate lake-wide zooplankton populations.

S3-16

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Food webs without borders? Watershed-coast interactions influence diet sources of fish in the St. Louis River

Complex ecosystems form where coastal rivers enter the Laurentian Great Lakes. These ecosystems span a river-to-Great Lake transition zone encompassing a mosaic of river channel, drowned river mouth, littoral, wetland and coastal habitats. Our goals were to determine whether we can detect a stable isotope gradient along the river-Great Lake transition zone in a coastal river mouth and use it to identify changes across this hydrologic gradient in the food web supporting young-of-year and juvenile fish production. We characterized the food web along the lower 35 km of the St. Louis River, MN, a coastal tributary that flows into Lake Superior, using carbon and nitrogen stable isotope ratios (d13C,d15N). The d13C of fish were significantly different among stations and increasingly enriched towards the river mouth. The gradient allowed us to describe local food webs. Throughout the river, the food web was supported by two trophic pathways: a bentho-pelagic pathway based on consumption of zooplankton and zoobenthos in the river channel and a littoral pathway based on consumption of macroinvertebrates in submerged vegetation beds. Near Lake Superior, isotopic data indicated that Lake Superior autotrophs (both phytoplankton and periphyton) contributed to production of fish captured in the river. The high diversity of fish in Great Lakes coastal habitat relative to offshore waters may be explained by both the array of potential organic matter sources that can sustain fish production and the diversity of fish life histories.

S3-17

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Trophic connections in the offshore food web of Lake Superior: a diet analysis approach

Detailed diet preferences and linkages within the offshore food web of Lake Superior are currently not well identified. We use analysis of fish stomach contents to create a baseline food web model of the Lake Superior offshore fish community. Fish were collected seasonally (spring, summer, and fall) from nine offshore locations in 2005 that spanned the entire lake, with two stations repeated in 2006. Samples were collected using bottom (day and night) and midwater (night) trawl tows. A total of 2,617 stomachs were examined, representing 12 different species. The predominant fish species were deepwater sculpin (Myoxocephalus thompsoni), siscowet lake trout (Salvelinus namaycush siscowet), kiyi (Coregonus kiyi), and cisco (Coregonus artedii). The majority of fish stomachs were either empty (20% of the total) or contained between one to four prey items (66%). Mysis relicta was the single most common prey item for all species, suggesting that changes in Mysis populations could have a significant impact on the entire offshore food web. The invasive Bythotrephes cederstroemi was also a primary diet component of the pelagic cisco in the late summer and fall. There was a sizable presence of Diporeia in deepwater sculpin diets, which was true irrespective of site depth. For all species besides deepwater sculpin, the shallowest offshore site separated out from the other sites, potentially indicating that the use of 80 m as the offshore/nearshore separation depth should be increased to 100 m. Overall, our data indicate that on a broad scale, all offshore sites were similar (but not identical).

S3-18

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Diel vertical migration in Lake Superior: variability in the vertical movement of siscowet lake trout in response to prey availability

The distribution of fishes may be influenced by a host of physico-chemical and biological variables including temperature and oxygen, prey abundance, realized feeding or assimilation rates and predation risk. We used hydroacoustics, midwater trawls and bottom trawls to measure the vertical distribution of pelagic fishes during a series of research cruises on Lake Superior in 2005 and 2006. Our objective was to assess vertical structuring in the fish assemblage over varying light levels at various locations in the lake. We observed variability in vertical distribution of both ciscoes (Coregonus spp.) and siscowet lake trout (Salvelinus namaycush). Our results indicate that deep-water predators and prey migrate extensively over a diel cycle. This migration pattern is most consistent with changes in the distribution of prey resources for siscowet and diel variability in predation risk driven by changing light levels for ciscoes. The magnitude of vertical migration in predatory siscowet was examined as a function of prey abundance. Our results suggest that the abundance of benthic and open water prey drive of siscowet vertical distribution. This study describes spatial variability in the extent of vertical migration in each group of fish, provides a statistical description of the pattern and addresses the implications for trophic interactions in the Lake Superior food web.

S3-19

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Selection for Mysis relicta by Planktivorous Fish in Lake Superior

Mysis relicta is a common prey item for both benthic and pelagic fish species in Lake Superior, and has been shown to be important in the transfer of energy between phytoplankton and fish production. To evaluate how important Mysis are to planktivorous fish in Lake Superior, we determined the seasonal prey selectivity of rainbow smelt Osmerus mordax, bloater Coregonus hoyi, kiyi Coregonus kiyi, and deepwater sculpin Myoxocephalus thompsoni from 18 sites across Lake Superior. We sampled Mysis, zooplankton, and the benthos to estimate invertebrate prey abundance, and fish for diet analysis. Samples were collected in the spring, summer, and fall of 2005. Prey selectivity indicates that kiyi have a high selection for Mysis which is relatively constant across seasons. This is partly due to vertical migrations by kiyi to spatially overlap with their prey. Rainbow smelt and bloater showed a positive selection for Mysis but did vary by seasons as a result of changes in prey availability. Deepwater sculpin also selected positively for Mysis, however when considering Mysis move off the bottom at night, deepwater sculpin lose access to this prey resource and most likely are selecting for Mysis higher than reported. Selectivities show that Mysis is an important prey item for planktivorous fish in Lake Superior.

S3-20

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The relationship between seasonally dynamic diel vertical migrations of Mysis relicta and coregonids in the pelagic area of Lake Superior

Diel vertical migrations of organisms are often associated with changing light levels over a 24-hour period, while the underlying mechanisms are generally attributed to optimizing growth or foraging efficiency, while avoiding predation risk. We used an optical plankton counter, hydroacoustics, and mid-water and bottom trawls to assess seasonal changes in vertical migration patterns and feeding behaviors of opossum shrimp (Mysis relicta), kiyi (Coregonus kiyi), and cisco (Coregonus artedii) in the pelagic area of Western Lake Superior from 2005-2008. We observed differences in the magnitude of vertical migration patterns between species and across seasons. Our results suggest that Mysis and kiyi migrate similarly during all seasons, but to a lesser extent in spring compared to summer and fall. In comparison, cisco appear to migrate less extensively regardless of season, which may be attributed to the spatial distribution of preferred prey resources. The observed difference in vertical migration and feeding behavior between species suggests that the abundance and distribution of prey and predators plays an important role. Overall, this study describes the dynamic relationship between vertically migrating Mysis, kiyi, and cisco, and addresses the impacts this might have on the Lake Superior pelagic food web.

S3-21

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Natural regime shifts in Minnesota shallow lakes

Shallow lakes commonly exist in either a phytoplankton dominated, turbid-water regime, or a macrophyte dominated, clear-water regime. Research in Minnesota has documented shifts between regimes, but only in response to human manipulation of fish communities. Thus, it's unknown whether natural changes in fish communities also induce regime shifts. We documented ecosystem responses to serendipitous changes in black bullhead abundance in three shallow Minnesota lakes. Lake 8 Mile shifted turbid to clear following 99% reduction in bullhead abundance between 2005 and 2006, as chlorophyll a declined from 243 to 3 ug/L and macrophytes increased from 0 to 0.7 kg/sample. Concurrently, Lake Sweet shifted clear to turbid following bullhead colonization, with chlorophyll a increasing from 8 to 50 ug/L and macrophytes decreasing from 4.7 to 0.2 kg/sample. No changes were detected in a third lake with stable benthivore abundance. These results suggest that natural changes in benthivore abundance may induce regime shifts in Minnesota shallow lakes.

S3-22

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Presentation

Fish Community Composition of the LeSueur River Watershed, Minnesota

The Minnesota Pollution Control Agency has implemented an intensive watershed monitoring design to assess all of the 81 major watersheds for water quality on a rotating ten-year cycle. In 2008, water chemistry, habitat and fish were systematically collected at 82 sampling locations in the three subwatersheds (LeSueur, Maple, and Cobb rivers) comprising the LeSueur River watershed. A total of 36,084 fish representing 54 species were captured in the LeSueur Watershed using standardized electrofishing techniques. Mean number of species per sample site was 12 and ranged from 0 to 28 for smaller streams (stream order 1 to 3); whereas, on average 25 species were captured in larger streams (stream order 4 to 6) and ranged from 16 to 31 species. Fathead minnows Pimephales promelas and creek chubs Semotilus atromaculatus were the most common species at most smaller streams, while spotfin shiners Cyprinella spiloptera and sand shiners Notropis stramineus were most common in the larger streams. Gamefish were captured at a 41% of all sites (n=34): channel catfish Ictalurus punctatus (n= 19), northern pike Esox lucius (n=15), walleye Sander vitreus and yellow perch Perca flavescens (n=12), flathead catfish Pylodictis olivaris (n=3), bluegill Lepomis macrochirus (n=4), black crappie Pomoxis nigromaculatus and largemouth bass Micropterus salmoides (n=2), and smallmouth bass Micropterus dolomieu (n=1). The data obtained in this intensive watershed sampling design will be used to assess the overall condition of the watershed, and provide baseline information for targeted stressor identification, TMDL, and potential restoration work.

S3-23

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Presentation

The effects of eutrophication and climate change on cisco abundance in Minnesota lakes

Recent cisco Coregonus artedi abundance declines in Minnesota lakes, as measured by 3,434 standard gillnetting assessments on 634 cisco lakes from 1947 through 2007, appear to be the result of changes in climate. Cisco have declined both in lakes that have experienced cultural eutrophication (Eastern Temperate Forests ecoregion) and in lakes that have not experienced significant cultural eutrophication (Northern Forests ecoregion). Significantly warmer summer nights and longer growing seasons have occurred in Minnesota since 1980. The increased warming and longer durations of summer stratification have apparently reduced thermal habitat to the point where cisco populations are being impacted. In addition, increased abundances of an important cisco predator (northern pike), may have also contributed to the decline. Increased northern pike abundance may also be a result of recent changes in climate (better reproduction from increased precipitation/higher lake levels). Cultural eutrophication since the late 1800s probably set a lower baseline abundance for cisco in some lakes (primarily in the Eastern Temperate Forests ecoregion), but recent declines in abundance were probably the result of climate change.

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S4-1

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Presentation

A Big Fish in a Bigger River: Monitoring Pallid Sturgeon in the Missouri River Downstream of Fort Randall Dam, South Dakota 2003 - 2008

As part of recovery efforts for endangered pallid sturgeon Scaphirhynchus albus, 6033 fish have been stocked in the unchannelized Missouri River downstream of Fort Randall, South Dakota since 2000 and a standardize monitoring program was initiated in 2003. Ten randomly selected river bends were sampled twice per year with drifted trammel nets, towed benthic otter trawls, and static gill nets (n = 8 - 10). A total of 384 pallid sturgeon were recaptured; 51 in 2003, 28 in 2004, 44 in 2005, 50 in 2006, 107 in 2007, and 102 in 2008. All fish were tagged prior to stocking with passive integrated transponders (PIT) tags and mean annual retention was 81%. Recaptured pallid sturgeon represented all years classes (1997 - 1999 and 2001 - 2007) stocked as part of population supplementation efforts. Relative abundance of pallid sturgeon captured in anchored gill nets tracked stocking efforts while drifted trammel nets and towed otter trawls increased with increased stocking. Duplicate sampling (i.e., sampling the same location where a gear initially captured a pallid sturgeon) proved effective for active gears, accounting annually for > 33% of recaptures during 2005 - 2007. Mean relative condition (Kn) of recaptured pallid sturgeons ranged from 0.94 to 1.08, with a general decline in Kn as fish increased in length. Mean growth rates of age-8 and older fish was < 0.1 mm/d, while growth rates for fish aged 2-7 ranged from 0.1 - 0.3 mm/d. Spatially, pallid sturgeons were captured throughout most of the length of the river but 59% of recaptures were in the delta formed downstream of the Niobrara and Missouri river confluence.

S4-2

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Presentation

Standardized pallid sturgeon and fish community monitoring in the Missouri River basin

In 2002 a team of federal and state biologists developed a standardized pallid sturgeon and fish community monitoring program for the Missouri River. Goals of the program included monitoring relative abundance, distribution, survival, and growth of remaining wild endangered pallid sturgeon and hatchery-reared fish stocked as part of recovery efforts. Relative abundance of the overall fish community and nine specific native species were also assessed. Based on presence of tributaries and fragmentation by reservoirs, the Missouri River from Fort Peck Dam, Montana to St Louis, Missouri was divided into 14 segments. Within each segment, 25% of the river bends (i.e. replicates) are randomly selected each year. The sampling year was comprised of two seasons delineated by water temperature, fall-spring and summer, with 8-10 subsamples per gear expended among various habitats in each bend each season. All stocked pallid sturgeon are tagged prior to release and all wild fish are tagged in the field for determination of survival and growth rates. To further target pallid sturgeon, whenever an active gear captures a fish, subsequent non-random samples in the same location occur until two successive attempts capture zero pallid sturgeon. Since 2002, an adaptive approach has been used to add or discontinue sampling gears after field evaluation. Also in 2004, review by an independent scientific panel provided 19 recommendations; 14 of which were adopted to improve achievement of program goals. Drifted trammel nets, static gill nets, and mini-fyke nets have been standard gears since inception and in 2004 a bottom otter trawl was added to the monitoring program. Since 2006 the monitoring program has been implemented throughout the Missouri River basin capturing over 50 species in addition to pallid sturgeon. As hatchery-reared pallid sturgeon mature, proposed program modifications focus on size selection of gears and their ability to detect natural recruitment and relative abundance of adults.

S4-3

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Presentation

Vulnerability of age-0 pallid sturgeon to predation

Mortality during the early life history can have a large effect on population dynamics of fishes. Predation is a large component of mortality and is primarily controlled by predator abundance, prey vulnerability, and environmental conditions. The pallid sturgeon Scaphirhyncus albus is a federally listed endangered species native to the Missouri and Mississippi River systems. Little is known about the population dynamics of pallid sturgeon, particularly factors affecting survival during the early life history. We conducted a series of laboratory experiments quantifying vulnerability of juvenile pallid sturgeon to predation by walleye Sander vitreus and smallmouth bass Micropterus dolomieu. Two sizes (40-50mm and 80-100mm) of pallid sturgeon were offered to predators, along with an alternative prey, fathead minnows Pimephales promelas, at varying densities. Trials were conducted in high (>70 NTU) and low (<5 NTU) turbidity conditions. Both predators negati vely selected pallid sturgeon and positively selected fathead minnows in high and low turbidity conditions. Further, both predators negatively selected pallid sturgeon across all prey density treatments. Preliminary feeding behavior experiments indicated that predator foraging costs (e.g. shorter pursuit and following distances and higher capture efficiency) were lower when feeding on pallid sturgeon than on fathead minnows, suggesting another mechanism is driving selection. Additional experiments are planned to investigate other mechanisms (e.g., pallid sturgeon palatability to predators).

S4-4

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Presentation

Characteristics of Shovelnose Sturgeon Populations Under Varying Levels of Commercial Fishing in the Upper Mississippi River

Commercial harvest of shovelnose sturgeon Scaphirhynchus platorynchus in the upper Mississippi River (UMR) has increased substantially since the collapse of foreign stocks and bans on imported caviar. Most commercial harvest of shovelnose sturgeon in the UMR occurs in pools bordering Iowa, Wisconsin, and Illinois, whereas pools bordering Wisconsin-Minnesota allow only setline and recreational harvest. Pool 4 of the UMR is especially unique since it has no recorded setline harvest and recreational harvest is very low. We began this study to describe and compare shovelnose sturgeon population demographics in commercially exploited and unexploited UMR pools. Over 1,900-shovelnose sturgeon were collected via trammel nets from eight study pools (i.e., Pools 4, 7, 9, 11, 13, 14, 16 and 18) in 2006 and 2007. Pools were categorized based on reported shovelnose sturgeon commercial harvest as having high, medium, low, or very low harvest. Two UMR pools fit each category and shovelnose sturgeon were pooled and population characteristics were compared among commercial harvest levels. Shovelnose sturgeon populations in low and very low commercially harvested pools had better size structure and age distribution than shovelnose sturgeon sampled from medium and high harvest pools. Growth of shovelnose sturgeon was lowest in the most heavily exploited populations. Additionally, mortality estimates were substantially lower in very low and low commercially harvested pools. This study demonstrated how collecting information on unexploited populations can aide in determining the effects of commercial or recreational harvest on a separate population, especially when evaluating the effects on sensitive species, such as shovelnose sturgeon.

S4-5

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Presentation

Assessment of the Lake Sturgeon Population in the Upper St Croix River

In 2003 a cooperative effort between the Wisconsin Department of Natural Resources (WDNR) and the Minnesota Department of Natural Resources (MDNR) was initiated to attempt to determine the population status of the lake sturgeon (acipenser fulvescens) in the Upper St Croix River.

Objectives of this study include calculation of growth rates, length at age, length frequencies, condition factors, and catch per effort data, and to calculate a population estimate by 2010.

Primarily hook and line sampling captured fish. A pectoral spine sample was taken from each fish for aging, total length and weight were measured, each fish was tagged with an individually numbered disc dangler tag, and each fish's location was recorded with GPS coordinates.

So far a total of 575 fish have been caught from 2003 to 2008. Fish from 11.4 to 68.8 inches in length have been captured, with the majority of fish between 18 and 33 inches. Growth rates have been found to be approximately one inch per year. Of the 575 fish, 84 have been recaptures. Most of the recaptures were caught close to where they were initially tagged.

Currently there is no open season for lake sturgeon on the Upper St Croix River, and based on the results so far it looks like it should stay closed for the present time.

S4-6

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Lake Sturgeon Population Characteristics in the Wisconsin Waters of Lake Superior

In Wisconsin waters of Lake Superior lake sturgeon spawning populations historically existed in the St. Louis River and the Bad River. The St. Louis River population was extirpated during the early 1900s due to overexploitation and degraded water quality. Following control of exploitation and improvements in water quality, the Wisconsin and Minnesota Departments of Natural Resources attempted to reestablish a self-sustaining population in the St. Louis River by stocking lake sturgeon from 1983 to 2000. Stocked lake sturgeon distribution and movement in western Lake Superior was monitored through mark and recapture in assessment nets. Fish were generally captured in less than 30 meters of water and generally ranged along the 65 km of Wisconsin shoreline east of the St. Louis River towards the Apostle Islands. Although likely overexploited historically, the Bad River has maintained a self-sustaining lake sturgeon population. Mark and recapture during various surveyshas shown lake sturgeon from the Bad River spawning population spend time in nearby Chequamegon Bay during portions of the year. Relative abundance of lake sturgeon in Chequamegon Bay has steadily increased since 1988. Tag recaptures have revealed lake sturgeon from other Lake Superior populations also inhabit Chequamegon Bay during non-spawning years. Mandatory registration shows harvest of lake sturgeon in Lake Superior is very low and currently not limiting rehabilitation efforts.

S4-7

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Lake Sturgeon Restoration in the Red River of the North Basin

Lake sturgeon (Acipenser fulvescens) were abundant in the Red River of the North basin until the late 1800's. Dam construction, over-harvest, declines in water quality, and habitat loss took their toll and sturgeon were effectively extirpated from the basin by the late 1900's. Minnesota is currently working to restore naturally reproducing lake sturgeon populations over the next 20 to 30 years. Primary restoration activities at this time are focused on fish passage barrier removal, stocking, and general watershed management activities to improve instream habitat conditions. This talk will summarize ongoing activities and accomplishments associated with lake sturgeon restoration efforts in the Red River of the North basin

S4-8

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Lake Sturgeon Restoration on the White Earth Reservation

In a multi agency cooperative effort to restore a viable self-sustaining population of lake sturgeon (acipenser fulvescens) to the Red River Watershed, The White Earth Ojibwe Nation has conducted a project that includes fingerling stocking, public education and outreach, habitat manipulation and stocking assessment.

The White Earth Reservation, Natural Resources Department in cooperation with the United States Fish & Wildlife Service, the Minnesota Department of Natural Resources, the White Earth Land Recovery Project and the Rainy River First Nations have reared and stocked the Rainy River Strain of Lake Sturgeon (acipenser fulvescens) in the Red River Watershed since 1999. Over ninety eight thousand Lake Sturgeon fingerlings have been reintroduced into White Earth Reservation waters since 2001, on an annual stocking basis. Fish passage structures were constructed, altering three dams on three rivers that connect the White Earth Reservation to the Hudson Bay drainage. Numerous media events and ceremonies have taken place to ensure public awareness and appreciation of this culturally significant species. Several attempts to sample the stocked fingerlings have produced a profile of management successes and failures and have provided incite to future management techniques and management recommendations.

Future goals are to improve sampling techniques to sample the larger age classes as individual size increases, radio telemetry to document emigration and preferred habitat, dam alteration to provide migration and spawning habitat and to ultimately provide a viable self-sustaining population for the sport fisheries and maintain a cultural existence.

S4-9

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Presentation

Mean Length and Angler Reporting Of Tagged Lake Sturgeon, by Sampling Gear

The lake sturgeon Acipenser fulvescens population of Lake of the Woods and Rainy River crashed at the turn of the last century. The population started to recover in the late 1960s, and recovery goals, based on age and length metrics, were established in 2004. Progress to recovery is monitored using gill nets, angling and hand-grabbing. An existing data set, created to produce a lake sturgeon population estimate in 2004, was used to describe inherent differences between sampling gears. All lake sturgeon sampled for this population estimate had total length measured, and were tagged with individually numbered disk dangler tags. Lake sturgeon concentrate in Fourmile Bay of Lake of the Woods after ice out. From this concentration, anglers captured the widest size range of lake sturgeon, with the smallest mean length. Mean length of sampled lake sturgeon increased with increasing gill net mesh size. Spawning lake sturgeon were sampled by hand-grabbing and gill netting on two tributary streams to the Rainy River. Mean length of spawning lake sturgeon was similar across sampling techniques and locations. For lake sturgeon sampled and tagged in Fourmile Bay, anglers reported significantly more sturgeon that were originally captured using angling, than those that had been captured by gill net. Managers must take gear selectivity into account when describing lake sturgeon recovery status. Also, exploitation estimates may be influenced by the gear used to capture lake sturgeon, since angler-caught sturgeon appear to be more vulnerable to recapture by anglers than gill net sampled lake sturgeon.

S4-10
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Lake Sturgeon Population and Angler Success on Yellow Lake,Burnett County, Wisconsin.

Two state hook and line records for lake sturgeon Acipenser fulvescens set in 1979 from Yellow Lake (Burnett County) brought fame to this fishery, however very little was known about the biological status of the sturgeon population. From 1981-1986 the Wisconsin Department of Natural Resources (WDNR) undertook a six year study to estimate population abundance, age and growth and angler information for lake sturgeon. Adult lake sturgeon (> 45 in) abundance in Yellow Lake was estimated at 290 or 0..13 fish/acre. The lake sturgeon population in Yellow Lake was found to be similar to Lake Winnebago's lake sturgeon population in terms of fish/acre and growth rates. Based on Lake Winnebago recruitment rates, a safe annual harvest of 15 > 45" (5% of the adult population) was postulated for Yellow Lake. The possibility of exceeding the safe harvest was high. Five creel surveys showed that anglers were catching twice that many annually, but most were being released. The registered harvest was the only mechanism to monitor the sturgeon population for the next 22 years. In 2005 through 2008, WDNR re-surveyed the population using similar methods as were used previously. Adult lake sturgeon were captured by DC electrofishing during spawning runs and juvenile and adult fish were captured by hook and line anglers during the 2007, 2008 seasons and processed by WDNR staff. Fish were double-tagged with a dangler tag and a Passive Integrated Transponder (PIT) tag was injected into the base of a pectoral fin. The opposite pectoral ray was taken for aging. The recapture sample for the population estimate was taken by anglers during the 2008 creel survey. The population of adult fish increased 400% since the 1980s to 1289 (0.58 fish/acre). The percentage of large, older fish in the population also increased with 34% of the spawning run > 60 in and 7% > 70 in compared to 19% > 60 in and 3% > 70 in. Since mandatory registration began in 1983, the average harvest was only 9.0 fish, but catch of legal fish was likely much higher. In 2007 the statewide minimum size limit increased from 50 to 60 in. Harvest under the new size limit was 10 fish in 2007 and 0 fish in 2008, but the creel projected a catch of 44 legal fish in 2008. Future management of this unique fishery will depend largely on the continued catch and release ethic currently practiced by anglers.

S4-11

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Growth and Movement Estimates from Tagged Lake Sturgeon in the Menominee River, WI

Wisconsin and Michigan Departments of Natural Resources manage lake sturgeon Acipenser fulvescens populations in four sections of the Menominee River. These sections are labeled as Sturgeon Falls, White Rapids, Grand Rapids and Hattie Street, in descending order. Each section is isolated from other sections by one or more hydroelectric dams. Hattie Street dam is the first on the river and sturgeon tagged in this reach have access to Green Bay and adjacent rivers (Whitefish and Cedar in Michigan and Peshtigo and Oconto river). None of these dams have upstream or downstream fish passage devices. Lake sturgeon have been tagged by Wisconsin Department of Natural Resources staff since the 1960s. Since 1999, over 9,000 lake sturgeon in the Menominee River and adjacent Green Bay waters have received passive integrated responder (PIT) tags. Management agency annual assessments have provided recapture information for lake sturgeon in this river and adjacent waters of Green Bay. We used tagging data from 715 recaptured Menominee River lake sturgeon that had been at large for as long as 26 years to examine growth rates, movements, and other population characteristics. Recaptured sturgeon ranged in size from 11.2 to 75.5 inches and averaged 42.4 with a standard deviation of 10.8. Growth rates varied in the four sections depending on population size and density, size of the recaptured fish, and section of the river. Growth was faster for small, sub-adult lake sturgeon compared to adults, greater than 45 inches. For lake sturgeon less than 45 inches, growth was less for the White Rapids and Hattie Street sections when compared to the Sturgeon Falls and Grand Rapids sections. Growth rates for 384 adults, greater than 45 inches, was less than 0.4 inches/ year compared to 0.9 inches/ year growth for subadults. Less than 1% of the recaptured sturgeon were subsequently caught in another river section or adjacent rivers in Green Bay. Results from recapture data should aid in the management of the lake sturgeon population in the Menominee River and other Great Lakes waters.

S4-12
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Presentation

Modeling the population dynamics and sustainability of lake sturgeon

Sturgeon have experienced excessive harvest and habitat loss over the last 100 years and are now seriously threatened throughout their holarctic range. To achieve recovery and effective management of sturgeon, their population dynamics must be clearly understood. I used 60 years of data, bomb radiocarbon dating, and a series of fisheries models including a statistical catch at age analysis of lake sturgeon (Acipenser fulvescens) from the Winnebago System in east central Wisconsin, USA, to validate age estimates, define age and growth, recruitment, mortality rates, and abundance. Age estimates of pectoral fin spines underestimated true age after age 14 defined by the power function True Age = Estimated Age^1.054796. Frontal cross sections of the otoliths accurately estimated true age. Growth of Winnebago lake sturgeon occurs in two growth stanzas with an inflexion point at 96 cm (total length), age 12, with dimorphic separation of length at age occurring between males and females at 131 cm, age 25. Mean recruitment during 1955-2007 was estimated at 9002 yearlings each year, although stock-recruitment exhibited a Ricker-style inverse relationship. Instantaneous natural mortality was estimated at 0.055, and total annual mortality at 8.8% during 1977-2007. Abundance of lake sturgeon increased fourfold during 1954-2007 in the Winnebago System, an intrinsic rate of increase of 0.049, likely reaching carrying capacity in the 1990s. Long term simulation modeling predicted Winnebago lake sturgeon maintain population robustness at or below an annual exploitation rate of 4.7%, but significantly decline at higher exploitation levels, and go extinct at 20% exploitation.

S4-13

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Bluegill Fishing in Public Waters- Tragedy of the Commons

In a break with his 35 year tradition, the author decides to talk about something other than coldwater species and the Namekagon River. Instead he compares and contrasts public versus non-public bluegill waters to defend his hypothesis that angling quality results primarily from low exploitation, rather than from slow growth. Lightly fished waters consistently produce more old and large bluegills than do heavily fished ones. From the standpoint of quality fisheries nearly all public waters are over-fished. Few anglers even understand what a quality bluegill is because they have no frame of reference. Pratt defines his own objective standard for an optimum sustained yield bluegill fishery as RSD-8 > 20%. Any harvest regulation designed to achieve that objective will have to Keep exploitation well under 10%. He proposes several, all of which are way more Draconian than anything currently in use.

S4-14

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Presentation

Predicting Food Consumption and Growth of Black Carp

The black carp Mylopharyngodon piceus is known to feed on mollusks, but food consumption and growth rates have not been quantified. Black carp have been introduced into the United States, and some fish have escaped into waterways in the Mississippi River Basin. Food consumption and growth rates are essential to predict the impact of black carp on mollusks in the wild. This study measured food consumption and growth of small (86-186 g) and large (537-1328 g) black carp fed formulated and natural diets in laboratory conditions at 20, 25, and 30 C. Consumption and growth of fish fed formulated feed increased with increasing temperature, but consumption and growth were highest at 25 C for fish fed live snails. Bioenergetic models to predict food consumption and growth were developed from laboratory feeding, metabolism, and fecal production trials supplemented with published results from other studies. These models were then used to predict mollusk consumption and growth in natural systems. The models predicted that a black carp with initial weight of 454 g on 1 July would consume 2405-4204 g of mollusks and grow to 1066-1290 g in 1 year in different waters in the Great Lakes and the Mississippi River Basin. Greatest and least food consumption were predicted in the Red River (Louisiana/Texas) and Lake Michigan, respectively. Greatest and least growth were predicted in the Tennessee River and Red River, respectively.

S4-15

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The Chicago Sanitary and Ship Canal Dispersal Barrier - will it ever be more than a demonstration?

The original demonstration electric fish barrier in the Chicago Sanitary and Ship Canal has been operating since April, 2002. Experience with that barrier influenced the design of a new, larger and more powerful electric barrier located just downstream. Yet even as the project moves towards full time operation of the new barrier, concerns have emerged regarding safety for humans and vessel operations. As we seek to complete the new barrier and bring it online, challenges continue to arise including flooding, invaders from up and downstream and long-term maintenance. I will discuss current and future challenges for the barrier project, the prospects for long-term operation and the need and potential for separation of Lake Michigan from the Des Plaines River.

S4-16

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Zebra Mussels in Mille Lacs Lake, Minnesota: A Case History

The first observed zebra mussel Dreissena polymorpha in Mille Lacs Lake was found incidentally on a scuba dive in 2005. For several weeks after the initial discovery, divers searched diligently for more zebra mussels, making over 40 dives all around the lake. A total of four adults were found, all in the northern third of the lake. Although breeding had not been confirmed, the lake was declared infested, which forced new regulations on anglers and bait dealers. Beginning in 2006, twenty 600-ft scuba transects were established to monitor the zebra mussel population. Monthly plankton tows were established to count veligers, and plate samplers were set out to measure settlement rates. Zebra mussels increased annually. In 2008, divers found 24,000 zebra mussels distributed over all transects, although density estimates were still relatively low at 4.8/m2. Veliger densities increased, and were as high as 0.5/l in August of 2008. Also in 2008, the first report s of zebra mussels on docks and boats were reported. A plan to document the long-term effects of zebra mussels in Mille Lacs Lake is being developed.

S4-17

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Presentation

Monitoring the Expansion of Round Goby (Neogobius Melanostomus) Into the Great Lakes Tributaries; Closing the Knowledge Gap for Fisheries Managers

Since its introduction the round goby (Neogobius melanostomus) has rapidly spread throughout the Great Lakes basin. Recent fisheries surveys in Ontario have documented the spread of this species into many tributaries of the Great Lakes. Within Ontario, watershed planning agencies have prepared Fisheries Management Plans developed to manage fisheries and fish habitat in Great Lakes tributaries. A recommendation common to all of these plans is controlling the spread invasive species into tributaries of the Great Lakes. However, implementation of such a recommendation has proven challenging. Currently there are no initiatives in Ontario to evaluate the extent of the round goby invasion into Great Lakes tributaries. Sampling was conducted during 2007 and 2008 to determine the extent of the round goby invasion into four Lake Ontario tributaries, and to develop a standardized electrofishing method to detect round goby in wadable streams. Of the four tributaries sampled, two had barriers to fish migration in close proximity to Lake Ontario. Sites were sampled with backpack electrofishing units using a combination of single-pass and triple-pass sampling methods. The sampling indicated that the round goby has successfully invaded all sampled tributaries. Sampling also indicated that single-pass backpack electrofishing methods were very effective at detecting round goby in wadable streams. Additional sampling is required to evaluate the influence of round goby on native fishes in these tributaries. Preliminary information suggests lamprey barriers have been successful in mitigating the spread of round goby in Great Lakes tributaries.

S4-18

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Presentation

Round Goby Flourish in Great Lakes Tributaries: A Look at the Current and Projected Distribution of this Invader in Wisconsin Streams

The Laurentian Great Lakes host > 180 non-native species, including the round goby (Apollonia melanostomus), a highly aggressive benthic fish that is native to large lakes of the Ponto-Caspian basin and has rapidly colonized coastal Great Lakes habitats during the past decade. Our objectives are: 1) document the dispersal of round goby inland from Lake Michigan and 2) use a habitat-based model to determine which Wisconsin streams are most vulnerable to round goby invasion. Round goby were detected in 26 of 73 streams sampled (36%), and were found >10km upstream of Lake Michigan in nine watersheds. We constructed a set of multiple logistic regression models that explained round goby presence/absence using habitat variables and selected the model that performed best on independent data. This model, incorporating stream gradient and watershed area, correctly predicted round goby presence/absence at 79 % of independent sites. 1,144 km of Wisconsin streams were designated as both accessible and suitable for round goby while 9,331 km of streams would be suitable for round goby if stream impediments (i.e. dams) were not a factor. The prevalence of round goby in small streams is surprising given that these systems are completely unlike the habitats they reportedly occupy in their native range. We demonstrate that round goby, conventionally thought of as a large lake species, have expanded their range into relatively small lotic systems, suggesting that the Laurentian Great Lakes are not only a catch basin of invasive species but also serve as a source population to inland systems.

S4-19

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A Physiological Basis for Predicting Lampricide Sensitivity in Sea Lampreys and Non-target Fishes.

The lampricide, 3-trifluoromethyl-4-nitrophenol, is applied to streams containing larval sea lampreys (Petromyzon marinus) to control populations of parasitic lampreys in the Great Lakes. Our goal is to identify physiological correlates that predict how sensitive sea lampreys and non-target fishes are to this lampricide. We recently proposed that TFM toxicity in lampreys was related to the depletion of plasma glucose, the main fuel of the central nervous system (CNS). Accordingly, we tested the hypothesis that TFM toxicity resulted from depletion of the glycogen pool, which serves as a glucose reservoir in the body. To test this hypothesis, rainbow trout (Oncorhynchus mykiss) and larval lampreys were exposed to toxic concentrations of TFM for 12h (12-h LC50), and tissues (brain, liver, muscle, blood) collected at regular intervals (3, 6, 9, 12h) for analysis of glycogen, ATP, phosphocreatine, lactate and other metabolites. As expected, lampreys were more sensitive to TFM and mortality was associated with a depletion of glycogen and ATP in the brain and liver, indicating that TFM-induced mortality resulted from CNS arrest. In trout, the depletion of glycogen was less pronounced, but accompanied by marked reductions in ion uptake by the gill suggesting that metabolic disturbances, plus interference with gill ion uptake, contributed to death in these non-target fishes. Due to the strong relationship between liver and brain glycogen stores and mortality in lamprey, and to a lesser extent trout, it may be possible to predict when (life stage, season) fish are most sensitive to TFM in the streams subjected to lampricide treatments, and therefore reduce TFM consumption.

S4-20

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Assessment of predation by rusty crayfish on walleye eggs in Leech Lake, Minnesota

The expansion of invasive rusty crayfish Orconectes rusticus in Leech Lake coincided with declines in year classes of walleyes Sander vitreus during 1998-2005, leading to speculation that rusty crayfish predation on walleye eggs was at least partly responsible. Laboratory experiments conducted during 2006-2008 and a field experiment during 2007 revealed no significant difference in rate of walleye egg predation between rusty crayfish and native northern crayfish O. virilis. Density estimates of crayfish were not available before introduction but were relatively high in 2006 (1.89/m2) compared with those known for other lakes. Density declined in 2008 (0.20/m2), concomitant with a large increase in walleyes and yellow perch Perca flavescens. The increase in walleye and yellow perch may have been part of recurring ~10-year cycles of abundance that have occurred regardless of rusty crayfish abundance. We hypothesize that high abundance of yellow perch may be an important factor for maintaining strong walleye populations and may minimize rusty crayfish through predation. The walleye population rebounded without management directly aimed towards rusty crayfish. Rusty crayfish do not appear to have an over-riding effect on walleye egg survival in Leech Lake.

S4-21

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Whole-lake changes resulting from intensive trapping of the invasive rusty crayfish

Rusty crayfish (Orconectes rusticus) are invasive in the states and provinces surrounding the upper Great Lakes. They negatively affect native crayfish species, aquatic macrophytes, benthic invertebrates, and some fish populations. In this talk, we describe an ongoing, whole-lake experiment designed to remove rusty crayfish from Sparkling Lake, Vilas County, Wisconsin. Our objectives are to 1) determine if manual trapping of rusty crayfish can induce sufficient mortality to cause the population to crash; and 2) evaluate the responses of native crayfish, macrophyte, and fish communities to rusty crayfish removal. Crayfish were removed by trapping throughout the summers of 2001-2008, and bass and walleye fishing regulations were also changed to increase fish predation on crayfish. The removal effort in each year has been above that required to achieve maximum sustainable yield, resulting in a drastic reduction in the rusty crayfish population. Native crayfish populations have recovered somewhat, although not to historical levels. Percent macrophyte cover has increased throughout the lake, as has the density of bluegill (Lepomis macrochirus) and pumpkinseed (Lepomis gibbosus) sunfish. Overall, the lake ecosystem has changed as a result of reductions in rusty crayfish numbers. We will discuss management actions that could prevent rusty crayfish populations from rebounding once the trapping stops, as well as the potential application of this work to other invaded lakes.

S4-22

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Effects of Stocking Large Bluegill on Male Size at Maturity

Research in controlled settings has shown that size at maturity for male bluegill Lepomis machrocirus can be influenced by presence of large males. Some studies suggest stocking large males into existing bluegill populations could delay onset of maturity. Between 2001 and 2005, large bluegills (190 mm average length) were stocked into several small lakes in the East Metro area of the Twin Cities (Minnesota) to provide "bonus" fish for anglers. Although stocking frequency and density varied among lakes, all were stocked three to five years (in the fall), with an average of 19 fish/acre/year. All lakes had fish communities typical of small lakes in the region, and had reproducing bluegill populations prior to stocking. Samples of bluegill were collected from five of these lakes between April and June of 2005 or 2006. Samples were also collected from six lakes that had not been stocked with large bluegill, but had similar fish communities and morphology. The size at which 50% of males were mature was determined via dissection and visual examination. Differences in size at 50% male maturity were detected among lakes, but did not correlate to stocking. Differences in size at maturity were better explained by angling pressure. Therefore, a tag return study was conducted at three lakes in 2007 and 2008 to measure angler catch and harvest of stocked bluegill. Tag returns confirmed high angler harvest at two of three lakes. Attempts to influence male size at maturity by stocking large bluegill will likely need to include harvest restrictions.

S4-23

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The use of fixed videography to examine daily and seasonal activity rates of pumpkinseed in a Michigan, USA Lake.

Activity rates of prey fishes can be used to understand predator prey interactions in lakes. We quantified prey fish activity using minnow traps and fixed video cameras in the littoral zone of a small (2.5 ha) north temperate lake. For both methods, pumpkinseed (Lepomis gibbosus) comprised greater than 95% of the total observed species. Activity rates (pumpkinseed passes/min) from video data, collected once a week for 48 hours, were derived through high frequency sub-sampling (every 10 minutes) of the continuous video. Activity rates as measured by camera were positively correlated to minnow trap catches. Over a seven week period we observed a decrease in both the video based activity rates and minnow trap catches of pumpkinseeds. Relative species composition determined by video data was more variable than that of the minnow traps across the whole sampling period. Decreased activity may have been the result of increased predation pressures presented by the experimental addition of largemouth bass (Micropterus salmoides) or varying food resources.

P-1

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Poster

Lake-specific Diel Movement Patterns of Yellow Perch

Increased activity in the crepuscular periods has been documented for several yellow perch Perca flavescens populations. While this behavior is common, some research has shown peaks of activity occur during midday. The disparate results regarding the diel movements of yellow perch indicate that several factors likely influence movement behavior including habitat characteristics, physicochemical conditions, predator avoidance, and prey availability. Two lakes in close proximity with similar fish communities and abiotic influences, but differing habitat complexities, were chosen to determine if habitat characteristics affect diel activity patterns of yellow perch. We used ultrasonic telemetry to simultaneously track the movements of adult yellow perch in a shallow, simple lake and a deep, complex lake in fall 2004, and spring and summer 2005. Movement rates in both lakes were highest in the fall and the spring and summer rates were similar. The simple lake population showed peak activity in the diurnal period and in the complex lake population activity was highest in the diurnal and dusk periods. Mean seasonal movement rates were highest in the simple lake for all three seasons. In our study, peak movement did not appear to be influenced by the habitat differences in these two lakes. Although, in the simple lake overall activity was higher in all three seasons suggesting habitat complexity may still have an influence on movement rates.

P-2

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Informational Resources on Stream Health from MN DNR

The MN DNR Stream Habitat Program has various informational resources available that address the five-component framework used to assess stream health, causes and effects of stream instability, streambank erosion, and stream restoration. ·The "Understanding Our Streams and Rivers" is a developing brochure series that addresses the components of stream health, the causes of stream instability and resultant streambank erosion, and the various streambank restoration approaches such as vegetative stabilization, rock vanes, and revetments. "Healthy Rivers: A Water Course" is a free dynamic CD-ROM program that explores the ecology and management of river systems. This interactive tool features hundreds of photos, audio and video clips, maps, animations, external links, a complete bibliography, and references. The program addresses the science of rivers, the value of rivers, case studies, and guidance for getting involved and making informed choices. The online Watershed Assessment Tool consists of two parts. The first is a series of explanations of the five components used to assess watershed health. The second is the interactive mapping tool with 40+ data layers and map books based on watershed or watershed component. The Stream Health and Restoration Workshops are a series of three week-long workshops that teach the basic functions and processes of rivers, the Rosgen method of stream classification, assessing and monitoring river health, and natural channel design river restoration. These workshops are designed for natural resource professionals whose work involves rivers directly or indirectly as well as those who are engaged in watershed-wide resource management issues.

P-3

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Evaluation of an Exploitation Management Benchmark in a Mixed Harvest Walleye Fishery in Northern Wisconsin.

A mixed walleye (Sander vitreus) fishery involving both angling and Chippewa spearing harvest exists in northern Wisconsin. To keep maximum adult walleye exploitation from exceeding 35% on more than 1 in 40 occasions, the State uses a sliding bag limit system to reduce angler harvest in response to tribal spear harvest declarations. During 1990-2007 an average of 16 lakes (range 11-24) were randomly sampled each year to estimate walleye abundance and angling harvest. All fish harvested via tribal spearing are counted each night on each lake. This information was used to estimate angling and spearing exploitation rates which were summed to estimate total walleye exploitation rates. Based on individual lake data from 1990-2007, 1.4% (4 of 296) of total exploitation rate estimates exceeded 35%. Total exploitation rates of walleye averaged 12.50% with angling and spearing exploitation averaging 8.13% and 4.36%, respectively. Monte Carlo simulations were used to determine how measurement error affected the likelihood of exceeding 35% total exploitation, since multiple components (angler harvest, walleye abundance and proportions of marked fish observed in creel surveys) used in estimating exploitation were measured independently and with error. Based on Monte Carlo simulations the overall probability of exceeding 35% exploitation was 2.4%. Variations in Monte Carlo simulation results across year, bag limit, recruitment source, and fishing regulations are being evaluated and will be discussed.

P-4

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Cooperative fisheries management between the WDNR and US Forest Service - 30 years of accomplishments in northern Wisconsin.

Since 1978, most fisheries management work on the Chequamegon-Nicolet National Forest (CNNF) has been conducted through a cooperative effort between the U.S. Forest Service (USFS) and the Wisconsin Department of Natural Resources (WDNR). This is a unique relationship in which the USFS supplies funding to the WDNR to do fisheries work on waters within the CNNF. With an abundance of lakes and streams in the CNNF (604 lakes greater than 10 acres, 2,000 miles of stream of which 1,200 miles are trout water), the contract fisheries program was designed to provide supplemental fisheries management activities on many of the smaller, less developed waters within the Forest. Through this program, an average of 6 comprehensive fishery surveys and 25 electrofishing monitoring runs are conducted annually. During the 30-year period of the contract program, these surveys have yielded over 160 lake and stream survey reports. These survey reports have resulted in numerous management activities and habitat improvement projects, which have included the installation of 16 aeration systems; over 720 log crib shelters and 610 tree drops; a 1,200-foot walleye spawning reef; stream and river habitat improvements; fish stocking; and various special size/bag limit regulations. The end result has been increased and improved fishing opportunities in northern Wisconsin, as well as an excellent working relationship between the U.S. Forest Service and the WDNR.

P-5

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A search for hybrids between slimy sculpin and mottled sculpin in southeast Minnesota

Hybridization is common among freshwater fishes and is often associated with changes in environmental conditions. When conditions are altered, e.g. through land-use or climate change, once distinct species barriers may break down and lead to changes in fish community structure. Slimy sculpin (Cottus cognatus) and mottled sculpin (Cottus bairdi), two species with similar appearance and reproductive habits, occur in southeast Minnesota, sometimes syntopically. A study conducted in Pennsylvania found hybrids between these two species, but in general the phenomenon is poorly documented. Our objectives were to determine if hybrids of the two sculpin species occur in southeast Minnesota and describe habitat characteristics associated with species overlap. Using species-specific microsatellite DNA markers, we genotyped 100 individuals from each of four locations where the species overlap. We collected habitat data from overlap sites, including sections of the stream where the species overlapped and sections where both species occurred alone. Slimy sculpin tended to occupy cold, headwater streams, whereas mottled sculpin inhabited warmer, larger systems. Overlap was constrained to confluences of these smaller and larger streams, and occurred mostly in the larger streams. We found no hybrids. Detailed analyses of habitat in overlap sites are pending; however, initial habitat assessments suggest that land-use and climate change impacts may create conditions that lead to increased species interactions, possibly favoring mottled sculpin. Continued monitoring of species distribution and hybridization will provide insight not only into how coldwater fish communities are impacted by environmental change, but also provide an indicator of that change should hybridization occur.

P-6

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Harvest within yellow perch (Perca flavescens) fisheries is often dominated by females, an artifact of size-selective harvest and sexual dimorphism in growth, with female perch growing faster than their male counterparts. We hypothesized that anglers may also select female yellow perch during certain seasonal periods (e.g., winter) under the assumption that females will yield higher fillet weights because they appear more robust than males of the same length due to the presence of eggs. Conversely, we encountered winter anglers contending that male yellow perch yield higher fillet weights due to the lack of egg production. To determine whether fillet weight-total length relationships differed between sexes we collected and filleted yellow perch from two popular winter fisheries in the upper Midwest. Fillet weights (i.e., ribs out and skin on) generally accounted for between 30 and 40% of total yellow perch body weight and fillet weight-total length relationships did not significantly differ between sexes in either of the two populations we sampled.

P-7

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Acute and Chronic Toxicity of Ammonia, Nitrite and Nitrate to the Endangered Topeka Shiner and Fathead Minnows

The Topeka shiner (Notropis Topeka), once abundant in many low-order prairie streams, is now found in 20 percent or less of its former range and is the only federally listed endangered fish species in Minnesota. Recovery of Topeka shiners in streams where they currently occur or historically occurred may be limited by the impact of point and non-point sources of nitrogen such as confined animal feeding operations and municipal wastes. While the U.S. Environmental Protection Agency (EPA) has set water quality criteria for nitrogen compounds, the specific concentrations that cause lethal and sublethal effects on the Topeka shiner are unknown. Laboratory experiments were conducted to determine the toxicity of ammonia, nitrite, and nitrate on the Topeka shiner. Experiments included acute 96-h LC50 tests and 30-d chronic tests using the Topeka shiner. In addition, chronic 30-d tests and embryo-larval tests using fathead minnows were conducted because Topeka shiner embryos were not available. Toxicity endpoints of Topeka shiner embryos and larvae were predicted by comparing the relationship between Topeka shiner and fathead minnow 30-d growth tests and fathead minnow embryo-larval tests. Results, reported as the no observable effect level (NOEL), lowest observable effect level (LOEL), and their geometric mean, suggest that current EPA water quality criteria for nitrogen compounds are sufficient to protect the Topeka shiner.

P-9

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Spatial Variation in Fecundity Among Minnesota Walleye Populations: Is A Single Model Sufficient?

Walleye represent the most economically important fish in Minnesota and the Minnesota Department of Natural Resources stocks more than 250 million walleyes annually. As part of a larger study examining walleye populations in Minnesota lakes, researchers are interested in estimating egg production and subsequent hatching success. This requires estimation of walleye fecundity. The goal of our evaluation was to determine whether fecundity relationships (eggs/kg female body weight) significantly differed among four Minnesota walleye populations. We were specifically interested in whether a single fecundity relationship can be used to estimate fecundity for female walleyes from multiple lakes.

P-9

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Upstream range expansion of the round goby in the St. Louis River Estuary

The round goby (Apollina melanostomus) is a benthic fish,native to the Ponto-Caspian Region of Eurasia. In the last 15 years this species has become naturalized in the Laurentian Great Lakes with dramatic impacts on local ecology. Once introduced to a novel area the round goby has exhibited the ability to quickly increase in number and overwhelm native species. Round gobies were first discovered in the Duluth-Superior Harbor, Lake Superior, in 1995. As populations inhabiting the most ideal habitat of the Duluth-Superior Harbor increase, range expansion into less desirable locations is expected. In another study through the Mensinger lab, Bergstrom et al. established the distribution and range expansion of the round goby throughout the Duluth-Superior Harbor and portions of the lower St. Louis River from 1998 to 2004. To collect this data Bergstrom et al. utilized a semi-balloon bottom trawl. Bergstrom et al reported, by 2004, round gobies had expanded throughout the Harbor and upstream to river kilometer 13, but remained absent in western Lake Superior. This study utilizes standard 16" minnow traps to continue monitoring upriver migration of round gobies. Using this method round gobies have been identified to river kilometer 36; indicating either additional upstream introductions or a greater rate of expansion than previously thought.

P-10

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Risk assessment experiments reveal the effect of environment on the relative fitness of genetically engineered fish

Transgenic fish being developed for aquaculture are likely to escape and interbreed with wild relatives in the nearby environment. Predicting the risk of transgene flow from genetically modified fish to wild relatives would help to assess the environmental risks of farming transgenic fish. Population models incorporating measurements of the relative fitness of transgenic and wild-type fish can describe the process of gene flow. Using transgenic medaka (Oryzias latipes) engineered with a salmon growth hormone gene, we collected the following fitness component data on wild-type and transgenic medaka in a confined laboratory: fecundity, fertility, age at sexual maturity, mating advantage, juvenile viability and adult viability. To better understand how fitness components might vary in different environments, we collected data under four different environmental conditions that are particularly relevant to the fitness of growth-enhanced transgenic fish: (1) high food a availability and no predation; (2) low food availability and no predation; (3) high food availability and simulated predation; and (4) low food availability and simulated predation. Our results suggest that particular environments may affect the fitness of transgenic fish differently than wild-type fish. For example, in high-food-availability environments, transgenic females produce relatively more eggs than wild-type females in the same environment. With regard to mating advantage, transgenic males were more likely to out compete wild-type males for matings with a female only in the high-food-availability, no-predation environment. Decisions regarding whether to permit farming of transgenic fish should be informed by confined tests that incorporate environmental factors important to the animal's life history.

P-11

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Seasonal distribution of adult lake sturgeon in Namakan Reservoir, Voyageurs National Park, MN

Since the late 1800s lake sturgeon (ascipencer fulvencens) populations in the Laurentian Great Lakes have declined. These declines have been attributed to over harvest, pollution, and dam creation fragmenting lake sturgeon spawning and nursery habitat. In the state of Minnesota, lake sturgeon are listed as a species of special concern (Minnesota Department of Natural Resources 2003). While western canadian populations of lake sturgeon are considered endangered with Rainy River-Lake of the Woods populations of special concern (Environment Canada 2005). A private company in Ontario in collaboration with the Lac La Croix First Nation is proposing to build hydroelectric dams at three sites on the Namakan River, the major spawning tributary for lake sturgeon in the Namakan Reservoir. The purpose of this study is to determine movement patterns and potential spawning locations of adult lake sturgeon within Namakan Reservoir in an effort to better predict the potential impacts of Namakan River dam development on the Namakan Reservoir lake sturgeon population. In the spring of 2007 and 2008 sixty adult lake sturgeon were collected by federal, state and provincial biologists in US and Canadian waters of the reservoir and implanted with Vemco V16 acoustic transmitters. Sturgeon movements were monitored using 24 stationary VemcoVR2W receivers deployed throughout the Namakan Reservoir and its tributaries. Distributional patterns of lake sturgeon were summarized by week during the spawning period (May and June) and by month throughout the rest of the year. Movement frequencies and total number of lake sturgeon detected were compared among locations.

P-12

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Sustaining Lakes in a Changing Environment

Changes to the landscape and climate due to population and economic growth are placing new constraints on Minnesota lake habitats and biologic communities. Conventional urban development and agricultural practices that are growing in extent, contribute large amounts nutrient-rich runoff into lakes. Marshy shorelines that were once deemed unsuitable for development are now in high demand for residential development. A highly mobile human population unwittingly disperses non-native invasive species. To top it off, the climate is changing and has the potential to exacerbate the effects of the aforementioned drivers of change. For example, various studies have indicated a range of potential climate change impacts to Minnesota waters over the next few decades due to increased evaporation, wet and dry periods, changing stream flow patterns, longer growing seasons, and a loss of cool/cold water fisheries. Hence, it will be important to identify informative and responsive indicators and to quickly evolve new adaptive management techniques to deal with these problems proactively. We outline a collaborative long-term monitoring lake program called Sustaining Lakes in a Changing Environment (SLICE). SLICE is in its initial phase of implementation and aims to understand, predict, and appropriately respond to the consequences of ecological drivers of change on lake habitats and fish populations.