Autonomous Underwater Vehicle Detections of Acoustically-Tagged Green Sturgeon to Identify Marine Habitat

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Identifying essential fish habitats in nearshore marine environments is needed for adequate management. This is particularly true for listed species that spend much of their lives at sea, like green sturgeon (*Acipenser medirostris*). However, monitoring marine species is typically time-consuming and expensive. We used an autonomous underwater vehicle (Slocum glider) with two integrated Vemco receivers to detect acoustically-tagged green sturgeon at sea. Two, 3-week missions were completed in spring and fall 2018 along the coast of Oregon to the 300-m contour. In both surveys the glider flew a zig-zag course southward as it transited the water column and collected water quality information. This information, glider position/performance data and sturgeon detections were transmitted in near-real time during each mission. A conventional fixed array of acoustic receivers with sentinel transmitters was also maintained to compare detection efficiencies of the two platforms. Green sturgeon and sentinels were successfully detected by both the fixed array and the glider. While detection efficiency was higher for the fixed array, the glider detected green sturgeon outside of the array and provided clues to sturgeon behavior during hypoxic events. This application of the Slocum glider shows promise for identification of sturgeon aggregation areas in the marine environment, as well as opportunities for public engagement, teaching, and outreach.

Submersible PIT-Tag Antennas – Are They a Viable Tool for Detecting White Sturgeon?

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In 2014, Idaho Power Company and state managers initiated efforts to augment several semi-isolated populations of white sturgeon with hatchery progeny in the middle Snake River, Idaho. However, we currently lack empirical estimates of post-release survival which is a critical statistic necessary to guide stocking levels and better estimate future population size. Obtaining precise estimates of survival requires recapturing substantial numbers of tagged hatchery sturgeon which can be both inefficient and costly over time with traditional collection gear (i.e., setlines, gillnets), plus these techniques require physically handling individual fish. During 2017, we tested the efficacy of submersible PIT-tag antennas (Biomark RM 310) as an alternative method to passively detect tagged (134 kHz ISO FDX-B) white sturgeon in a riverine section of the Snake River between C.J. Strike and Swan Falls dams [CJSF]. From October 3 to November 21, 2017, we deployed up to 9 antennas baited with commercial sturgeon feed in the CJSF reach. During that time, antenna detections totaled 90 white sturgeon (unique individuals), 50 of which were hatchery juveniles, demonstrating that PIT-tag antennas are a viable method for collecting tag data while at the same time reducing the need for field crews and handling of fish. During 2018, we initiated a structured sampling effort which detected a total of 237 juveniles (unique detections) from 4 different release cohorts (2014-2017) in the CJSF reach. The proportion of individual detections from each release group were notable, ranging from 30.7% (2014) to 64.5% (2017) while apparent survival at 1-year post-release was estimated at 0.83 (2016 cohort). Based on these findings, we consider mobile PIT-tag antennas as a versatile tool to efficiently collect tag data for estimating important population statistics such as survival. Additionally, PIT-tag detections realized with mobile antennas can provide valuable information on white sturgeon distribution and movement.

Side-Scan Sonar as an Effective Tool for Estimating Atlantic Sturgeon Spawning Run Size

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The Atlantic Sturgeon (*Acipenser oxyrinchus oxyrinchus*) is a large, benthic, anadromous fish that occurs in the waters off the east coast of North America. Many populations were nearly extirpated by commercial harvest and the construction of dams on spawning rivers; this resulted in the species being listed as federally endangered in 2012. The Altamaha River in Georgia hosts one of the most robust Atlantic Sturgeon populations within the South Atlantic Distinct Population Segment (DPS), based on recruitment studies. Unfortunately, population estimates for the large, migratory adults are lacking because it is logistically challenging to quantify them. The recent availability of cost effective side-scan sonar technology offers a new method for estimating adult spawners during their upstream migrations. The objective of this study was to assess the run size of spawning Atlantic Sturgeon in the Altamaha River. We conducted side-scan sonar surveys throughout the entire 451 river km of navigable potential spawning habitat within the Altamaha River system, including the Oconee and Ocmulgee River tributaries, from September through November of 2017 and 2018. An N-mixture model was used to estimate spawning run size; this model takes into consideration count data from a continuous survey of the whole system and estimated detection probability calculated from repeated surveys of selected river reaches. We estimated that there were 161 adult Atlantic Sturgeon in the 2017 spawning run (95% CI: 101-249), with a detection probability of 0.57 (SE 0.13); 2018 results are forthcoming. This study provides the only recent estimates of adult Atlantic Sturgeon abundance in the Altamaha River and the South Atlantic DPS, and provides important quantitative data to species managers. Additionally, compared to previous mark-recapture estimates of spawning run size, side-scan sonar was less invasive, required substantially less effort, and resulted in tighter confidence intervals.

Slocum Glider Detection Efficiency and Active Tracking of Acoustically Tagged Atlantic Sturgeon (*Acipenser oxyrinchus oxyrinchus*) off Mid-Coast Maine

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Atlantic Sturgeon (*Acipenser oxyrinchus oxyrinchus*) are federally threatened in the Gulf of Maine (GOM). Recent status reviews note a lack of information on marine habitat use, migratory pathways, and as potential bycatch in commercial fisheries. Based on acoustic telemetry in the GOM, sub-adults spend approximately six months at sea during winter before returning to rivers in late spring. Incidental coastal telemetry detections suggest that these fish may aggregate in winter near the mouths of seasonally used rivers, and are important corridors to seasonal movements. Current technological advances of gliders retrofitted with acoustic receivers show promise as a method to scan large spaces for tagged fish while collecting environmental data. To test the hypothesis that Atlantic Sturgeon spend the winter in coastal regions near river outlets, over 100 fish were gill netted from the Penobscot, Kennebec, Saco and Merrimack Rivers and surgically implanted with acoustic transmitters. Three spring missions were conducted along mid-coast Maine with a glider equipped with an acoustic receiver, using a search grid pattern near previous incidental detections. The glider was programmed to collect bathymetry, temperature, and salinity information. Detection efficiency was also determined by having the glider approach stationed transmitters positioned at the surface and near bottom. Transmitter pings were binned by distance to calculate efficiency. Pilot missions demonstrated that the glider can operate in complex coastal bathymetry, and detection efficiency decreased with distance and during diving. These data will prove useful to managers to minimize bycatch and inform critical habitat designation.

Lake Sturgeon Population Size and Trajectory: Churchill River near the Little Churchill River Confluence

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North/South Consultants Inc.

Despite severely reduced flows down the Lower Churchill River, Manitoba, following the Churchill River Diversion project (1977), Lake Sturgeon persist in a small section centered on the Little Churchill River confluence. In 2003, a Lincoln-Petersen estimate of 1,812 fish >834 mm fork length (95% CI: 1,304 – 2,320) was produced. Over the past fifteen years, the water regime has been constant (i.e. reduced flows relative to historical hydrograph) and subsistence harvest has occurred. As a result of potential listing as an endangered species under the Federal Species At Risk Act as well as ongoing stewardship initiatives, there has been increased interest in the size and trajectory of the population. Juvenile/recruitment monitoring piggy-backed onto annual Coordinated Aquatic Monitoring Program studies (2010 – 2016 results considered herein) indicates that recruitment is ongoing, and that fish are growing at an average rate relative to other Manitoba Lake Sturgeon populations. Adult mark-recapture gill netting conducted between 2014 and 2016 produced a total of 989 Lake Sturgeon capture events, including 225 of fish tagged in previous years. Despite high recapture rates, POPAN analysis indicated a high likelihood of 'entry into the population' which could not be entirely explained by young fish being recruited into the large mesh sampling gear. Specifically, an influx of large unmarked individuals into the catch during 2016 may be indicative of immigration from an area yet to be sampled. While the population does not appear to be in danger of imminent collapse, 'closed system' assumptions appear to have been violated meaning that estimates produced based on 2014-2016 data may be biased, complicating the understanding of trajectory.

Lake Sturgeon Population Trends in the Nutimik and Numao Lakes Region of the Winnipeg River

Lee Murray and Derek Kroeker

Manitoba Sustainable Development

Mark-recapture methods have been used to monitor the population size and characteristics of Lake Sturgeon in the Nutimik and Numao lakes region of the Winnipeg River since the early 1980's. Over the past four decades, several tag types have been employed with varying degrees of success (retention). Since 2006, PIT tags have been used to generate encounter histories that we have been iteratively analyzing using program MARK. The population estimate for all Lake Sturgeon susceptible to the gear (5.5, 9, and 12" stretched measure, equal effort by mesh size) has increased steadily since the 2014 and similarly the number of adult fish has increased since 2012. Precision of estimates has also increased rather dramatically of late, an apparent function of the length of the dataset and increased tag saturation. The population estimate for all Lake Sturgeon in 2018 was 62,598 (95% CI 59,318 - 66,061) and 16,345 for adults (95% CI 14,543 – 18,386). The rarity of Lake Sturgeon movement between Nutimik and Numao lakes as well as differences in growth rates suggest that these two lakes, although close in proximity, are demographically independent, suggesting that they should be considered separately in the context of population estimation. As of 2018, Nutimik Lake was estimated to harbour ~36,660 Lake Sturgeon and Numao Lake had ~25,551. Nutimik and Numao lakes also differ in life stage contributions within the catch with sub adults accounting for 70%, adults 18% and juveniles 12% in Nutimik Lake while in Numao Lake sub adults accounted for 44%, juveniles 40% and adults 15%.

Recruitment Dynamics in a Changing Environment: Age-1 Atlantic Sturgeon in the Altamaha River, Georgia

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The Atlantic Sturgeon (*Acipenser oxyrinchus oxyrinchus*) is an anadromous fish species that was once of great commercial importance in many of the coastal rivers along the eastern U.S.A. The life history traits of this species, including its slow growth and late age at maturity, have made this fish particularly vulnerable to the effects of overharvest and habitat degradation. Over the course of the 19th century, commercial harvest and infrastructural projects, such as damming and dredging, have severely depleted most of the historical stocks of Atlantic Sturgeon. Consequently, the species was placed on the endangered species list in 2012. As a result, researchers have rigorously studied the population dynamics and life history of this species in hopes of eventually reversing this listing. The objective of this study is to use capture-mark-recapture data to 1) estimate the recruitment of age-1 juvenile Atlantic Sturgeon in the Altamaha River, GA and 2) examine the effects of river discharge and water temperatures on juvenile recruitment levels. The project will involve capturing river resident juveniles in gill and trammel nets during slack tides. Fish will be measured and individuals identified using passive integrated transponder (PIT) tags. Capture histories of individual sturgeon will be put into Huggins closed capture models in the RMark package of Program R to obtain juvenile recruitment estimates. These estimates will give managers insight into the long term population trends of Atlantic Sturgeon in southern rivers as well as provide information about the effects of flow fluctuation and water temperatures on juvenile recruitment.

Lake Sturgeon Movement and Spawning Behavior in Winnebago System Tributaries, Wisconsin

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Understanding the movement and spawning behavior of sturgeon is important for long term management of fish populations given that sturgeon species typically do not spawn annually and seasonal movement can impact catchability. A total of 351 Lake Sturgeon (Acipenser fulvescens) captured from the Winnebago System, Wisconsin, were implanted with 10-year sonic tags between 2008-2018 to evaluate movement, spawning periodicity and spawning tributary fidelity. PIT mark-recapture data were used to evaluate spawning site fidelity. In general, pre-spawn adults migrate out of Lake Winnebago to winter staging areas in the Upriver Lakes and rivers between September and March, and initiate final migration to specific spawning sites when spring river temperatures reach 8-10° C. After spawning, females immediately begin their descent back to the Winnebago Pool Lakes, while males remain at one or more spawning sites until all females have spawned before they begin their downstream descent. Males exhibited annual or biannual spawning periodicity, while females spawned on 3, 4 and 5 year cycles in close to equal proportions. Modest spawning tributary and site fidelity was observed, but fish were frequently observed straying between tributaries and spawning locations during consecutive spawning runs.

Nucleo-cytoplasmic Large DNA Viruses of Wild Lake Sturgeon (*Acipenser fulvescens*) in Central Canada

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Namao virus (NV) is a sturgeon nucleo-cytoplasmic large DNA virus (sNCLDV) that can cause a lethal disease of the integumentary system in Lake Sturgeon *Acipenser fulvescens*. In this study, the spatial, temporal and genetic patterns of sNCLDV were evaluated for the first time for wild Lake Sturgeon from 11 rivers in central Canada. A total of 1329 pectoral fin biopsies were collected between 2010 and 2015. Quantitative PCR results indicated that sNCLDV are endemic in sturgeon of the Hudson Bay drainage basin with 24% of the fish testing positive. As part of this study, samples were collected annually from a population of Lake Sturgeon from the Landing River, a tributary of the Nelson River in northern Manitoba. Bayesian hierarchical models were developed with 11 environment and fish-specific variables to identify predictors of fish condition and sNCLDV presence and titer in this sub-population. Sample collection year was included as a random effect. The presence of sNCLDV in these wild sturgeon did not have a measurable effect on their individual length-weight ratio, a proxy for their body condition. The model revealed that 95.2% of the variability observed in fish weight was explained by length. Sturgeon weight and age were identified as the best predictors of virus presence and titer, respectively, whereas water flow rate, level and temperature, fish length, cohort year and number of previous captures did not significantly improve model fit. A negative relationship was estimated between virus presence and sturgeon weight and virus titer and sturgeon age with the models explaining 16.5% and 19.5% of the variability in the respective response variables. Genetic typing of 21 virus isolates indicated that the NV genogroup of sNCLDV was dominant in the basin. The results of this study can be used to inform disease management strategies for Lake Sturgeon conservation and recovery programs.

Epidemiology and Genetic Variation in the Cnidarian Roe Parasite of Sturgeons and Paddlefishes, *Polypodium hydriforme*

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The cnidarian roe parasite, *Polypodium hydriforme*, has a one-host life cycle with free-living adults and a parasitic larval stage that develops in oocytes of Acipenseriform fishes (sturgeons and paddlefishes). Morphological similarity suggests a single Polypodium species with a widespread distribution (Eurasia to North America). A stolon of connected tentaculate individuals emerges from spawned eggs, and subsequent fragmentation releases up to 100 benthic individuals. A specialized multicellular stage in mature individuals enables infection via contact with a fish larvae host. Post-infection life history is unknown prior to maturation of the fish host, when development within oocytes has been characterized. High infection rates (78% of individuals) and intensities (up to 100% of oocytes infected) for Sterlet Sturgeon Acipenser ruthenus is cause for concern given potential impacts on caviar production or wild recruitment of sturgeon or Paddlefish stocks. As part of larger investigations, we collected Polypodium from roe of American Paddlefish (Polyodon spathula) in Oklahoma and Montana, USA, and from Russian Sturgeon (A. gueldenstaedtii) for genetic analysis and genome development. Covariate data such as fish size, age, condition (gonadosomatic index), and year of collection aided in describing presence and intensity of Polypodium infection. This collaborative work enabled us to explore genetic variation in Polypodium and characterize epidemiology of Paddlefish infections. Results include evidence for genetic divergence of Old and New World Polypodium based on housekeeping genes, however, little divergence between New World populations was observed, perhaps reflecting connectivity within river systems. Approximately half of fish were infected each year and infection intensity was negatively skewed. Presence of infection was positively associated with fish size and age, though negatively with fish condition while infection intensity showed no significant association with these variables. Relationships were consistent across years. Research on genetic variation amongst stolons within individual hosts is ongoing and will also be reported.

Acipenserid Herpesvirus 1 (AciHV1) in Wisconsin Lake Sturgeon (Acipenser fulvescens): Not Just for White Sturgeon (*Acipenser transmontanus*) Anymore

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Alloherpesviruses have been described in a wide range of fish species. In 1991, an alloherepsvirus was described in a population of white sturgeon (*Acipenser transmontanus*) from a commercial farm in California and was later described in farmed white sturgeon in Italy. This alloherpesvirus, referred to as Acipenserid herpesvirus 1 (AciHV1), caused microscopic lesions within the epithelial cells of the skin and oropharynx. In the spring of 2017, during a transfer event on the Wolf River in Wisconsin, cutaneous plaques were noted on two wild-caught lake sturgeon. Biopsies were collected from these lesions for molecular diagnostics and histopathology. PCR screening and histopathology confirmed the lake sturgeon were infected with a strain of AciHV1. Through the distribution of sampling kits (for non-invasive skin scrape collection) to hatchery managers and field biologists throughout Wisconsin, efforts are underway to better characterize the virus, as well as understand its distribution and role in disease.

Thermal Plasticity of Age-0 Lake Sturgeon (*Acipenser fulvescens*) from Geographically Different Populations

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This study examined responses to chronic and acute changes in environmental temperature in northern and southern populations of Lake Sturgeon (*Acipenser fulvescens*) in Manitoba, separated by 3.5° latitudinally. Lake Sturgeon, at 30 days post fertilization, from both the Nelson River (northern) and Winnipeg River (southern) populations, were acclimated to one of 16, 20, and 24°C treatments for 60 days. CTmax trials were then conducted by raising water temperatures by 0.3°C minute-1 until a loss of responsiveness endpoint was reached. Rearing temperature had significant effects on in the Nelson River individuals with the 20°C (34.1°C) and 24°C (34.6°C) groups having a greater CTmax than the 16°C (31.9°C) group ($P < 0.0001$). Similar trends were also observed in the Winnipeg River population with significant differences apparent between the 16°C (32.6°C) and 24°C (34.1°C) ($P < 0.0001$) as well as the 20°C (33.3°C) and 24°C treatments (34.1°C) ($P < 0.05$). Comparison of CTmax between populations showed significant differences observed in the 16°C ($P < 0.05$) and 20°C ($P < 0.01$) treatments, where the Winnipeg River and Nelson River populations had the higher CTmax, respectively. Significant differences in mortality rate and mRNA expression patterns were observed between treatments throughout the temperature acclimation period. After CTmax trials were completed, larval Lake Sturgeon from all treatments were held at 16°C until approximately 170 days post fertilization when they were transferred to 8°C for one week. Thirty individuals from each treatment were then acutely exposed to 6 and 4°C, to determine the effects of cold shock on mRNA expression mimicking what could be encountered during late season stocking. Data will be discussed in terms of the effects of acclimation temperature between populations.

Community Based Management - Nelson River Sturgeon Board

Don Macdonald

Nelson River Sturgeon Board

Following the 1990 Sparrow decision, there was increased subsistence harvest of Nelson River Lake Sturgeon. This stock was already commercially fished and was not considered capable of sustaining additional harvest. In 1992, First Nations and communities along the Nelson River created the Nelson River Sturgeon Board to address these concerns. One of the first steps was the closure of the commercial fishery. Since then the Board has monitored fish stocks, developed harvest recommendations, initiated a conservation aquaculture program, partnered in research studies, and developed community and school outreach programs.

Nelson River Lake Sturgeon were initially depleted by an early 20th century commercial fishery. Subsequent fisheries were more sustainable in that they may not have further depleted stocks, but they also prevented their recovery. In addition, large scale hydroelectric development in the late 1950s and early 1970s altered flows and habitat. This history complicated the relationship between government, industry and indigenous communities. The Board is an example of an adversarial situation gradually being resolved as individuals, communities and organizations work together on a common purpose.

The Board's successes include monitoring the initial decline in stocks followed by an ongoing recovery. Stock monitoring results support the Board's management recommendations to harvesters and confirm that these recommendations are effective.

An early initiative was a conservation aquaculture program aimed at rebuilding stocks in the uppermost reach of the Nelson, an area where sturgeon were considered nearly extirpated. The primary stocking reach has been extensively studied providing insights into stocking success and subsequent growth and behavior.

The Nelson River Sturgeon Board is an example of a successful collaboration among communities, government, and industry. This collaboration has extended further to include researchers, other sturgeon management boards, Species At Risk programs and schools.

Biology, Status and Management of Lake Sturgeon (*Acipenser fulvescens*) in the Province of Quebec, Canada

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Ministère des Forêts, de la Faune et des Parcs

Lake sturgeon of the Lower St. Lawrence River (between Montreal and downstream Quebec City) are distinct in many aspects. In that section of the Great Lakes drainage basin, lake sturgeon are abundant and support an important commercial fishery. It is also the only area were lake sturgeon overlap with the distribution of the Atlantic sturgeon (*Acipenser oxyrhynchus*). Lake sturgeon in the lower St. Lawrence River has a long history of research and management. In 1987, lake sturgeon was considered overexploited by commercial fishing activities. Different management plans aimed to lower the exploitation rate and to protect spawners. Commercial catch was reduced by 60% and an individual barcoded plastic tag was established to control its application. Twenty years later, lake sturgeon populations of the lower St. Lawrence River are considered healthy and support a sustainable commercial fishery (80 tons/year). Restrictive management measures, close supervision of landings combined with periodic monitoring of the population were key elements in managing this long-lived species. The history of lake sturgeon in the St. Lawrence River also highlighted the importance of habitat connectivity. Further habitat fragmentation in the lower St. Lawrence River would have an important impact on the status of lake sturgeon in this fluvial ecosystem.

Saskatchewan River Sturgeon Management Board

Stephanie Backhouse[1] and Marcy Bask[2]

1. Manitoba Hydro, 2. SaskPower

The Saskatchewan River Sturgeon Management Board was formed in 1998 in response to concerns over the decline of the Lake Sturgeon population between E.B. Campbell Dam and Grand Rapids Dam on the lower Saskatchewan River. The Board takes a co-management approach, and consists of members from Manitoba and Saskatchewan First Nations, Provincial Governments and Utilities. The long term goal of the board is to support establishment of a self-sustaining population of Lake Sturgeon on the river that is capable of supporting traditional uses of local First Nations. Board activities are guided by successive 10 year management plans, and include monitoring (adult and juvenile populations, movement, harvest and habitat) and outreach/education activities. Board activities and long term population and movement monitoring data will be presented.

Sturgeon Soup; Balancing the Needs for Sturgeon Conservation and Industrial Users in the New York Bight

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Atlantic Sturgeon in the Delaware and Hudson Rivers were federally listed as in 2012. Although recovering in some regions, managers face the usual gambit of threats (e.g. bycatch,and habitat loss) in addition to the hazard of commercial shipping, a major contributor to the economic lifeblood of the New York Bight. Traditional water management issues including flows and impediments to migration do not appear to be near-term threats to conservation in this region. Instead, the cumulative impacts of commercial shipping may play a large role in mitigating recovery. We have employed several lines of inquiry to underscore the nature of commercial shipping's bearing on direct mortality including implementing a carcass-reporting network, augmented with an ongoing study to derive empirical estimates of carcass reporting rates of dead sturgeon. Our reporting rates are coupled with telemetry studies to identify the location and behavioral effects of commercial navigation on Atlantic Sturgeon. Finally, we have looked at the previously unreported impacts of anchoring by commercial vessels in ESA designated critical habitat adjacent to spawning sites. Commercial shipping is critical to the New York Bights economy and resource managers need to develop novel approaches to balance commerce, national security, and conservation of this imperiled species.

The Heterocercal Tale of White Sturgeon Recruitment in Hells Canyon

Jacob Hughes

Idaho Power Company

White sturgeon (*Acipenser transmontanus*) below Hells Canyon Dam represent one of the most robust white sturgeon populations in the Snake River. Recent studies however, have documented extremely slow growth, delayed age-at-maturity, and suggest declining recruitment. Recruitment studies were initiated in 2014 within Lower Granite Reservoir (LGR), focusing on young-of-year (YoY) production in Hells Canyon, the first such studies since 1990-91. Failed detection of YoY during 2014-2016, as well as no juvenile catch < 60 cm, further supported a declined recruitment frequency theory compared to early 1990s. These findings prompted additional research beginning in 2017 to detect white sturgeon larvae. Since then, larvae have been detected in 2017 and 2018, with stage (age) and timing of larvae similar between years. Larvae drift behavior exhibit a brief initial dispersal phase as free-embryos, followed by several days of hiding, and concluding with a second brief drift phase at approximately 10-12 dph. Back-calculated spawn dates suggest spawning events occur frequently from late-May to early-July, with genetic analysis estimating 142 spawning adults in 2017. Recruitment of YoY was documented in 2017 and 2018, following three years of no recruitment (2014-2016). Data suggest age-1 sturgeon are more catchable (n = 283) than YoY (n = 17) and exhibit an average growth rate of 213 mm/yr, approaching lengths of sturgeon known to be decades older rearing upriver. A subset of YoY and age-1 white sturgeon were implanted with acoustic transmitters during fall 2017 (n=9) and 2018 (n = 39) and passively tracked with stationary acoustic receivers. To date, data indicates young sturgeon utilize the entire reservoir and can move great distances within a day and across months. Movements will be followed through 2019 to determine if/when these cohorts leave LGR, direct recapture attempts for growth metrics, and help design future sampling methods.

Ploidy Analysis using Non-lethal Blood Sampling and a Coulter Counter

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A coulter counter can measure the volume of erythrocyte nuclei, and is a fast and accurate technique to identify ploidy in sturgeon. Non-lethal blood sampling has been done on white sturgeon as young as 60 days post-hatch, at 3-6 grams body weight, and can likely be done on even slightly smaller, younger fish. Only one microliter of blood is needed for analysis. This tiny amount of blood can be collected from the caudal vasculature of anesthetized fish, using a 31 gauge needle, 1/3 cc insulin syringe, inserted just anterior to the anal fin. Collected blood is immediately placed into a coulter vial containing saline and a lysing reagent, and usually is analyzed within a couple hours. Alternately, the vials can be stored in a refrigerator for up to 6 days, warmed to room temperature, and then analyzed. From larger 50-100 gram fish, 50-100 microliters of blood can be collected and placed into a 1 ml lithium heparin micro-tube. And from even larger fish (>1 kg) a 5 ml heparin vacutainer with a 22 gauge needle can be used. Accurate ploidy analysis can be obtained from heparin blood samples stored in a refrigerator for up to 30-40 days. Hematology of small/young fish (<2 months) will change with age, as blood cell formation progresses towards a dominant population of mature erythrocytes. Sturgeon blood contains primarily erythrocytes but also leucocytes (thrombocytes, lymphocytes, granulocytes), and monocytes, that have different size nuclei. During the first couple months of age, there are more immature erythrocytes (reticulocytes), that have larger nuclei, compared to mature erythrocytes. Although mode nuclei volume will change as these young fish grow and age, the difference between 8N and 12N nuclei volume, at any given age/size, will shift proportionally. Procedures and ploidy data from different juvenile ages will be presented.

Otolith Calcium Carbonate Composition in Sturgeons: Influence of Ontogenetic Development and Environmental Conditions

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Otoliths are calcified structures that form by the accumulation of biominerals deposited on a proteinaceous matrix in the inner ear of fish. Calcite, aragonite and vaterite are crystallized biomineral polymorphs of calcium carbonate ($CaCO_3$) and make up the primary composition of otoliths. Otoliths of primitive fishes, including sturgeons, were previously described as being composed entirely of vaterite. Recently however, it was demonstrated that the otoliths of adult Lake Sturgeon, Acipenser fulvescens, also contained significant proportions of calcite (18-30%). These findings were surprising given that the ability to form calcite in otoliths was not thought to have evolved until the separation of teleosts from ray-finned fishes. It was unclear, however, if this shift in CaCO3 polymorph phase was due to ontogenetic development or a physiological response to changes in environmental conditions. In this study we quantified the variations in percent otolith polymorph composition throughout the ontogenetic development of larval Lake Sturgeon and White Sturgeon, A. transmontanus, via X-ray microdiffraction. Results identified both species showed similarly changing patterns of otolith polymorph composition with increasing proportions of aragonite forming as larvae developed. This, however, did not account for the calcite crystallization observed in the adult otoliths. To identify whether the environment influences polymorph precipitation, Lake Sturgeon larvae were reared in varying temperature and pCO2 conditions for six months. Interestingly, pH had no effect on polymorph composition, however, fish raised in elevated temperatures had significantly different aragonite and vaterite proportions as well as inclusions of calcite crystals. These results suggest both ontogenetic development and environmental conditions play a significant role in the precipitation of otolith CaCO3 polymorphs. In addition, our data indicate that sturgeon have the capacity to precipitate all three forms of CaCO3 polymorphs countering long standing classifications of otolith composition among fish species.

Stock Discrimination of Lake Sturgeon in the Lake Winnebago System using Otolith and Fin Ray Microchemistry

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Lake sturgeon (*Acipenser fulvescens*) spawn in multiple tributaries of the Lake Winnebago system (LWS) but the relative contribution of recruits from these tributaries to annual spearing harvest is not known. Microchemistry of calcified structures is often used to determine natal origins of fish. Although otoliths are commonly analyzed for this purpose, pectoral fin rays provide a non-lethal sampling method that could be used for microchemical analysis. The efficacy of using microchemistry in calcified structures for determining natal origin has not been evaluated for lake sturgeon. Thus, the objectives of our study are to: 1) determine if otolith microchemistry can be used to assign lake sturgeon to specific rivers where spawning occurs; 2) determine if chemical signatures are consistent between otoliths and fin rays; 3) estimate abundance of larval sturgeon among spawning locations; and 4) determine if contribution to spearing harvest varies among rivers. To accomplish our objectives, laser-ablation inductively-coupled mass spectrometry will be used to assess the microchemistry of calcified structures in juvenile and adult sturgeon. Larval and juvenile fish will be collected downstream of spawning locations in the Wolf, Fox, Embarrass, and Little Wolf rivers in late spring (larvae) and late summer (juveniles). Chemical signatures from the juvenile fish will be used to determine the extent to which fish origin can be discerned among the four rivers. Otoliths and fin rays from adult fish harvested by spearers will be used to determine the contribution of different spawning locations to overall harvest.

Movement Patterns and Site Fidelity of Hatchery-origin White Sturgeon following Release into the Wild

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1. BC Hydro, 2. Golder Associates, 3. Colville Confederated Tribes

Movements and site fidelity of hatchery-origin white sturgeon (*Acipenser transmontanus*) released into the upper Columbia River (2002 to2014) was evaluated to determine distribution across key habitats, including the international border between Canada (CAN) and the United States (US). While both countries have been releasing hatchery-origin fish annually as part of a recovery plan, the segment of the population in CAN is listed as endangered while the US segment is not. Recently, a harvest fishery was initiated in the US focused on removal of hatchery-origin fish. Understanding movement of fish following release is critical to inform stocking strategies used to meet differing management objectives within each country. We summarized movement patterns between key habitat zones, including the international border, using an annual mark recapture program (2013-2018). Movements were calculated relative to river kilometer values recorded at each recapture event, and the distance and direction of relocations were evaluated against the time of year and the period of time between captures. Two types of movement across the international border were possible: 1) movement after original release but before recapture in the mark-recapture program, and 2) movement between capture events during the mark-recapture program. Overall, movement across the international border has been higher for fish moving from CAN to the US compared to the US to CAN. Movements from the US to CAN was highest in the early years of the program (25%; 2002-2006) but has declined in later years (5%; 2007-2014). Conversely, movements from CAN to the US were lower for fish released in early years of the program (42%) compared to later years (85%). While movement between locations of original release and subsequent recapture was high, movement between recaptures during the sampling program was low, with fish in upstream habitats having high fidelity to specific sites. Distance traveled between subsequent recaptures did not have apparent patterns with time between recaptures, season of capture or recapture, or direction (downstream or upstream). Describing movements between key habitats is important for the development of stocking prescriptions where multiple management goals exist for a population.

Lake Sturgeon Movements in Northern Lake Michigan and Lake Huron

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Wisconsin Department of Natural Resources, 2. U.S. Geological Survey, Wisconsin Cooperative Fishery Research Unit, 3. Michigan State University

Lake Sturgeon movements in the Great Lakes are largely unknown beyond specific project boundaries usually restricted to tributaries. Several arrays of acoustic receivers were deployed in the Great Lakes under the Great Lake Acoustic Telemetry Observation System (GLATOS) to monitor movements of several fish species. Since receivers were indiscriminate in tag detections, we were able to obtain information for our lake sturgeon project from other GLATOS receivers. Vemco V 16 tags were inserted into 311 spawning adult lake sturgeon from four Green Bay tributaries (Menominee, Peshtigo, Oconto and Fox) in 2011-2018. 177 of those fish were determined to be males with 133 females. While many detections have been documented on river acoustic receivers, the movements of these sturgeon were previously unknown during non-spawning periods. In cooperation with GLATOS and their collaborating researchers, we were able to obtain records from receivers deployed for lake trout, walleye, and lake whitefish projects located in northern Lake Michigan and Huron. In general, this data revealed movements outside of lower Green Bay and as far away as northern Lake Huron and largely scattered throughout the year. Female sturgeon moved as broadly as male sturgeon. Preliminary information supports our previous conclusions of high and asymmetrical movement patterns for Green Bay lake sturgeon. We intend to draw more specific conclusions with additional data.

Analysis of White Sturgeon Movement using Fine-scale Tracking and Behavioral State Models

Caleb Jetter[1], Eduardo Martins[1], James Crossman[2]

1. University of Northern British Columbia, 2. BC Hydro

With the development of fine-scale acoustic tracking, fishery managers can better explore the movement and behavior of aquatic species. A Vemco VR2W positioning system (VPS) was used to examine the fine-scale movement patterns of white sturgeon (*Acipenser transmontanus*) below the Hugh L. Keenleyside Dam (HLK) on the Upper Columbia River in relation to critical habitats (overwintering and spawning) and environmental variables. Using hidden Markov models (HMM) with the R package moveHMM, two distinct behavioral states were identified. These states comprised of short, localized movements (State 1) and long, wandering movements (State 2). Environmental covariates including temperature, discharge, and water elevation were incorporated in each model to assess their influence on the probability of an animal switching states. Additionally, behavior states between individually tagged fish were compared over time and space to better understand white sturgeon seasonal interactions. Results of this study are currently in development, but will help shed light on the effectiveness of fine-scale tracking and behavioral state models in understanding the ecology of the species as well as fine-scale movements in regulated rivers.

Keeyask Generation Project Tailrace Spawning Shoal Design Evolution: Planning to Construction

Martin Hunt

Manitoba Hydro

This presentation reviews the multi-decade process of planning, assessment, design and construction of the tailrace spawning shoal offsetting measure currently under construction as part of the Keeyask Generation Project in the Nelson River in Northern Manitoba. The Keeyask Generation Project is a 695-megawatt (MW) hydroelectric generating station located approximately 725 km north of Winnipeg being developed as a partnership between Manitoba Hydro and 4 Manitoba First Nations (The Keeyask Cree Nations, KCN). The GS will have approximately 18 metres of head and the powerhouse will pass a maximum flow of 4100 m3/s. Early planning for the Keeyask Generation Project began in the 1990s with an 8 year study period focusing on Lake Sturgeon occurring from 2001-2008. Impacts on Lake Sturgeon were assessed based on habitat suitability index models predicting changes to lake sturgeon habitat in the Keeyask area; and condition of sturgeon populations in Stephens Lake and other representative hydroelectric reservoirs. The criteria developed for the Lake Sturgeon HSI models subsequently formed the basis of engineering design criteria for measures that would be incorporated into the project's environmental mitigation and compensation plan. These designs were developed in the late 2000s and were outlined in the project's Environmental Impact Statement and subsequent Keeyask Application for Fisheries Act Authorization (KAFAA). A key component for Lake Sturgeon was commitment to construct 5.3 ha of shoal along the North shore of the tailrace channel extending downstream into Stephens Lake. This location was selected using hydraulic modeling to identify areas matching the high score HSI criteria (depth and velocity). A portion of the shoal was to be constructed 'in the dry' within the tailrace cofferdam while the remainder (3.65 ha) would be constructed by barge 'in the wet'. Subsequent to the finalization of the KAFAA additional monitoring of Lake Sturgeon spawning behavior (primarily at the Pointe du Bois GS on the Winnipeg River), modifications the stations design, and changes to the construction methodology and schedule have offered opportunities to modify the design and location of the tailrace spawning shoal. Monitoring at Point du Bois has indicated a preference for Sturgeon to spawn as close as possible to an upstream barrier (physical or velocity). Also, modifications to the tailrace channel width and depth have reduced velocities within the channel creating desirable spawning conditions closer to the station. As a result of these factors it has become feasible to adjust the footprint of the tailrace spawning shoal to allow for all of the construction to be completed 'in the dry' within the tailrace cofferdam. This change offers cost savings to the project while also offering greater diversity of habitat (depths ranging from 2-11 metres) over the shoal.

The Assiniboine River Lake Sturgeon Story: Post-extirpation Stocking, Monitoring, and the Search for Evidence of Reproduction

Laura Henderson[1], Jeff Long[2], and Craig McDougall[1]

1. North/South Consultants Inc, 2. Manitoba Sustainable Development

The Assiniboine River is a 1,070 km long prairie river that merges with the Red River in Winnipeg, Manitoba. While Lake Sturgeon were historically known to inhabit the Assiniboine River, as of the 1970's, the species was believed to be extirpated as a result of overexploitation and habitat related impacts. To evaluate post-stocking survival and attempt to re-establish a population, a stocking program was conducted by Manitoba Sustainable Development in the mid-1990's. Between 1996 and 2008, broodstock from the Winnipeg, Saskatchewan, and Nelson rivers were used to facilitate the re-introduction of approximately 16,683 Lake Sturgeon (4,000 fry, 12,416 fingerlings, 205 yearlings, 55 juveniles, and 7 adults) into the Assiniboine River near Brandon. Based on anecdotal recaptures by anglers and limited fishery survey conducted in 2013, it is apparent that a fair proportion of the stocked fish have survived and some have attained the large sizes typically associated with maturity. Genetic analyses based on SNP markers indicate the presence of Winnipeg, Saskatchewan, and Nelson River signatures among the 30 fish analyzed to date. Despite increasing reports of small fish captured by anglers, confirmation of reproduction by stocked fish has thus far proved elusive. Upcoming fisheries data collection undertaken collaboratively with Manitoba Sustainable Development will focus on determining if natural reproduction has begun.

Effects of Hurricane Michael on the Gulf Sturgeon Population in the Apalachicola River, Florida

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1. Warnell School of Forestry and Natural Resources, University of Georgia, 2. United States Fish and Wildlife Service

Gulf Sturgeon (*Acipenser oxyrinchus desotoi*) have undergone a significant population decline since the start of the 20th century because of overfishing and habitat loss; in the Apalachicola River, the Jim Woodruff Lock and Dam, constructed in 1957, cut off access to 78% of historic spawning habitat within the basin. Recent studies of Gulf Sturgeon in the Apalachicola River have indicated that annual recruitment is very low, suggesting that the population is not yet recovering. In the face of climate change, the increasing frequency and severity of hurricanes may present an additional threat to Gulf Sturgeon populations. In October 2018, Hurricane Michael struck the Apalachicola River basin, causing sudden changes to water quality and a documented fish kill that included adult sturgeon. Using a combination of telemetry, mark-recapture, and other information collected after the storm, we have assembled a preliminary picture of how Hurricane Michael affected Gulf Sturgeon in the Apalachicola River system. The hurricane had potential effects on movement patterns, annual recruitment, and juvenile overwinter survival.

Twenty-five years of Lake Sturgeon Conservation Closure on the Manitoba Portion of the Winnipeg River. What have we learned and where are we going?

Derek Kroeker and Lee Murray

Manitoba Sustainable Development

In response to concerns about overexploitation and population sustainability in combination with other assumed stressors (e.g. hydroelectric development), a Conservation Closure was invoked on the Manitoba portion of the Winnipeg River, prohibiting capture and harvest of Lake Sturgeon by all potential user groups. 2019 marks the 25th consecutive year of closure, and long-term monitoring initiated in the early 1980s for select portions of the Winnipeg River provide important temporal perspective regarding the population responses. We are currently witnessing unprecedented densities of Lake Sturgeon in the sections in which long term monitoring has focused. Changes in population estimates, catch-per-unit-effort, condition factor, and bycatch rates are discussed in this presentation. Managers are concerned what implications high densities of Lake Sturgeon (predominantly slow-growing juveniles) will have on the rest of the fish community, which is important to recreational users. While Lake Sturgeon populations in several sections of the Winnipeg River appear to be "healthy", and likely approaching carrying capacity, other sections are trending positively but are not as far along in their recovery from historical stressors. The lack of consistency in population status among proximal (even adjacent) river sections poses complications in the context of fisheries management.

Understanding the Physiological and Behavioural Response of Lake Sturgeon (*Acipenser fulvescens*) to Catch and Release Angling

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Catch and release fishing, a conservation-based management tool, operates under the assumption that the health and survival of released fish is not compromised. However, angling may have lethal and sub-lethal impacts to fish that are vigorously exercised, air exposed, and handled prior to release. Lake sturgeon (*Acipenser fulvescens*), once widespread in Manitoba, are now endangered, however, catch and release fisheries for the species exist throughout their natural range. In this study we hypothesise that Lake Sturgeon subjected to catch and release angling would be minimally impaired. Fish were captured by volunteer anglers in the spring and summer of 2018 on the Winnipeg River. Blood and behavioural samples were taken immediately upon capture then approximately 0.5, 24 and 48 hours later. Behavioural responses for all fish sampled, regardless of season, were deemed normal within 24 hours post capture. Blood acid-base status in all fish followed a predictable immediate decline and then increase during recovery. Plasma lactate was increased post release with observable recovery by 24 hours. Plasma glucose remained elevated throughout the recovery period while cortisol concentrations increased steadily up to 48 hours post release suggesting some level of confinement stress that may have masked any acute response observed from the angling event. Physiological and behavioural data collected from sturgeon post angling will be assessed and the fishes response to angling duration, air exposure, water temperature and angler behaviour will be presented. This data will be used to inform best handling practices to reduce stress and the potential for delayed mortality of lake sturgeon caught and released by anglers.

Assessment of Multiple Tools to Describe the Reproductive Structure of White Sturgeon in the Lower Columbia River, Canada

Paige Maskill[1], James Crossman[2], Christopher Guy[3], and Molly Webb[4]

1. Montana State University, 2. BC Hydro, 3. U.S. Geological Survey, Montana Cooperative Fishery Research Unit, 4. USFWS, Bozeman Fish Technology Center

The population of hatchery-origin White Sturgeon (*Acipenser transmontanus*) in the lower Columbia River, Canada are approaching sexual maturity, and knowledge of the reproductive structure is required to determine when integration with wild spawning events will occur. We measured reproductive structure of the hatchery-origin White Sturgeon population using multiple tools that are available to assign sex and stage of maturity in fishes. Furthermore, the accuracy in assigning sex was evaluated within and among tools. In the spring and fall of 2017 and 2018, sex was assigned to hatchery-origin White Sturgeon in the field using ultrasound and endoscopy. In addition, we collected blood plasma to measure sex steroids and a gonadal biopsy for histological analysis. Gonadal biopsy accuracy was based on the presence of germ cells. To measure the accuracy of ultrasound, endoscopy, and sex steroids, the assigned sex from each tool was compared to the true sex based on histology of the gonadal biopsy (n = 215 and n = 132 in 2017 and 2018, respectively). Reproductive structure of the hatchery-origin population was described as the proportion of individuals assigned to each stage of maturity within sex. Assignment of true sex using histology was 97% as several biopsies did not contain germ cells. All hatchery-origin fish were pre-spermatogenic or pre-vitellogenic and have yet to reach sexual maturity. For individuals where true sex could be assigned using histology, accuracy was highest for endoscopy (98%). The other tools evaluated were less accurate with 69% accuracy for plasma sex steroids and 57% accuracy for ultrasound. We recommend using a combination of histology and direct field evaluation using endoscopy for programs looking to measure and track reproductive structure in a population that has not yet reached puberty.

Evaluation of Methods for Estimating Age and Growth of Lake Sturgeon

Aaron O'Connell[1,2], Ryan Koenigs[2], and Dan Isermann[3]

1. University of Wisconsin Stevens Point, 2.Wisconsin Department of Natural Resources, 3. U.S. Geological Survey, Wisconsin Cooperative Fishery Research Unit

Age estimation via sectioned pectoral fin rays is the current preferred method for estimating age of Lake Sturgeon (*Acipenser fulvescens*), as well as other sturgeon species. However, previous research has shown that age estimates from pectoral fin rays underestimate true age of Lake Sturgeon ≥ age 14. Age estimates from otoliths were previously reported as valid for Lake Sturgeon, but difficulties in otolith availability, collection, and processing have resulted in little to no comprehensive work. We are evaluating five different techniques for estimating age and growth of Lake Sturgeon including: use of sectioned pectoral fin rays, use of otoliths prepared via alternative sectioning methods, the applications of a correction factor and age-error matrices to correct pectoral fin ray ages, and the Wang variation of the Fabens mark-recapture growth model. Preliminary findings indicate that only 20% of otolith sections were readable. Further, initial configurations of the Fabens-Wang growth model have yielded plausible growth trajectories that are based on observed changes in length of Lake Sturgeon implanted with passive integrated transponders (PITs) and recaptured on later dates.

Growth of Juvenile Atlantic Sturgeon in the Altamaha River, Georgia, USA

Adam Fox, Catlyn Chapman, and Michael Baker

University of Georgia Warnell School of Forestry and Natural Resources

Over the last century, Atlantic Sturgeon suffered major population declines as a result of human activities including dam construction and unsustainable fisheries. These actions led to the listing of Atlantic Sturgeon as endangered in the USA in 2012. Despite their status, major knowledge gaps remain and many sturgeon traits, including growth, are understudied – especially in the southern portion of their range. In order to assess juvenile growth in the Altamaha River, GA, we analyzed capture data from 2006-2018 to calculate 1) growth increment during the summer of age 1, and 2) growth increment between age 1 and age 2. Growth increments were calculated as the difference in fork length between initial and final capture divided by the number of weeks between captures. The mean summer growth rate across all years was found to be 3.52 mm/wk; 2011 and 2018 had significantly different growth rate compared to other years. The mean between-year growth rate across all years was 3.85 mm/wk. We also examined the relationship between summer growth increment and two environmental parameters, river flow and temperature. Our results help fill an important knowledge gap and inform managers of trends in growth, and will give insight into the factors that might affect growth in the face of a changing climate.

Long-term Effects of Early Rearing Temperature on Energy Density, Body Composition, Growth and Metabolic Scope of Age-0 Lake Sturgeon

Gwangseok Yoon[1], Cheryl Klassen[2], Laura Groening[2], Catherine Brandt[1], and Gary Anderson[1]

1. University of Manitoba, 2. Manitoba Hydro

Developmental environment during early life is particularly important as early phenotypic development can strongly influence growth trajectory and thus ecological fitness later in life. Specifically, in the northern temperate zone, energy allocation toward somatic growth and energy reserves are critical in age-0 fish as these will affect survival during the first winter of life. In the present study, we examined how environmental temperature would impact energy density, body composition, growth and metabolic scope of age-0 Lake Sturgeon. At 2 months of age fish were exposed to one of three temperature regimes for 3 weeks: 16°C, 18°C or ambient river temperature (ART). After the temperature manipulation, fish were raised in ART for 10 months; including an overwintering event when food was withheld, and water temperature was approximately 1.5°C for 120 days. Our data indicated that fish exposed to 18°C for the three-week period showed higher energy density and growth rates prior to the simulated overwintering event. Long-term effects of temperature on the development of metabolic phenotypes will be discussed in terms of conservation aquaculture of Lake Sturgeon, a species at risk or endangered across its natural range.

Lake Sturgeon and Hydro Development on the Lower Churchill River

Mark Lowdon

AAE Tech Services Inc.

The Churchill River Diversion (CRD) Project was initiated by Manitoba Hydro in the late 1970s to provide an increase of water flow to the generating stations on the Lower Nelson River. As a result of the diversion, up to 85% of the water flowing down the Churchill River was diverted. This alteration to the flow dynamics within the Lower Churchill River system has likely had significant impacts to the Lake Sturgeon population, although, to what degree is unknown. In the summer of 2018, The Tataskweyak Creek Nation has initiated a five-year long study to assess the impacts CRD has had on the Sturgeon Population within the Lower Churchill River System. Key components of the study include, defining the population of Lake Sturgeon along the 450 kilometers of river from the control structure at Missi falls on South Indian Lake to the mouth of the Lower Churchill River, conducting tagging studies with Vemco telemetry equipment to assess movement, modeling the changes to habitat as a result of CRD and finally developing a recovery strategy with recommendations to protect and help conserve the species.

Movement Ecology of White Sturgeon (*Acipenser transmontanus*) in the Regulated Upper Columbia River, Canada

Laurence Masson[1], Eduardo Martins[1], and James Crossman[2]

1. University of Northern British Columbia, 2. BC Hydro

Many fish species, like the endangered white sturgeon (*Acipenser transmontanus*), rely on connectivity among feeding, overwintering and spawning habitats to complete their life cycle. Dams have fragmented river systems, impeding movements and potentially altering how fish use habitats as suitability may have changed following regulation. Additionally, alterations to natural discharge and temperature regimes as a result of regulation may affect habitat use and movements of white sturgeons. The population of white sturgeon in the Upper Columbia River, Canada, is listed as endangered and knowledge on their movement ecology is necessary to develop and implement recovery actions. Adult white sturgeon of known sex (male =67; female=72) were tagged with acoustic transmitters and monitored using a passive array of receivers over a 10-year period to evaluate movements and habitat use. We measured residence time in specific habitats within a 57 km section of the upper Columbia River and estimated the probability of movement and distance migrated as a function of habitat selection and environmental conditions. Results from this study will help determine the effect of environmental factors and river regulation on habitat use and movements of white sturgeons.

Dispersal and Overwinter Survival of Stocked Age-0 Lake Sturgeon in Two Missouri River Tributaries

Michael Moore[1] and Craig Paukert[2]

1. Missouri Cooperative Fish and Wildlife Research Unit, The School of Natural Resources, University of Missouri, 2. U.S. Geological Survey, Missouri Cooperative Fish and Wildlife Research Unit, The School of Natural Resources, University of Missouri

Lake Sturgeon were nearly extirpated from Missouri by the 1970's and recovery efforts commenced in 1984. However, biologists have not documented natural reproduction in the Missouri River Basin. Therefore, short-term recovery efforts are reliant on continued stocking of hatchery-reared individuals. Although Missouri has stocked over 400,000 Lake Sturgeon, managers do not have reliable information on survival and dispersal that may influence the selection of stocking locations or size of fish selected for stocking. We implanted 100 age-0 Lake Sturgeon with Vemco V8 telemetry tags. Hatchery staff monitored their recovery for two weeks and survival to time of stocking was 95%. Lake Sturgeon were introduced at four stocking sites in approximately equal numbers on October, 8th, 2018. Two sites were located on the Osage River and two on the Gasconade River. We monitored movements of juveniles with a network of 31 stationary receivers and monthly manual tracking events of the study area until February 13 when tag batteries expired. Overall study survival of stocked Lake Sturgeon was at least 46% and was not influenced by stocking location. Upstream dispersal was higher than expected with some individuals traveling at least 140 km. Final locations for surviving fish was not related to stocking location in the Osage River but was affected by stocking site in the smaller Gasconade River. Only three tagged Lake Sturgeon left the Osage or Gasconade rivers during the study period and one immigrated to the Osage River from the Gasconade River. These findings contrast with results from telemetry studies conducted in other areas of its range (including the Meramec River in Missouri) which showed rapid dispersal downstream into larger bodies of water. Missouri River tributaries may provide important nursery habitat for juvenile Lake Sturgeon.

Paddlefish Dam Passage Efficiency and Habitat Use in the Upper Mississippi River (Pools 14-19)

Dominique Turney[1], Kyle Mosel[2], Kevin Irons[3], and James Lamer[1, 4]

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The construction of navigational dams on the Upper Mississippi River (UMR) has disrupted movement and changed available habitat of the highly migratory paddlefish. The gates at each dam are open for different periods of time, allowing varying streamflow and opportunities for passage throughout the river. Lock and Dams (LD) 14, 15, and 19 are infrequently at open river conditions, making it difficult for fish passage. To better understand native fish passage and habitat use in this poorly understood region, we acoustically tagged 121 paddlefish and tracked their movements manually and with stationary receivers in Pools 14-19. Our manual and stationary receivers detected 97% of our tagged paddlefish. Our results indicated that 18 of our tagged fish successfully crossed over at least one dam barrier, either upstream or downstream direction. Paddlefish have demonstrated the ability to cross difficult barriers: 6 passages at LD 15 and 4 passages at LD 14. Most paddlefish detections were observed in backwater habitat in summer 2018 and have been observed to move towards channel borders in the late fall. A clear understanding of paddlefish movement and habitat use in the UMR will allow researchers and biologists to better understand dam passage of other migratory fish species.

Nechako White Sturgeon Conservation Centre Update

Mike Manky

FFSBC

The Nechako White Sturgeon Conservation Centre (NWSCC) is a facility that houses a conservation fish culture program for the unique population of Nechako white sturgeon. This population of sturgeon is listed as Critically Imperiled by the British Columbia Conservation Data Centre, Endangered according to the Committee on the Status of Endangered Wildlife in Canada (COSEWIC), and as an Endangered Species under the Species at Risk Act (SARA). This conservation fish culture program is in place as a stopgap measure to mitigate recruitment failure of Nechako white sturgeon. The Nechako White Sturgeon Conservation Centre was built in 2014 and has released hatchery reared juvenile white sturgeon every year since 2015. An adaptive management strategy has been used every year since opening in 2014 and this approach continues to be utilized. The Nechako White Sturgeon Conservation Centre also supports the ongoing efforts of various research projects administered by groups such as the Nechako White Sturgeon Recovery Initiative, Province of BC, Rio Tinto, School District 91, University of Northern British Columbia, University of British Columbia, and local First Nations. The 2018-2019 update will include fish culture practices, release numbers, spawn monitoring, juvenile monitoring, and education and outreach.

Development of Germ Cell Transplantation Methods in the White Sturgeon, *Acipenser transmontanus*

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The white sturgeon is the largest freshwater fish in North America. Because of their unique life history characteristics including longevity, late maturation, and long spawning intervals, white sturgeon aquaculture can be a significant investment of resources. Even so, California is the largest producer of white sturgeon meat and caviar in the United States. Germ cell transplantation (GCX) is an innovative technology previously demonstrated in other fish species for the production of a surrogate broodstock. The technique relies upon germ-line stem cell (or primordial germ cell; PGC) isolation, purification, and transplantation. Here, we determine cell types and optimal germ cell recovery from juvenile gonads, as well as the transplantation success and colonization rates into newly hatched larvae. Histological examination revealed that gonads from 1 to 2 year old females and as old as 4 year old males had a high proportion of PGCs compared to other ages. Gonad dissociation using trypsin enzyme yielded high numbers of cells that were subsequently determined as PGCs after Percoll sorting and immunolabeling with the antibody DDX4, or vasa, as a marker specific to germ-line stem cells. Suspensions of PGCs were labeled with a cell membrane dye, PKH26, and transplanted by microinjection into the peritoneal cavity of newly hatched larvae close to the presumptive genital ridge. Larvae were reared until 1 and 2 months post-transplantation to monitor for colonization and proliferation of PKH26-labeled cells within the recipient gonads. Determining optimal methods for PGC localization and transplantation will support this new reproductive management tool, GCX, to use alternative species for the production of sturgeon, and for hatcheries to utilize natural gamete production without genetic modification. These preliminary findings summarize our efforts in adapting GCX for the improved production of white sturgeon, and the management of other threatened sturgeon species.

Progress toward a Predictive Egg Quality and Spawning Potential Index in Paddlefish

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In the past, Blind Pony Fish Hatchery (BPH), operated by the Missouri Department of Conservation (MDC), has experienced inconsistent ovulation, fertility, and development rates in female paddlefish. Even if ovulation occurs, some paddlefish eggs stop developing prematurely; at times only half of the paddlefish spawned have resulted in usable fry. This inconsistency decreases the effective management of the put-grow-take paddlefish fishery, as well as drives up MDC's production costs. This project aims to develop a paddlefish broodstock ranking index for both egg quality and spawning readiness. The goal is to improve MDC's efficiency in selecting fish that will spawn in response to the hormonal injection and produce high-quality progeny that are more likely to survive the rearing process. Due to the limited knowledge available on paddlefish reproduction, there are sparse techniques and spawning protocols available, and even fewer molecular assays. Because of this, the creation of a broodstock ranking index of about 20 female fishes a year requires the development and optimization of the required scientific end points. The specific end points to be evaluated include spawning readiness indicators (i.e., egg polarity index [PI] and an egg bioassay) and egg/progeny quality indicators (i.e., plasma estradiol, testosterone, and cortisol concentrations. The data presented were developed from tissues collected during the spawning of the 2015, 2016, 2017, 2018, and 2019 year classes and include the optimization data required to validate the following endpoints: PI, egg bioassay, and the hormone concentrations of estradiol, testosterone, and cortisol.

Estimating the Number of Spawning White Sturgeon (*Acipenser transmontanus*) Adults the Hells Canyon Reach of the Snake River

Aviva Fiske[1], Jake Hughes[2], Ken Lepla[2], and Andrea Schreier[1]

1. University of California, Davis, 2. Idaho Power Company

White sturgeon (*Acipenser transmontanus*) face a number of threats to their continued survival across their range in North America including habitat degradation resulting from impoundments and diversions, historical overfishing and recruitment limitation in some areas of their range. A major tributary of the Columbia River, the Snake River is impacted by numerous impoundments that divide the river into segments with white sturgeon in impounded reaches connected by limited downstream migration. Degraded habitat in the Hells Canyon Reach of the Snake River has resulted in lack of detectable juvenile recruitment for several decades. To better understand factors affecting juvenile recruitment, in this study we aim to estimate the number of spawning adults (Ns) in the Hells Canyon Reach. We captured 125 wild larvae in the Hells Canyon Reach and genotyped each individual at 13 microsatellite loci. Using a maximum likelihood approach (COLONY), we first created a training dataset in order to establish inclusive and exclusive probability thresholds. We then used these probability thresholds to determine which reconstructed families to accept from COLONY. We estimate the Ns contributing to the 2017 year class in the Hells Canyon Reach to be ~108-175 individuals, representing ~71 full sibling families.

New High Throughput Sequencing Technologies Allow for Assembly of Polyploid Sturgeon Genomes

Andrea Schreier[1], Scott Blankenship[2], Daphne Gille[1], Lutz Froenicke[1], Jie Li[1], Matt Settles[1], Shawn Narum[3], and Ben Sutherland[4]

1. University of California Davis, 2. Cramer Fish Sciences, 3. Columbia River Inter-Tribal Fish Commission, 4. Department of Fisheries and Oceans Canada

Although sturgeon are charismatic megafauna of conservation and commercial interest, progress in sequencing and assembling sturgeon genomes has been slow for biological and technical reasons. Polyploid sturgeon genomes are very complex, containing duplicated regions that are difficult to resolve with short read sequencing. Also, most genome assemblers were developed with relatively simple diploid mammalian genomes in mind. However, new, cutting-edge long read sequencing technologies and associated genome assemblers allow us to phase duplicated regions and generate high quality reference genomes for sturgeon. These reference genomes can be used to develop genome-wide neutral markers for population genetic studies that will vastly improve resolution of parameters such as effective population size, to identify the sex determining mechanism in sturgeons, and to determine the genetic architecture behind adaptive traits. In this talk, I illustrate the complications of sequencing and assembling sturgeon genomes, describe new long read sequencing technologies that have great potential to advance sturgeon genome sequencing, and provide a case study of an ongoing collaborative effort to sequence the white sturgeon genome.

Winnipeg River Lake Sturgeon Genomics: Historical Population Structuring and Contemporary Gene Flow

Craig McDougall[1], Thierry Gosselin[2], and Patrick Nelson[1]

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To improve the understanding of historical population structuring and contemporary gene flow of Winnipeg River Lake Sturgeon *Acipenser fulvescens*, RADseq was used to generate SNP markers from samples contributed by several research groups working along the heterogeneous flow axis. Including headwater samples (English River, Rainy River, and Rainy Lake) as well as outgroups from the Saskatchewan, Nelson, and Churchill rivers, 1,480 fish were genotyped. Data yield was ~95% (excellent) for both ethanol preserved and dried tissue samples. As hypothesized, population structuring (based on standard equilibrium metrics) was evident from upstream to downstream along the river which, due to lengthy generation times of the species, pre-date Winnipeg River hydroelectric development (1900 – present). Upstream to downstream migrants are revealed in considerable numbers for some adjacent population pairs, but the downstream extent of demographic influence of a given populations appears to be small. Based on Discriminant Analysis of Principal Components, membership proportions suggest either an increased rate of upstream to downstream dispersal in recent years, or that historically upstream to downstream migrants did not effectively contribute much to subsequent generations (i.e. minimal historical effective dispersal).

Analysis of Morphological Variation among Two Genetically-distinct Paddlefish Stocks in the Arkansas River Basin

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Paddlefish (*Polyodon spathula*) management in Oklahoma has been informed by fine-scale genetic research showing the distinction of three Genetic Management Units (GMUs): Arkansas River, Red River, and the Grand/Neosho River, a tributary of the Arkansas. Obvious variation in morphological traits, such as body size, shape, and condition, have been long-observed throughout the range across habitat gradients, and more recently examined among two large, reservoir stocks of the Arkansas and Grand/Neosho GMUs. To further inform and quantify differences in population structure, we used geometric morphometric analysis to evaluate gross morphological differences between two stocks. Live Paddlefish (n=140, Grand/Neosho; n=66, Arkansas) were photographed with standardized equipment and fixed body coordinates were established using ImageJ software to define body geometry. MorphoJ software was used to further analyze geometric morphometric differences between the stocks while adding context of covariates from harvested fish including weight, sex, estimated age (from dentaries), gonadosomatic index, and gonadal fat reserves. Preliminary results will demonstrate the utility of these methods and warrant additional support for historically isolated stocks within Oklahoma (i.e. Red River) and across the species range. Further, results will guide management decisions on possible translocation of Oklahoma Paddlefish into the Grand/Neosho GMU to supplement low genetic diversity.

Lake Sturgeon and the Keeyask Generating Station: Population Viability Analysis and Adaptive Management

Patrick Nelson[1], Craig McDougall[1], Claire Hrenchuk[1], Friederike Schneider-Vieira[1], and Stephanie Backhouse[2]

1. North/South Consultants Inc., 2. Manitoba Hydro

During the Fisheries Act Authorization process for the Keeyask Generating Station on the Nelson River, Manitoba, a population viability analysis (PVA) was used to assess the risk the project posed to local Lake Sturgeon populations. In 2013, a stage-structured model was designed which incorporated contemporary adult abundance and erratic natural recruitment patterns (based on data collected between 1995 and 2010). Projected entrainment rates and hypothesized contributions of stocked yearlings were also incorporated. Following the first PVA iteration, additional Keeyask Aquatic Effects Monitoring Plan studies generated data that improved the understanding of adult abundance (trajectory), natural recruitment, and the survival of stocked fish. In 2016, the PVA was re-run based on revised parameters. In 2019, PVA parameters were again updated and the model re-run. At present, the primary uncertainty in relation to Keeyask and Lake Sturgeon relates to the density of Lake Sturgeon that can be supported and the quantity that should be stocked out, given that the population has a positive trajectory and natural recruitment is ongoing. PVA results are discussed in the context of stocking optimization, and more generally the utility of PVA under an adaptive management framework in relation to long-term recovery and mitigation strategies for Lake Sturgeon.

Lake Sturgeon in the Lower Nelson River: An Evolution of Understanding

Don MacDonell, Patrick Nelson, Craig McDougall, and Cam Barth

North/South Consultants Inc.

Lake Sturgeon inhabit the entire 650 km length of the Nelson River, Manitoba, which flows from Lake Winnipeg to Hudson Bay. While the Upper Nelson is characterized by Boreal Shield habitat (lakes separated by falls/rapids), the Lower Nelson (LNR) consists of predominantly moderate to high-velocity channel habitat, characteristic of the Hudson Bay Lowlands. In the 1980s, it was assumed that Lake Sturgeon abundance was low in the LNR. In hindsight, that belief probably stemmed from access difficulties (remoteness) precluding it from being targeted by the commercial fishery. As a result of environmental studies related to hydroelectric development, it is now clear that a relatively robust population inhabits the LNR. Despite marked flow/water level fluctuations due to the daily cycling of turbine units on dams located upstream, the population was most recently estimated to consist of >8,400 adults based on mark-recapture tagging; the increasing trajectory evident from that analysis is consistent with observations of ongoing recruitment (i.e. the presence of large quantities of juvenile fish captured during targeted inventories). Multiple spawning locations have been identified, but high resolution genetics based on RADsequencing provides no evidence of within-reach population structure. This population is unique because individuals occasionally utilize the shared Nelson/Hayes river freshwater plume in Hudson Bay to move into the Hayes River proper, which falls under a separate COSEWIC designatable unit. Interestingly, these movements do not appear to result in effective dispersal. This presentation will detail the current understanding of the Lake Sturgeon population within the Lower Nelson River, and the extensive steps taken to get us to this point.

Current and Future Challenges of the Nechako White Sturgeon Recovery Initiative

Nikolaus Gantner[1], Trevor Davies[1], Ian Spendlow[1], Cale Babey[2], and Steve McAdam[3]

1. BC Ministry of Forests, Lands, Natural Resource Operations, and Rural Development, 2. University of Northern British Columbia, 3. BC Ministry of Environment

Two White Sturgeon (*Acipenser transmontanus*) populations in central British Columbia, Canada are currently listed as Species at Risk under the Canadian Species at Risk Act (SARA). The Nechako White Sturgeon Nationally Significant Population (NSP) is listed primarily from low population size due to ongoing recruitment failure from habitat alterations. The Upper Fraser NSP is listed due to its small estimated population size. A third population, the mid-Fraser NSP, is downstream in the Fraser River and currently not listed under SARA. All three are genetically similar to each other, yet are considered distinct from Lower Fraser White Sturgeon populations. Due to the lack of successful natural recruitment, a conservation aquaculture facility reared and released several cohorts of juveniles at various age and size classes into the Nechako River to supplement the Nechako White Sturgeon NSP. In addition, habitat restoration efforts have been conducted at the one identified spawning site near Vanderhoof, BC to improve natural recruitment. The success of such efforts depends on multiple factors, including how well sturgeon at any life stage respond to natural conditions upon release, including interactions with potential predators. North American river otters (*Lontra canadensis*) are one confirmed predator to hatchery sturgeon and are potentially impacting recovery efforts. Movements and survival of juvenile sturgeon are monitored by acoustic, radio telemetry, and mark-recapture studies. Monitoring of all three NSPs yielded insights into movements of hatchery-origin juveniles within and beyond their expected range. Consequently, concerns of hatchery-impacts such as resource competition and genetic introgression with downstream populations need to be balanced with ongoing recovery efforts. We will present current challenges and opportunities within this recovery initiative by providing an overview of adult and juvenile sturgeon movements, potential predation impacts, as well as discuss potential approaches to mitigate downstream risks.

Winnipeg/English River Lake Sturgeon Mitigation and Recovery: Caribou Falls and Whitedog Falls Generating Stations, A Case Study

Cam Barth[1], Craig McDougall[1], Dan Gibson[2], and Laura Henderson[1]

1. North/South Consultants Inc., 2. Ontario Power Generation

In Ontario, Canada, Lake Sturgeon, *Acipenser fulvescens*, are listed under the provincial Endangered Species Act. Ontario Power Generation (OPG) operates the Whitedog Falls generating station (GS) (Winnipeg River) and the Caribou Falls GS (English River) that represent the upstream boundaries of Winnipeg River Lake Sturgeon Management Unit (MU) 4. Historically, it is thought Lake Sturgeon abundance was high in this MU and spawning occurred at the rapids where the GSs were built. There has been considerable study of Lake Sturgeon in this MU over the last two decades. Results indicate that: i) although spawning and rearing habitat appears to be suitable, recruitment resulting from spawning downstream of the Whitedog Falls GS has been minimal or nil over at least the last decade; ii) the relative abundance of spawning adults and large subadults captured downstream of the Caribou Falls GS was higher relative to the Whitedog Falls GS; iii) egg deposition and hatch has been documented downstream of the Caribou Falls GS; iv) recruitment resulting from spawning downstream of the Caribou Falls GS has occurred multiple times over the last decade; and vi) two primary genetic signatures exist within this MU, with few 1st generation migrants from other populations. Given these results, three potential Lake Sturgeon mitigation strategies, station operation (discharge manipulation), substrate enhancement, and stocking, were evaluated for their potential to improve MU4 populations.

Kischi Sipi Namao Committee – a collaborative Stewardship Approach

Stephanie Backhouse[1], Cheryl Klassen[1], Darcy Wastesicoot[2], and Jimmy Lockhart[3]

1. Manitoba Hydro, 2. KSNC Chair, York Factory First Nation, 3. KSNC Vice-Chair, Fox Lake Cree Nation

Lake Sturgeon have a social and historical significance in Manitoba and a strong cultural significance to Indigenous peoples in the province. Over the past century, a combination of intensive commercial fishing and habitat disruption has had serious effects on Manitoba sturgeon populations. The Kischi Sipi Namao Committee was established through a formal agreement in 2013, as a partnership committed to protecting and enhancing Lake Sturgeon populations in the lower Nelson River (Northern Manitoba). Membership includes representatives from Fox Lake Cree Nation, Shamattawa First Nation, Tataskweyak Cree Nation, War Lake First Nation, York Factory First Nation, as well as Manitoba Hydro, Keeyask Hydropower Limited Partnership and Manitoba Sustainable Development. The community led, collaborative structure of the KSNC ensures the incorporation of Indigenous Traditional Knowledge (ATK) and perspectives into the important work of protecting and enhancing Lake Sturgeon populations. Committee activities are guided by a Stewardship Plan, which identifies priorities of gathering and sharing information, bringing communities together, and engaging youth. These all contribute to the KSNC vision of working together to conserve sturgeon for future generations, or “Mamawi Ahtoshehmitowin - Namao Kakekeh” (“Working Together, Sturgeon Forever”). Committee activities and achievements to date will be presented.

ABSTRACTS FOR POSTER PRESENTATIONS

Is Conservation Aquaculture of Nechako White Sturgeon (*Acipenser transmontanus*) Being Impeded by River Otter (*Lontra canadensis*) Predation?

Cale Babey[1], Nikolaus Gantner[2], Cory Williamson[3], and Mark Shrimpton[1]

1. University of Northern British Columbia, 2. B.C. Ministry of FLNRORD, 3. Nechako White Sturgeon Recovery Initiative

The Nechako White Sturgeon population in British Columbia, Canada has shown recruitment failure since 1967 and is currently listed as Species at Risk under Canadian Species at Risk legislation. In the absence of natural recruitment, a conservation aquaculture facility, the Nechako White Sturgeon Conservation Center (NWSCC), began rearing White Sturgeon (*A. transmontanus*) and has released PIT tagged and radio tagged cohorts of juveniles into the Nechako River to supplement the population since 2015. The success of such conservation aquaculture depends on multiple factors, including how well sturgeon respond to natural conditions upon release, including interactions with potential predators. North American river otters (*Lontra canadensis*) have been suggested as one predator potentially impacting the post-release survival of juvenile sturgeon. This study presents, for the first time, evidence of this predator-prey interaction. The detection and retrieval of >300 PIT tags in 13 river otter latrine sites using a handheld PIT tag scanner, including 84 tags from a single site, provides one line of evidence confirming this predator-prey interaction. The collection of radio tags in river otter feeding sites using radio telemetry, including tags from sturgeon released up to 60 cm, provides a second line of evidence suggesting river otter predation indeed has an impact on post-release survival. This research now aims to determine the spatial extent of this predation and to characterize factors affecting the interaction by identifying river otter latrine sites using common latrine site characteristics and retrieving PIT tags using a standardized approach. As a potential tool to mitigate this issue and increase post-release survival, field and laboratory-based chemical conditioning experiments using sturgeon alarm cues are being explored. Knowledge gained from this research will allow for a better understanding of this predator-prey interaction and can be used by recovery programs to improve the post-release survival of hatchery juvenile sturgeon.

Population and Movement Monitoring of Lake Sturgeon during Construction of a Hydro Generating Station in Northern Manitoba, Canada: Results to Date

Stephanie Backhouse and Cheryl Klassen

Manitoba Hydro

The Keeyask Hydropower Limited Partnership (KHLP; a partnership between Tataskweyak Cree Nation, War Lake First Nation, Fox Lake Cree Nation, York Factory First Nation and Manitoba Hydro) is currently constructing the Keeyask hydroelectric generating station (GS) on the lower Nelson River in northern Manitoba. During the environmental assessment, it was determined that Lake Sturgeon (*Acipenser fulvescens*) populations in this area were vulnerable to the effects of hydroelectric development as a result of low population numbers and specific habitat requirements. A comprehensive and long-term monitoring plan, focusing on adult and juvenile Lake Sturgeon populations and movements, as well as stocking success, has been implemented to determine the actual impacts of construction and operation of the generating station. In 2018, population estimates of adult Lake Sturgeon derived from mark-recapture datasets estimated a population of 820 individuals (95% CI: 678–991) in the future Keeyask reservoir and 296 individuals (95% CI: 218–401) downstream of Keeyask, with overall abundance estimates (2001 – 2018) in both areas showing a significant increasing trend over time. For the first time, sufficient numbers of juvenile Lake Sturgeon were captured to generate juvenile population estimates, with estimates of 4,133 individuals (95% CI: 2,955–5,780) for the future Keeyask reservoir and 1,101 individuals (95% CI: 749–1,620) downstream of Keeyask. Survival estimates for adults and juveniles above and below Keeyask ranged from 77 – 91%. The continued presence of YOY and hatchery raised fish indicates that stocked fish are surviving, and natural recruitment is continuing throughout construction and habitat change. Mark-recapture and acoustic telemetry data indicate that long-range movements continue to be rare, and fish tend to stay in the area in which they were originally tagged. Continued monitoring will reveal if long-range movements become more common as construction of the Keeyask GS progresses.

Early Environmental Effects on Yolksac Use, Growth Rate and Muscle Development in Lake Sturgeon, Acipenser fulvescens.

Catherine Brandt and Gary Anderson

University of Manitoba

In fishes, differences in egg incubation, water temperature, and substrate can have a significant impact on phenotypic development. This is particularly relevant during the first year of life when growth rate typically peaks and strongly influences an individual's life history trajectory. In the present study Lake Sturgeon were reared in different temperature environments at Grand Rapids, MB for approximately one year. In the first year, sturgeon were reared in temperature regimes (with or without substrate) that mimicked river temperature profiles. In the second year, embryos were incubated in one of two rearing treatments (tumbling or adhering to substrate) and newly hatched larvae were then exposed to 16, 18 and 20°C for two weeks before being transferred to a common garden experiment where all tanks were fed surface water from the Saskatchewan River and subject to ambient temperatures. In year one, fish were exposed to a simulated overwintering period of 40 days at ~3°C and food deprivation and in year two fish were exposed to 4.5 months of overwintering food deprivation and ~1.5°C. Yolksac volume was measured daily during the larval phase in both years and total length and body mass were assessed at least monthly for the duration of the experiments. In the first year, there were differences in yolk sac absorption between substrate treatments, and differences in larval length between temperature treatments following the overwintering. In the second year, fish raised at higher temperatures during the larval phase exhibited the highest growth rate during the first six months of life. Further the accelerated growth rate phenotype persisted following the over-wintering phase. Results will be discussed in the context of early life history development and improved rearing environments to promote survival when fish raised in conservation hatcheries are stocked out into the wild.

Effects of Hatchery-rearing on White Sturgeon (*Acipenser transmontanus*) Development

Madison Earhart[1], Chrissy Schellenberg[2], Domika Clarke[2], Patricia Schulte[1], and Daniel Baker[2]

1. University of British Columbia, 2. Vancouver Island University

White Sturgeon, *Acipenser transmontanus*, are an anadromous species native to the West Coast of North America used in both commercial and conservation aquaculture since the 1970s. Conservation aquaculture facilities rear larval white sturgeon with the intent to release individuals into their natural environments to bolster wild populations. Previous research investigating hatchery reared fish, has demonstrated that the rearing environment can have lasting effects on multiple phenotypes such as growth, behavior, metabolism and life-history traits. These rearing environments often cause unintentional effects on phenotypical development, different from that of wild fish, ultimately altering fitness. Hatcheries vary in their rearing techniques from site to site. More importantly, these artificial environments are generally vastly different from the wild habitat and these differences likely result in many unknown consequences. This study, with white sturgeon, aimed to uncover some of these consequences. Particularly, ones associated with the rate of embryogenesis at different rearing temperatures (ranging from 13°C and 19°C), and between rearing in tumbling (McDonald) jars, commonly used in conservation hatcheries, and a less disturbed method of rearing eggs on mats. We hypothesized developmental rate would occur in a non-linear pattern across the three temperatures. We further hypothesized tumbling jars would be detrimental to growth, survival, and stress indicators (i.e., cortisol) when compared to egg mats, due to the vastly different environment from the natural life-history of the sturgeon. Developmental rate, growth and survival will be discussed in terms of both temperature and rearing techniques.

Ontogeny of Light Avoidance in Juvenile Lake Sturgeon

Chris Elvidge[1], Stephanie Backhouse, C.H. Reid, M.I. Ford, M. Sills, P.H. Patrick, Dan Gibson[3], and Steven Cooke

1. Carleton University, 2. Manitoba Hydro, 3. Ontario Hydro

Hatchery-reared age 1+ and 4+ lake sturgeon (*Acipenser fulvescens*) were assayed to determine the effectiveness of coloured, strobing LED light guidance device (LGD) at achieving behavioural guidance for attraction or avoidance responses. Based on an initial y-maze dichotomous choice study in age 1+ fish during daytime, we selected green, blue, orange, and full-spectrum white light, all strobing at 1 Hz, for further testing. During nighttime light guidance trials, age 1+ sturgeon demonstrated the fastest entries and greatest proportion of entries to the cone of illumination in the experimental raceway when the LGD was producing blue light, and the lowest proportion of entries in response to orange light. Conversely, they also spent the greatest amounts of time under illumination during orange light trials. Blue light was associated with the greatest proportion and total numbers of complete passages through the illuminated zone, although passage rates through this area were observed during the unilluminated control trials. White light resulted in the least time spent in the illuminated zone, and the lowest rates of passage. Under the nighttime testing scenario, the age 4+ sturgeon, by contrast, demonstrated strong avoidance of blue light and white light. While their behaviour was negatively phototactic in general, orange light was the least repulsive. For the behavioural guidance of lake sturgeon moving at night, we recommend the use of blue light strobing at 1 Hz for the attraction of the 1+ age class and white light strobing at 1 Hz for their repulsion. For age 4+ fish, we recommend the use of blue light or white light strobing at 1 Hz for repulsion and caution that i) light as a behavioural guidance tool appears most effective as a repulsive stimulus, and ii) further testing under both laboratory and field conditions are required.

Side-Scan Sonar Revisited - Estimating Sturgeon Abundance

Jacob Hughes

Idaho Power Company

Side-scan sonar (SSS) is mobile imaging sonar, providing a sonar equivalent to aerial surveys, and enabling researchers to quickly survey large areas. Recent applied research has led the utilization of SSS in fisheries to estimate sturgeon abundances. We used SSS to estimate White Sturgeon (*Acipenser transmontanus*) abundance within the Snake River between C.J. Strike (CJS) and Swan Falls dams (58 km). High spring runoff in 2017 and 2018 led to sustained spill events at CJS, likely entraining sturgeon from the upstream Bliss Reach to below CJS. Subsequently, we conducted SSS surveys in winter 2018 and 2019 to detect abundance change below CJS. White sturgeon abundance (> 1 m total length) was modeled within a Bayesian framework using a N-mixture model that utilizes replicate count data to estimate abundance, accounting for detection probability. In 2018, sturgeon abundance (241, 210-271 95% CI) suggested an 85% (~110 individuals) increase in abundance since the 2016 estimate (142, 120-167 95% CI), after accounting for known losses (translocation and documented mortalities). The 2019 estimate (243, 213-278 95% CI) suggests the smaller spill event in 2018 had a much less population effect, but still added approximately 14% more white sturgeon after accounting for known losses. These data show spill events can significantly change abundance within the middle Snake River, however the magnitude of spill is an important factor. Correlating specific spill-event-effects to population-level change is useful for fisheries management and would otherwise be difficult to obtain using traditional periodic stock assessments (e.g., every 5 years). Our SSS survey illustrates relatively precise, reliable, and quick method to estimate white sturgeon abundance. While our methods are successful within the study reach, more research may be needed to best sample sturgeon populations in other river systems.

The Bladder Rapids Area: Lake Sturgeon Population Investigations on a Hard to Access Stretch of the Upper Nelson River

Craig McDougall and Michael Alperyn

North/South Consultants

Conducting fisheries research on large rivers presents numerous logistical challenges, which are compounded in remote areas. The Bladder Rapids area of the upper Nelson River, Manitoba, historically supported a Lake Sturgeon spawning run, but little is known about contemporary use. A project designed to assess use of the area by Lake Sturgeon was originally scheduled for the spring of 2015. After two years of high water (which results in dangerous conditions in this bedrock controlled reach) and one failed accessing attempt, the project did not get underway until the spring of 2018. Over the course of three weeks of sampling, a total of 25 sturgeon were gillnetted. Four fish tagged in previous studies were identified in the catch. Of the 21 new fish, 11 were immature (< 800 mm total length) and 10 were adults, one of which appeared to be a female in pre-spawn condition. All the adult sturgeon were netted in close proximity to Bladder Rapids (<1.5 km), while juvenile sturgeon were captured further downstream in deep pools (>20 m) with sand/clay substrate.

Growing Like a Weed: White Sturgeon Growth in the Bliss to CJ Strike Reach of the Snake River

David Meyer and Phil Bates

Idaho Power Company

White Sturgeon in the Snake River exhibit differing rates of growth and maturity. These rates vary both between river reaches and within reaches as individuals utilize different habitat types (riverine and reservoir). We used tagging data from recaptured White Sturgeon in the Bliss to CJ Strike reach to show differences in sturgeon growth among habitat use. Considering only wild White Sturgeon at-large for 365 days, measured fork lengths and time at-large was used to generate annual growth increments [AGI]. Individual AGI were assigned one of three categories signifying locations of first and second capture: river/river, reservoir/reservoir, and river/reservoir recaptures. Although habitat preferences between capture events are unknown, White Sturgeon AGI and condition factor increased with reservoir presence, whereas White Sturgeon captured in-river displayed higher site fidelity and a lower AGI and condition factor.

Assessing Spatial Overlap among Two Asian Carp and One Native Planktivorous Species in the Upper Mississippi River

Dominique Turney[1], Andrea Fritts[2], Brent Knights[2], Kevin Irons[3], Jeena Credico[4], and James Lamer[1,5]

1. Western Illinois University, 2. U.S. Geological Survey, 3. Illinois Department of Natural Resources, 4. U.S. Fish and Wildlife Service, 5. Illinois Natural History Survey

Paddlefish populations have been in dramatic decline since the mid-twentieth century as a result of overfishing, habitat destruction, and the construction of dams that have restricted seasonal migrations. Recent studies suggest that the accidental introduction of invasive Asian carp species has created direct and indirect interspecific interactions that may further decline paddlefish populations. Bighead carp and silver carp populations are increasing in abundance and expanding their upstream range in the Upper Mississippi River. Paddlefish and bigheaded carp are both adapted for filter feeding and have been found to occupy similar habitat. Our study aimed to quantify paddlefish and bigheaded carp spatial overlap by evaluating habitat use and selectivity in Pools 14 through 19. Paddlefish and bigheaded carp were manually tracked with VR100 receivers to assess habitat use and the magnitude of overlap. We evaluated the effect of introduced species on native taxa from their spatiotemporal overlap. From this information, we can assess the available refugia for this native species.

Condition and Size Structure of Paddlefish in the Upper Mississippi River

Zachary Witzel, Dominique Turney, and James Lamer

Western Illinois University

Paddlefish (*Polyodon spathula*) are native throughout the Mississippi River basin. In recent years paddlefish on the Upper Mississippi River (UMR) have experienced reductions in their populations which in some cases had caused them to become threatened or even extirpated in areas where they were once abundant due habitat fragmentation, reductions in suitable spawning habitat, and over exploitation. These fish are important to recreational fishermen for their flesh and roe, they are also a charismatic native species who are poster children for conservation. For these reasons it is important that we monitor the condition and size structure of paddlefish in the UMR. Monitoring these metrics would yield information on recruitment and overall health of the population in the UMR. Therefore, the objective of our study is to examine body condition and size structure of Paddlefish in multiple pools within the Upper Mississippi River. Paddlefish were caught using gillnets, length and weight were recorded and relative weight was determined using standard weight equations for Paddlefish.